Attachment 1

Cherry Hills Village Traffic Management Plan

Spring 2000

Introduction

In the spring of 1999 the Planning and Zoning Commission presented a Draft Traffic Management Report to the Mayor and City Council. This final report constitutes the Planning & Zoning Commission's further assessment of the traffic issues and makes specific suggestions for improvements at various intersections and streets to institute a comprehensive traffic management program. In preparing this report, the Commission performed a traffic survey. The results of that survey are attached. In general, the survey results reveal a desire on the part of Village residents to protect and maintain the semi-rural atmosphere of the Village and to manage traffic in accordance with that goal.

The Commission presents this report as a draft to allow for revisions based on ongoing review and discussions. The Commission also anticipates that Councils' input and comment could result in changes to the current draft. The Commission believes that a public dialogue focused on these recommendations can create a consensus-based plan that builds the support of Village residents.

The Cherry Hills Village Master Plan states as one of its goals the preservation of a semi-rural atmosphere. Roads with lower traffic volumes characterize this environment. The Commission's analysis has been based, in part, on the goals of the Cherry Hills Village Master Plan that designates Hampden Avenue, University Boulevard and Belleview Avenue as regional arterial streets. These streets are intended to carry commuter traffic passing through Cherry Hills Village to other destinations.

The specific purpose of this plan is to maintain the goal of the Master Plan of keeping "... relatively low traffic volumes within Cherry Hills neighborhoods." To accomplish this goal, the Commission recommends continuation of the program that resulted in the improvements that have been done to Quincy Ave. at Clarkson, University & Happy Canyon, Hampden & Colorado and Belleview & S. Holly. In each of these areas the right-of-way was realigned to alter the way the intersection operates and the way a driver perceives the intersection. The effect of these improvements has been to create a distinctive entrance to the Village that alters the driver's perception of the street. The approach used in this example (realignment of the right of way) is only one approach to achieving this goal. It is this underlying philosophy of changing the psychological feel of the street that the Commission embraces in this report. For more information and a further explanation of the this concept and the general techniques of traffic management, please see Appendix D, "What Is Traffic Calming and How Does It Work?," (Cynthia Hoyle AICP, Planners Advisory Service Report #456, American Planning Association).

There are certain basic traffic management considerations that should be identified as a context for evaluating the recommendations.

- In general, wide roads encourage higher motor vehicle speeds and higher speeds are associated with travel efficiency and therefore higher volumes. It follows that narrowing roadways should decrease both speed and volume. Road narrowing can be accomplished by either physically altering the roadway surface or by the addition of street treatments that will make the road seem narrower.

- No matter what steps are taken to manage traffic on local neighborhood streets there will always be traffic that is resistant to taking other routes. Some commuters may take routes through the Village simply because it is more picturesque. No amount of slowing or inconvenience is going to deter this type of commuter.
- Most of these recommendations will affect noise, air quality, congestion, fuel consumption and many other factors. Some of the measures may improve these conditions; others may aggravate these conditions causing other unintended results.
- The South Metro Fire and Rescue District should be consulted with respect to this draft proposal and any specific plans. The recommendations offered were prepared so that emergency response times would not be affected.

Recommended Improvements

Entrance Improvements

In order to both facilitate traffic on Hampden Avenue, Belleview Avenue and University Boulevard and to reduce the volume and manage speed on local streets the Commission recommends intersection improvements that will distinguish the Village's non-highway entrances and mark the division between commuting routes and local neighborhood streets. There are thirty-five (35) entrances to the Village from either state highways or other arterial streets. These entrances have been classified as either major or minor depending on perceived and documented volumes. They are:

Minor	Major
1. Clarkson & Viking Dr.	1. Hampden & Colorado
2. Clarkson & Layton	2. Happy Canyon & Quincy
3. Clarkson & Tufts	3. University & Quincy (East and West)
4. Clarkson & Stanford	4. Clarkson & Quincy
5. Clarkson & Radcliffe	5. Clarkson & Hampden
6. Clarkson & Oxford Lane	6. Clarkson & Belleview
7. Clarkson & Martin Lane (2)	7. Belleview & Holly
8. Clarkson & Kenyon	8. Belleview & Franklin
9. Mansfield & S. Dahlia	9. University & Hampden
10. Belleview & S. Albion	10.University and Belleview
11. Belleview & S. Birch	
12. Belleview & S. Dahlia	
13. Belleview & S. Fairfax	
14. Belleview & Summit	
15. Hampden & S. Dahlia	
16. Hampden & S. Albion	

17. Hampden & S. Monroe
18. Hampden & Sedgwick
19. Hampden & Buell Mansion
20. Hampden & S. Gilpin
21. Hampden & S. Clermont
22. Mansfield and S. Hudson Way
23. S. Holly Way & Happy Canyon
24. Happy Canyon & S. Ivanhoe
25. Happy Canyon & Princeton

A map of these intersections and the Commissions' recommendations appears in Appendix B.

Major intersections 1, 2, 3, 4, and 7 currently feature either re-alignment of the road, landscaped medians or both. Of the thirty-five intersections, only major intersections 1 & 8 and minor intersection 9 should receive significant improvements. At the intersection of Hampden & Colorado (#1), the Commission recommends that the existing median be extended to the north, closer to Hampden. Similarly, the Commission recommends construction of a landscaped median at the intersection of Franklin and Belleview (#8) and the intersection of Mansfield & Dahlia (#9) where medians should be placed on Mansfield west of Dahlia and on Dahlia south of Mansfield. Additionally, the Commission recommends planting more trees in existing medians of a species that will grow taller and fuller. Making these changes will reduce the perceived width of the various rights-of-way while preserving the functionality of the intersection and offering a entrances to the Village that distinguish between arterial commuter routes and neighborhood streets. No specific recommendations are made for major intersections 5 & 6 and 9 & 10 at this time..

Minor intersections 1-8, 10-14, 16-19 and 21-25 appear to be used currently as local neighborhood access streets. Many of the intersections have no outlet. The Commission is aware that improvements to the Belleview/Franklin intersection may deflect traffic to Clarkson and then onto streets like Radcliffe, Stanford or Tufts. The traffic management plan includes recommendations for study and analysis of impacts that result from recommended improvements to all of the intersections. Additionally, there has been some suggestion by neighbors in the area that the Happy Canyon & Princeton intersection (#25) should be closed. The Commission does not have a recommendation at this time regarding closure of this intersection.

The Hampden/Dahlia/Happy Canyon (#15) intersection is unique as it is the meeting point for three streets. The intersection serves as an alternate route for Tech Center commuters. The Commission makes no recommendation at this time for improvements to this intersection.

The Commission recommends some form of either landscaping or median improvements to the Hampden & S. Gilpin intersection (#20). Because of the signal, there is concern that this intersection will be used as an alternative for Hampden traffic to access University.

Street Treatment

Certain portions of Village streets, e.g. Colorado between the canal crossing and Quincy, should be physically altered with street treatments that cause traffic to slow down. Most would be more of a visual effect as opposed to physical barriers. For example, physical changes to the shoulders such as reflectors, curbs, shallow gutters, wooden posts or additional trees would create a visual effect of a narrower, and therefore slower, roadway.

All trails that are adjacent to roads and separated by the white traffic buttons (e.g. Quincy between Random and Random and Colorado between the canal and Quincy) should be delineated with posts, fencing or some form of vertical projection. This will have the effect of narrowing the road and offering additional protection to trail users.

In some cases a narrow center median or a physical narrowing of the roadway may be appropriate. This type of treatment would be used in areas where the road and adjacent foliage widen giving drivers incentive to increase speeds. The result would be a perceived narrowing of lanes and reduced speeds. These treatments also offer an opportunity to landscape the interior of the street that will have the effect of breaking up the visual element of the street and reducing speed (see Appendix D).

The Commission has decided against other devices such as speed bumps because of significant negative impacts, including reduced emergency vehicle response time, interference with snow removal, increased noise and general lack of effectiveness (see Appendix D).

Traffic Volumes

The historical data for traffic volumes suggests a trend of annual increases of 4 to 5% per year. The traffic survey indicates that many residents are at or near their tolerance point for traffic volumes. The Commission recommends that the Council consider a trigger point for additional traffic mitigation measures if volumes reach or exceed certain levels. The Commission is particularly concerned that impending reconstruction of I-25 will divert an even greater volume of non-local traffic onto Village streets. These more aggressive actions would be implemented at least through the I-25 reconstruction period.

Informational Signage

The Commission recommends that signage be placed at all major entrances to the Village to deter commuter traffic. The signs would be used to clearly define the interface between what is a neighborhood and what are appropriate commuter routes. Examples of the types of signs would be "Cherry Hills Village", "Local Traffic Only" and where appropriate "Not A Through Street" and "No Outlet". The Commission would only consider physical turn movement restrictions (i.e. no left turn from east bound Belleview to north bound Franklin) if post implementation assessment revealed that the informational signage were not having the desired effect on traffic deflection.

Stop Signs

Many Village residents commented in the Survey on the Highline Canal Trail crossings at Quincy and at Colorado. Their comments involved establishing greater safety and/or giving pedestrians the right of way over vehicles at these crossings. The options include:

(1) erecting vehicle only stop signs at these crossings, (2) placement of signs instructing vehicles to yield for all trail users crossing the street or (3) erection of additional safety warnings to alert vehicles to trail users, but not requiring them to stop or yield the right of way.

Because stop signs are 24 hour a day/7 day a week devices, the Commission is not recommending Option 1. The second option is consistent with the goal of defining the Village as a residential area and establishing pedestrian rights over vehicles.

The Commissions recommends the third option if Village staff can identify a system of warning lights and a sign reading: "Yield To Trail Users When Flashing". Trail users pushing a button similar to a pedestrian cross walk system would activate the lights. In the event such a system is not feasible, then additional signage should be used so that motorists are advised to watch for trail users.

Speed Limits

Additionally, the Commission recommends a Village wide speed limit of 25 MPH on all streets that are not state highways. The two purposes for a reduced, consistent speed limit are: 1) reducing speeds can reduce volume and 2) reducing speed limits makes a statement that all Village streets have a local character and purpose that does not lend itself to commuter traffic. The Commission feels all Village streets are local in nature and higher speed limits suggest an arterial role.

Special Enforcement Zones

Special enforcement zones should be established in school zones that would double the fines for motorists caught speeding in these areas. Provision for these types of zones is included in the new model traffic code. City staff is currently reviewing this code in anticipation of its adoption by Council in the spring of 2000.

The 1998 traffic count was inadvertently performed on a day when local schools were not in session. The results indicate a 13% decrease in traffic that is not at all helpful in understanding what the increases to the transportation network were from 1997 to 1998. It does, however, reveal the contributed impact on the system from the schools. Although annoying, the Commission believes that the congestion attributable to the local schools (specifically Kent Denver and Cherry Hills Elementary) does perform the function of making it less attractive to commute through the Village on non-arterial or non-state highway roads.

Traffic Facilitation Recommendations

Changing the way the driving public perceives the Village's rights-of-way with the goals of reducing speed and volume is only one approach to managing traffic in the Village. Other types of approaches might include:

- Participation in the DRCOG Transportation Improvement Program (TIP) process for specific projects relating to improvements on Hampden, Belleview and University to facilitate traffic flow on these arterials. This is the process for accessing Federal transportation dollars. The TIP process requires coordination with other local governments and the state and competition for limited funds.

Conservatively speaking the process would require a 3-5 year planning horizon after a specific project were suggested. Any projects submitted for inclusion on the TIP must include engineered cost estimates for specific improvements and probably a match of local dollars (or at least an infusion of dollars and in-kind services). Submittals could include a variety of project types. Examples might include:

  - Grade separation at state highway intersections;
  - Pedestrian walkways over University;
  - Sidewalks where they do not presently exist along state highways to encourage alternative modes of transportation, i.e. bikes, walking, bus routes . . . etc.

- The addition of new bus shelters on University along with encouragement to residents to take the bus;
- Additional bus lines on Belleview Ave.;
- Village support for a comprehensive, metro-area, light-rail system;
- Review signal timing/coordination for state highways including Hampden, Belleview and University (See Appendix C).
- Trail underpass at Franklin & Belleview and somewhere along University Blvd. to allow pedestrians/equestrians/bicyclists to cross in safety and relieve congestion at Quincy & University and Belleview & University.

Cherry Hills Village Police Department Traffic Enforcement Plan 2000

Identification of problem areas, methods:

- Officer Knowledge—Officers already have knowledge of most problem areas. It may be the result of working traffic accidents at a particular location or from actually receiving complaints from residents. Officer input in targeting specific locations/violations is essential
- Extra Patrol Requests—Requests from residents for extra patrols will be related to officers at each shift.
- Accident History—Violation themes emerge from the traffic accident history. As these themes are identified, resources can be allocated to address specific locations/violations.

Specific direction to patrol teams—the CHVPD will provide officers with a weekly list of targeted sites or problems to be addressed. Patrol teams will develop plans to address specific complaints and/or problem areas identified by officers. Innovation and ingenuity in identifying and contacting violators should be encouraged. Enforcement activities may include:

- Use of unmarked vehicles,
- Plain clothes officers on foot acting as spotters,
- Team approach (motorcycles and chase cars).

Officers may be given specific problems or locations to work. They can be given the latitude to develop an action plan to work the site.

Follow up—Each week the effort of the previous week will be measured and evaluated (i.e. numbers of stops, number of citations issued, types of citations, comparison of citations to complaints). Complainants should be contacted and advised of the results of the efforts. The traffic survey should be repeated on an annual basis to test results of enforcement activities and to further refine and direct the CHVPD's efforts.

Speed Trailer—Continued use of the speed trailer is essential. Deployment should be planned to target specific problem areas. Deployment should cover all areas of the City on a rotational basis.

Legislation—Legislative creation of "Safety Zones" near schools or other problem areas. Safety zones may have a speed limit that is lower than typical for the area and traffic citation fines can be doubled as extra incentive to be aware of the zones.

Special enforcement efforts—Typically during the holiday season, extra officers can be put on duty on an overtime basis. This is usually done to target DUI enforcement, but there is no reason it can't be used to target an area subject to other traffic complaints.

Additional personnel—The present call load provides officers with a substantial amount of discretionary time that can/should be directed toward traffic issues. There may come a time, however, that additional personnel will be required.

Meetings—Many of the individual comments in the 1999 Traffic Survey made mention of the desire to attend town meetings to discuss traffic issues. A forum should be established to provide residents with a place to discuss traffic issues during development of the Traffic Management Plan.

Procedure

Once Council has reviewed and commented on the Traffic Management Plan, it is the recommendation of the Commissioners that the Plan be summarized and published. If possible, the Commissioners believe the summary should be mailed to each household in the Village and copies should be made available. A town meeting will be scheduled to discuss the recommendations.

The focus of the town meeting should be on the recommendations contained in this plan and the rationale for choosing these approaches over others. The goal of the meeting is to direct attention to the complexity of the issues and to create consensus and support for the plan.

Assessment

The Commission recognizes that a Traffic Management Plan such as this is a reiterative process that will require post implementation testing and analysis to determine if the desired results are being achieved.

This phase of analysis and testing should include the continued use of yearly traffic counts and deployment of the City's speed trailer. Additionally, input from Village residents should be solicited to determine if the recommended improvements are having the appropriate effect, or if there are unanticipated, negative side effects.

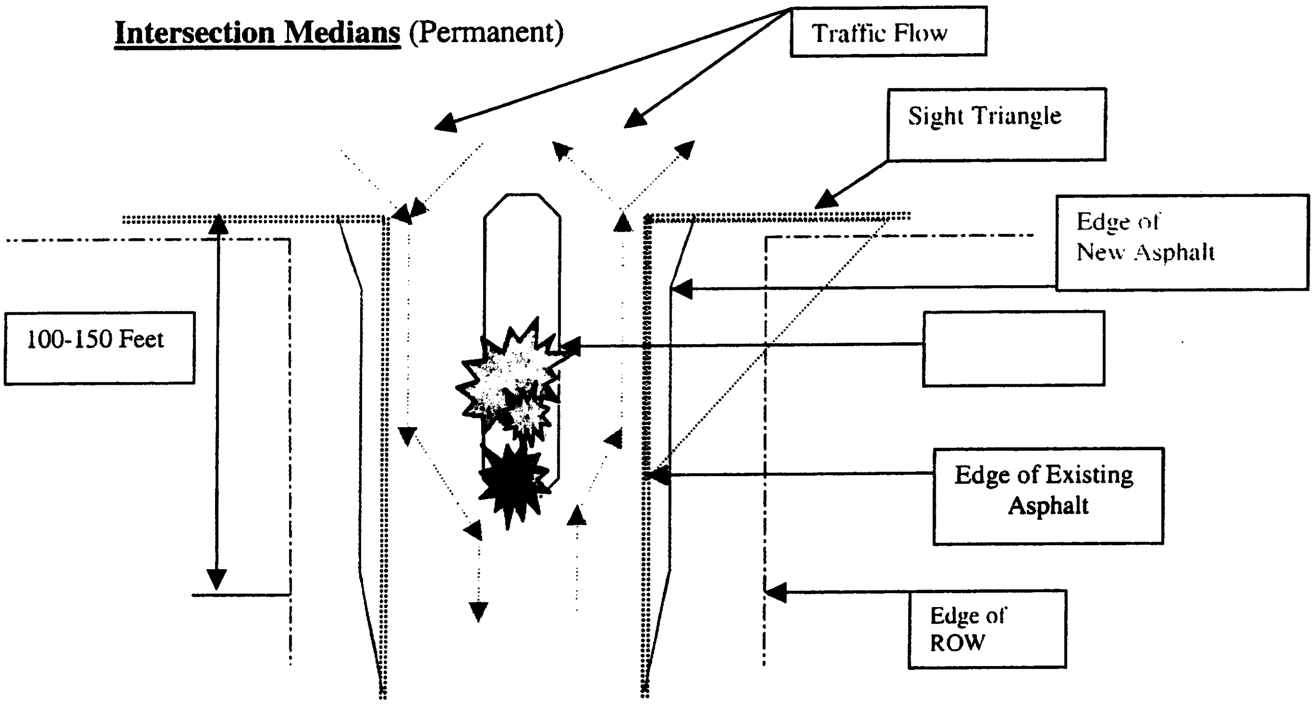
Cost

Kevin Louis, Public Works Director developed the following cost estimates for a landscaped median. These costs are based on what would be required to place the improvements in a typical City right-of-way assuming no existing infrastructure. Each site could, of course, have a number of variables that would add to the cost of the improvements. The City's engineer would have to review each location and review the estimates. These numbers are for use as a planning tool only.

Signage

Cost per sign $50.00 to $75.00

Capital Improvements



Center Median Estimate

Curb and gutter:	Demo @ $8.00 per linear ft	$ 1,400
	Installation @ $14.00 per linear ft	$ 6,000
Asphalt replacement		$10,250
Irrigation		$ 5,500
Tap fee		$ 4,500
Landscaping		$ 5,000
Signage		$ 500
Engineering		$ 2,000
	Total Project Estimate	**$35,150**

Appendices

A—1999 Traffic Survey Results

The results of the Planning and Zoning Commission's survey are as follows:

1) *In which area of the Village, or in what subdivision do you live? (Staff split the Village into a grid containing 8 areas. Area 9 is for those surveys either that did not answer the question or that gave a response too vague to map.)*

We received two hundred and twelve (212) responses—just shy of ten percent of the households in the Village (est. 2340). The responses were fairly evenly distributed across the Village. Sectors 1 and 8 had the most responses corresponding to their relatively higher density and Sector 5 had the lowest response rate due to a relatively large portion of the land being used by the Country Club.

Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8	Sector 9
38	18	17	23	14	21	26	48	7

2) *On average, how many trips a day are made by you and other members of your household including domestic help (count both going and returning as separate trips)?*

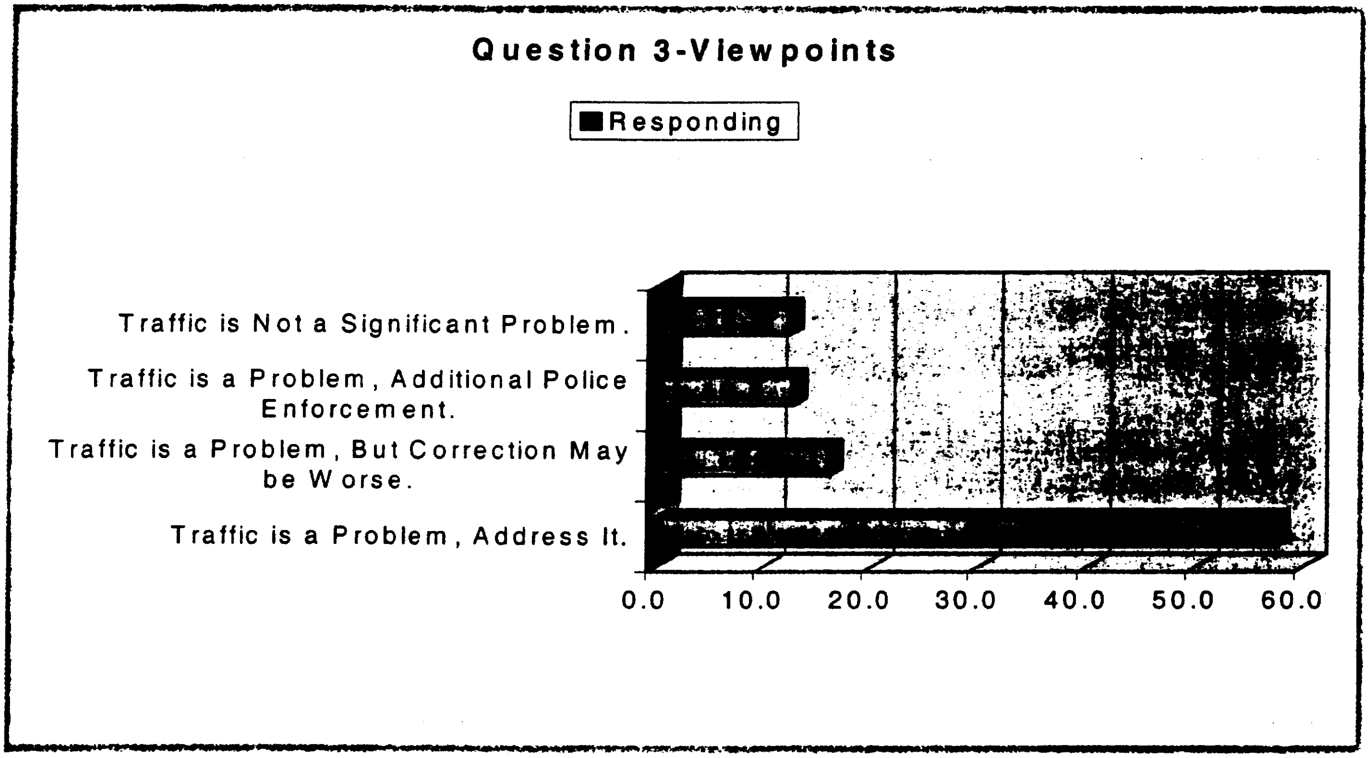
The mean and median number of trips per day reported by Village residents in Question 2 is 8.03 and 8 respectively. Staff considered all responses in the calculations and did not throw out outliers (responses that would tend to skew the results, i.e. "26 trips" or "1 trip"). These responses may include construction help, or they may just represent very busy, mobile people. Inclusion of these outliers in the calculations tends to increase the mean and broaden the standard deviation figure.

Mean	8.03
Median	8
Mode	6
Standard Deviation	4.8

3) Please check the one statement below that most closely reflects your viewpoint on traffic in Cherry Hills Village:

It seems clear from the response to Question 3 that many residents (57.3%) consider traffic to be a problem. Only twelve point three percent (12.3%) of those responding indicated that they did not perceive a problem with traffic. However, only slightly more (12.7%) indicated that increased enforcement of existing traffic laws would address the problem (This response seems to contradict responses received to Question 5(n)).

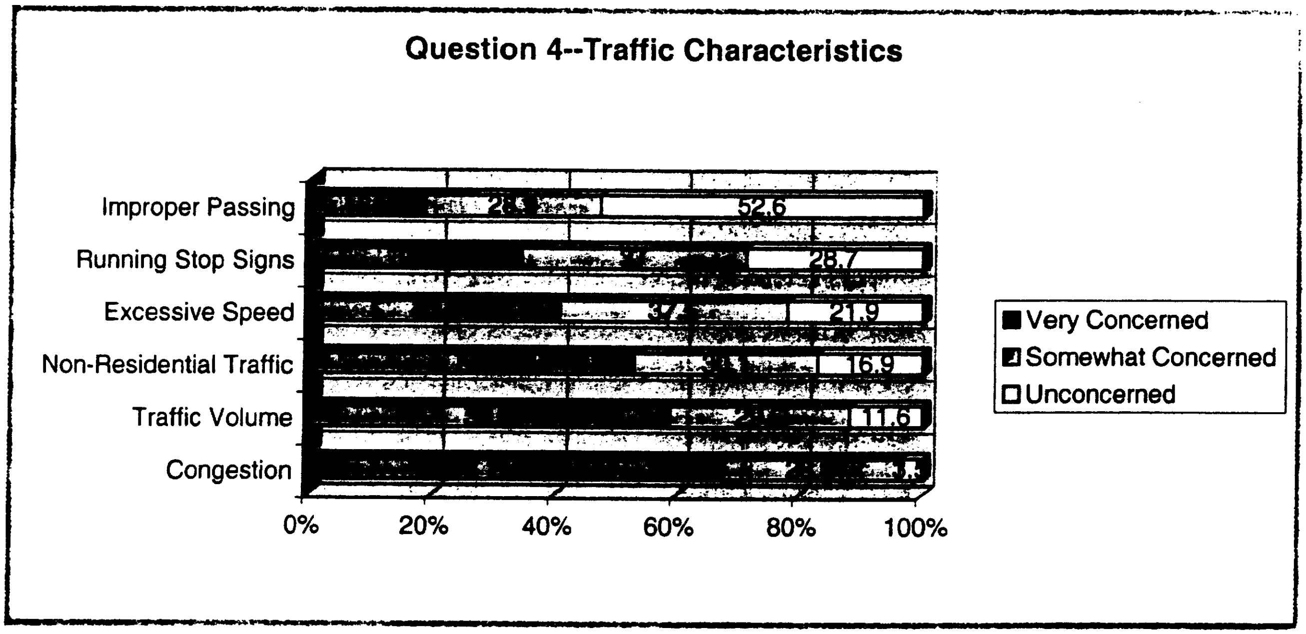
Sixteen percent (16%) of the responses indicated that correction of the problem may cause more harm than good.



4) Please indicate your concern with the following characteristics of Village traffic using the following scale: (1=Very Concerned · 2=Somewhat Concerned · 3=Unconcerned)

The most important concern of those who responded to Question 4 was congestion during commuting hours (67.7% or 96.6% of those who were either very concerned or somewhat concerned). This was followed by concerns for the volume of traffic (58.8% or 88.4% of those who were either very concerned or somewhat concerned) and concerns about non-residential traffic (53% or 83.1% of those who were either very concerned or somewhat concerned). Excessive speed (40.6% or 78.1% of those who were either very concerned or somewhat concerned) and running stop signs (34.3% or 71.3% of those who were either very concerned or somewhat concerned) were next in order of importance. Improper passing incidents were of a concern to eighteen point five percent (18.5% or 47.4% of those who were either very concerned or somewhat concerned) of those responding.

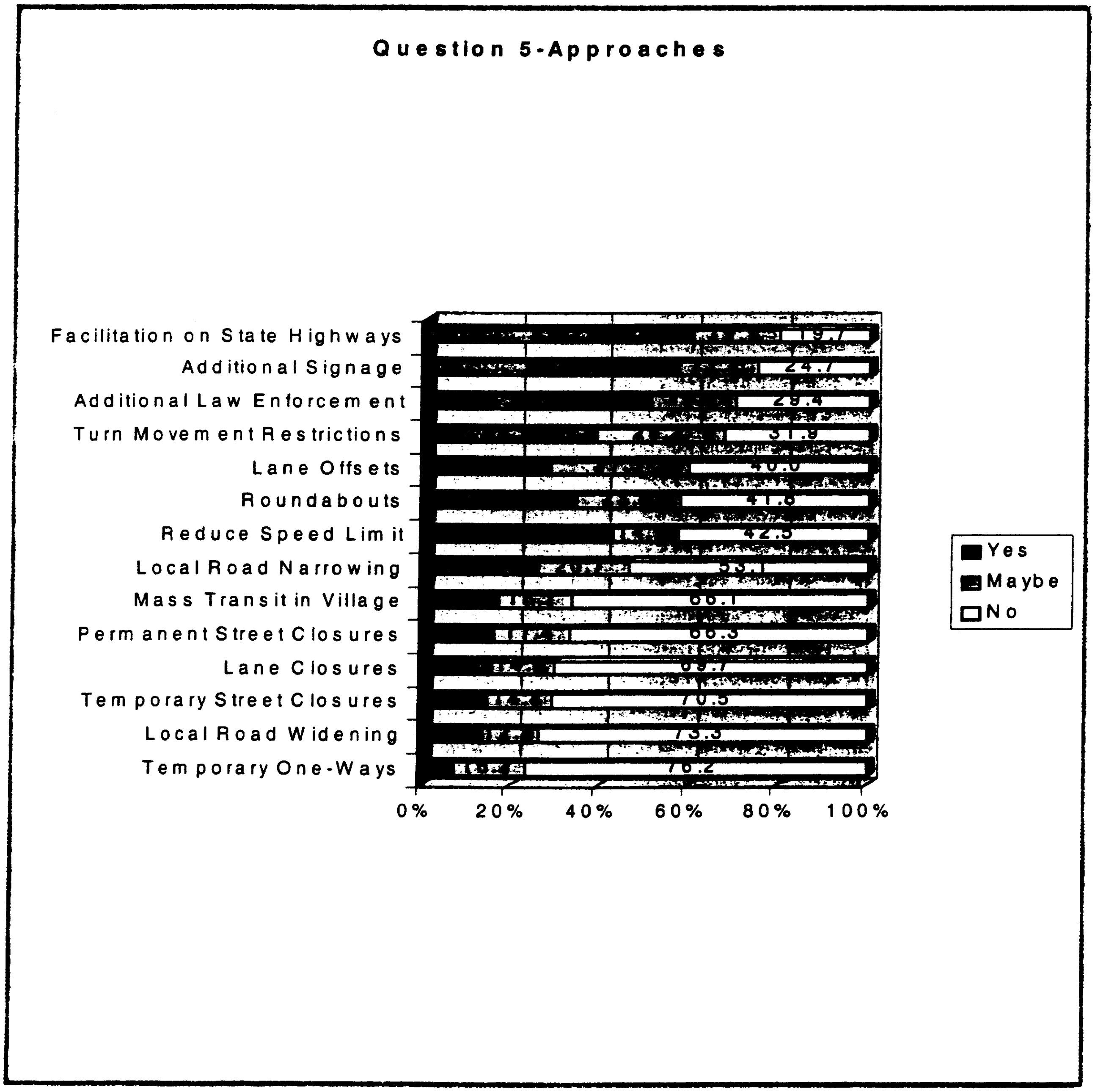
The 1998 Traffic Count occurred by happenstance on a day when the public schools were out for "Fall Break". The results indicated a decrease by about 13% in Village traffic. This "reduction" in volume highlights the impact produced by the schools on congestion. Most residents will have noticed a marked decrease in traffic during these types of school break periods. Please refer to attached sheet for responses to "Other" characteristics not specifically included in the survey.



5) If you indicated you are concerned or somewhat concerned with traffic problems, which of the following approaches would you support? (1=Yes · 2=No · 3=Maybe)

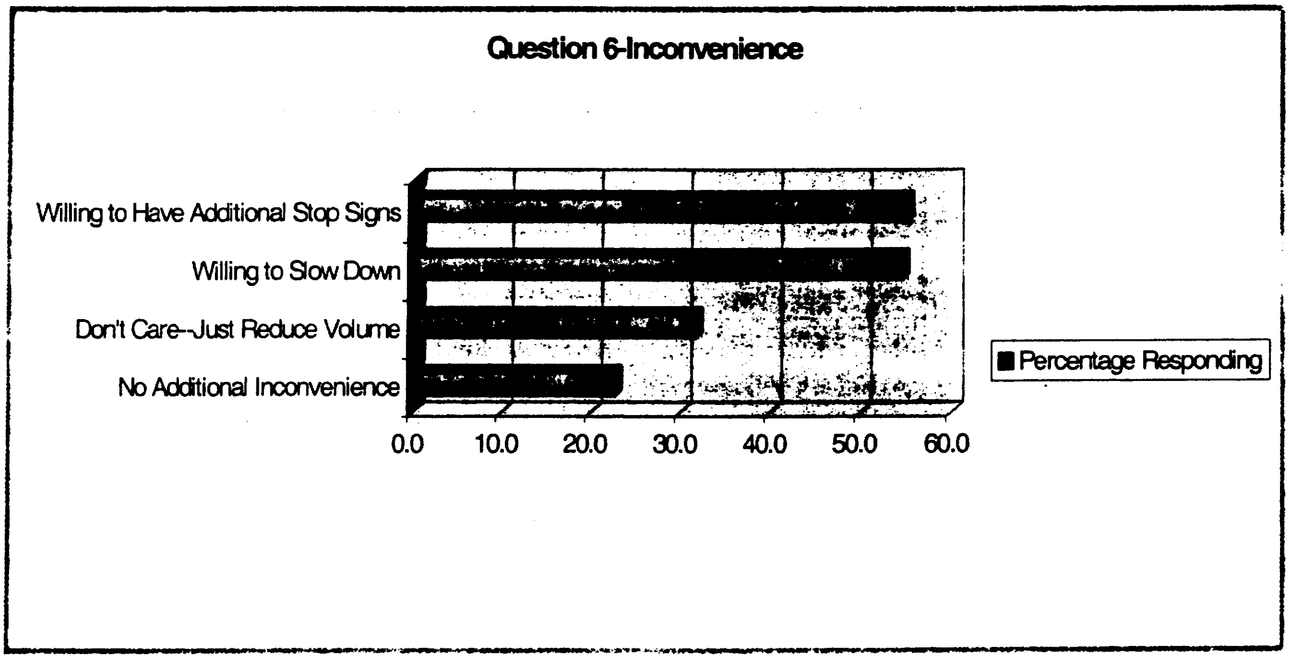
When asked what approaches to traffic management residents would support in Question 5, the top response was facilitation of traffic movement on Belleview Ave., Hampden Ave. and University Blvd. (60.7%). The next two approaches that were most favored were additional signage (56.7%) and additional law enforcement (51.3%). Reduction of speed limits on all Village streets was next in order of ranking (43%).
Turn movement restrictions received a 38.9% share of response while roundabouts (34.6%), lane offsets (28.5%) and local road narrowing (26.3%) round out the approaches that received at least twenty percent (20%) response rate.

Finally addition of mass transit routes through the Village gained only 17.2%, permanent street closures received 16.3%, lane closures received 15.7%, temporary street closures received 14.8%, local road widening received 13.9% and temporary one-way streets received only 7.6%.



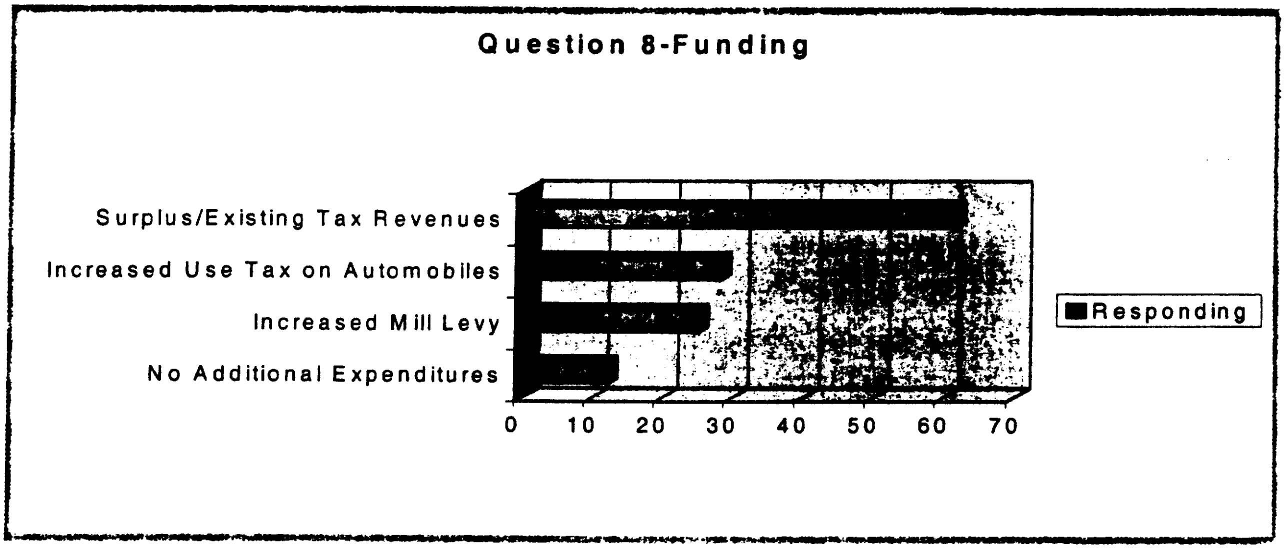
6) *If you feel concerned about traffic volume and have indicated support for attempted remedies, you should know that additional measures might have little effect. In addition, there will be an additional level of inconvenience for Village residents. Please indicate how much inconvenience you are willing to tolerate. Check all that apply:*

A majority of those responding to question 6 indicated that they would be willing to slowdown (54.5%) by either reduced speed limits, road offsets or roundabouts. A majority also indicated they would be willing to have one or two additional stop signs on their way to a major arterial (55%). About one third (31.6%) said that they did not care what the effect of the approach was on them, they just wanted something done. Finally, less than a quarter (22.7%) indicated that they would not want to suffer any additional inconvenience.



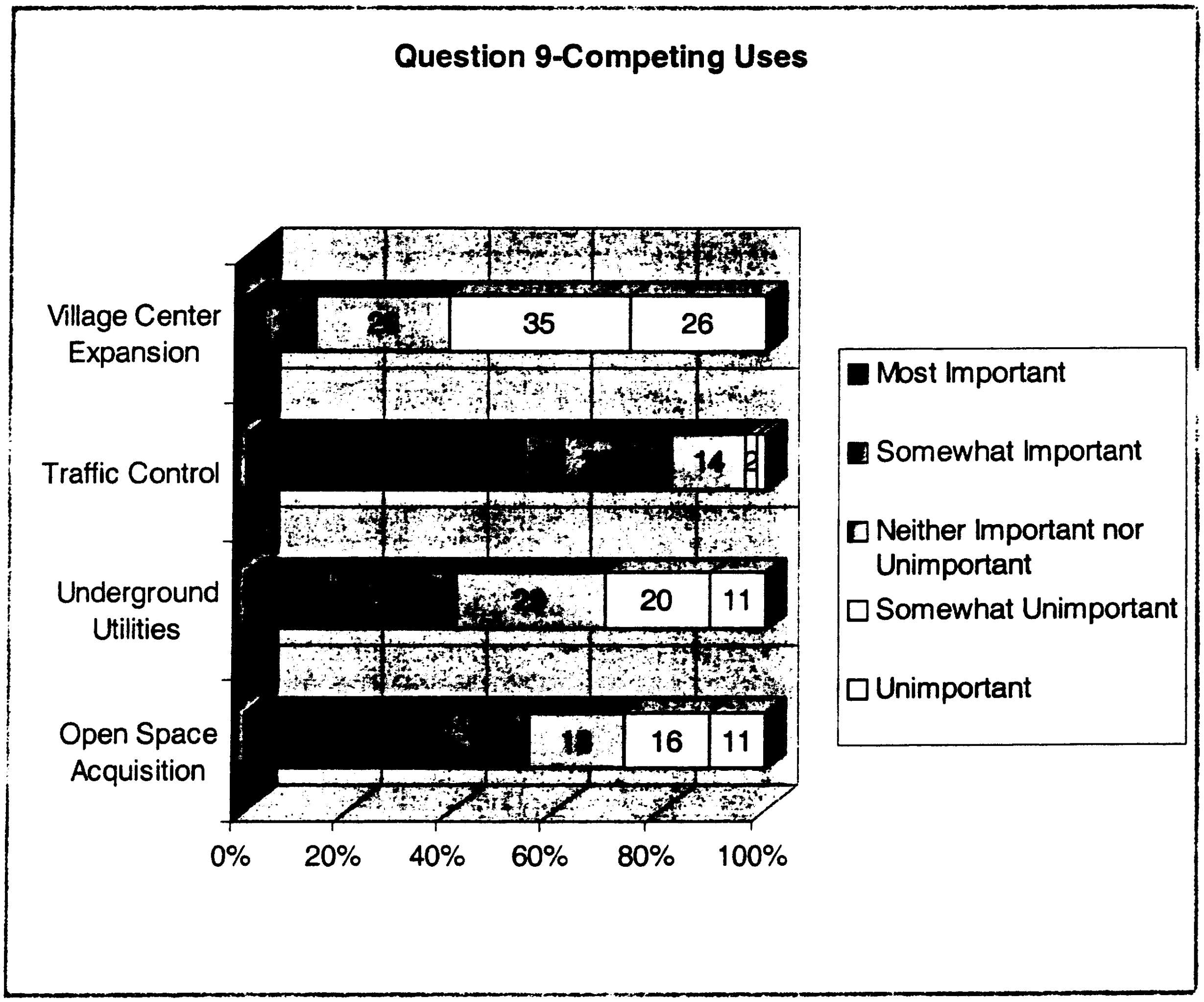
8) How should these improvements be funded?

A majority said that traffic management approaches should be funded from surplus tax revenues (61.6%). Only about a quarter of those responding would support additional taxes—increased mill levy (25.1%) and increased auto use tax (28.3%). Finally, only twelve point three percent (12.3%) indicated that the City should make no additional expenditures to address traffic management issues.



9) If you checked "Expenditure of surplus tax revenues/Use revenue from existing taxes", there may not be enough to fund some desired improvements for a few years. In addition, there are competing uses for our limited revenues. How would you rate the following expenditures? (1=most important, 5=least important)

Not surprisingly those surveyed about traffic management problems and perceptions answered that traffic control issues were the highest priority (53%). Open space acquisition (36%) and burying public utility lines (16%) were next. Expansion of the Village Center was most important to only 3% of those surveyed about traffic concerns.



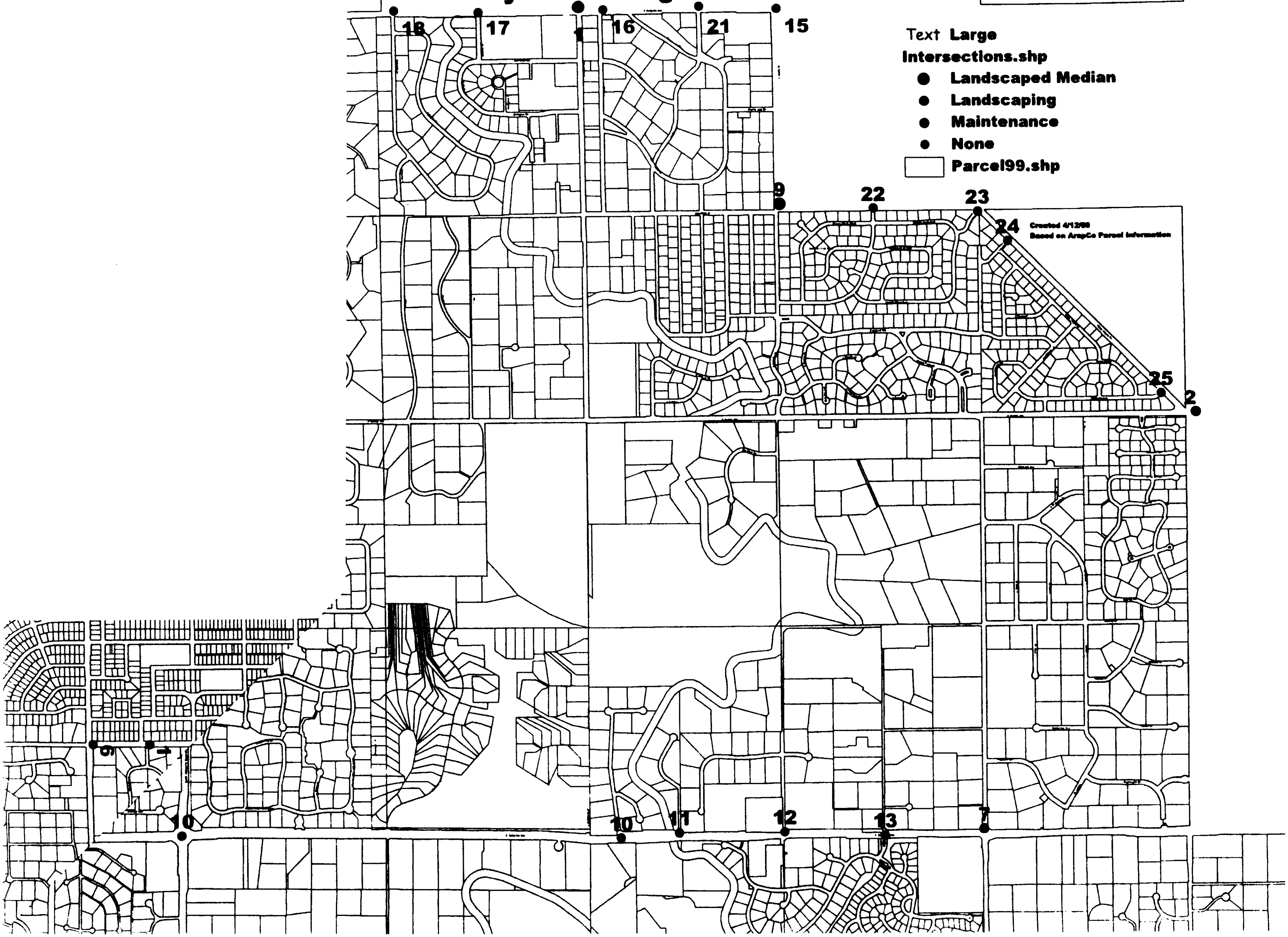
There appears to be broad-based support to doing something to address traffic congestion and volume in Cherry Hills Village. Those surveyed indicated that programs involving minimal cost and disruption were the ones most favored. It is clear from the survey that any programs/approaches should be funded with surplus tax revenues as opposed to additional taxes.

The approach most favored by those surveyed was facilitation of traffic on the state highways. This approach will involve the City and staff in the metro area transportation planning process for funding and buy in by the metro region. Improvements like road widening and grade separations will need to be coordinated with CDOT and DRCOG at a minimum. Any such proposal will likely take a number of years to develop and fund due to involvement with several organizations and other jurisdictions competing for limited federal dollars. Other 'minor issues' on the state highways could be revisited with CDOT to determine if a change were necessary—i.e. the signalization of the University Blvd. and Quincy Ave. intersection.

The additional comments are interesting in that there are quite a few people who would like to be more involved in the process either through neighborhood or Citywide meetings. The success of any traffic management plan is dependent on an open, participatory planning process that includes invitations to the public to attend meetings to discuss problems and solutions and a commitment to building consensus within the community on the issues.

B— Village Map

Recommended Improvements to
Cherry Hills Village Intersections



C— Signal Timing Coordination Study

DRCOG Technical Briefs

Denver Regional Council of Governments

August 1999 T99-4

Traffic Signal Timing/Coordination Improvements

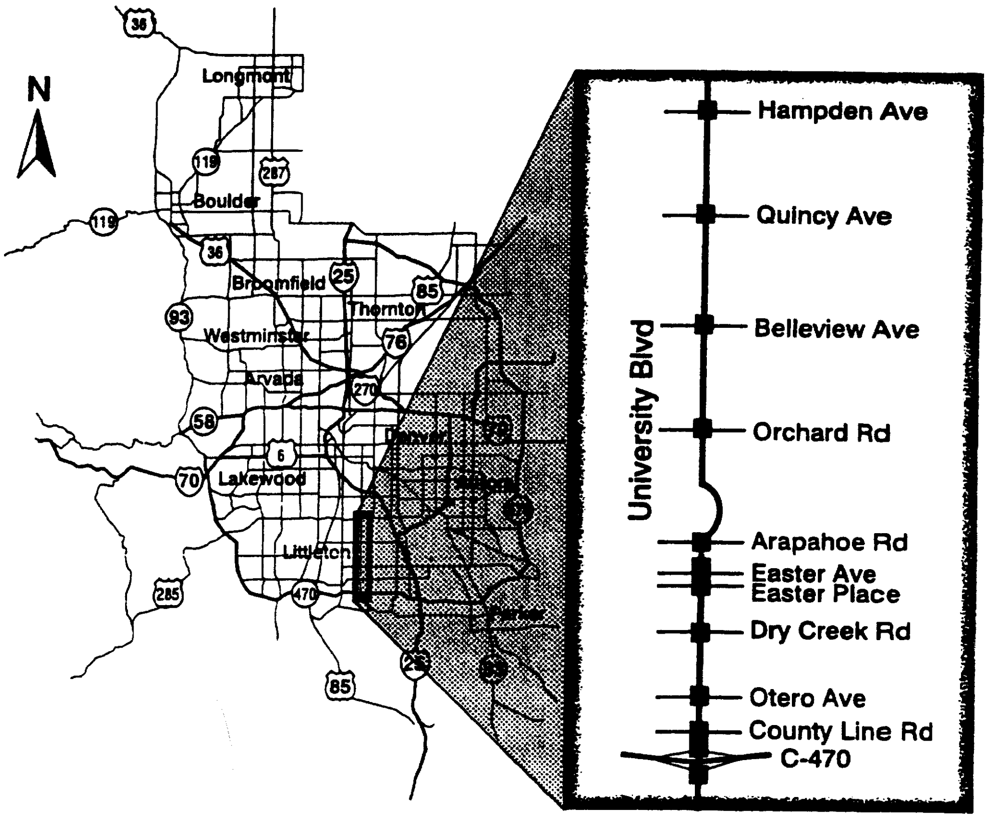
University Boulevard
Hampden Avenue to C-470

Project Description

This project encompassed the re-timing of 12 traffic signals along a six-mile segment of University Boulevard through the cities of Cherry Hills Village and Greenwood Village, and unincorporated Arapahoe and Douglas counties. The objective of this project was to improve corridor travel time by reducing the delay caused by the traffic signals.

University Boulevard is a major regional north-south arterial roadway in the south-central portion of the metro area. The adjacent land use is a mix of commercial and residential properties. University Boulevard is designated as State Highway 177 within the project area.

PROJECT LOCATION



■ Colorado Department of Transportation Signal

DRCOG

Denver Regional Council of Governments
2480 W. 26th Ave.
Suite 200B Denver CO
80211-5580
(303) 455-1000

Traffic Operations Program Mission

Traffic signal timing and coordination improvements play a key role in improving the efficiency of the Denver metro area's arterial, or major, roadways. Coordinated signals allow traffic to move smoothly from one signal to the next, reducing the number of vehicles stopping at traffic lights and decreasing the time drivers must wait when stopped.

Local governments asked the Denver Regional Council of Governments (DRCOG) to spearhead the region's efforts to improve traffic signal timing and coordination, prompting establishment of a Traffic Operations Program in 1989. The Traffic Operations Program is tasked with improving signal timing on principal arterial roadways with special emphasis on multi-jurisdictional corridors.

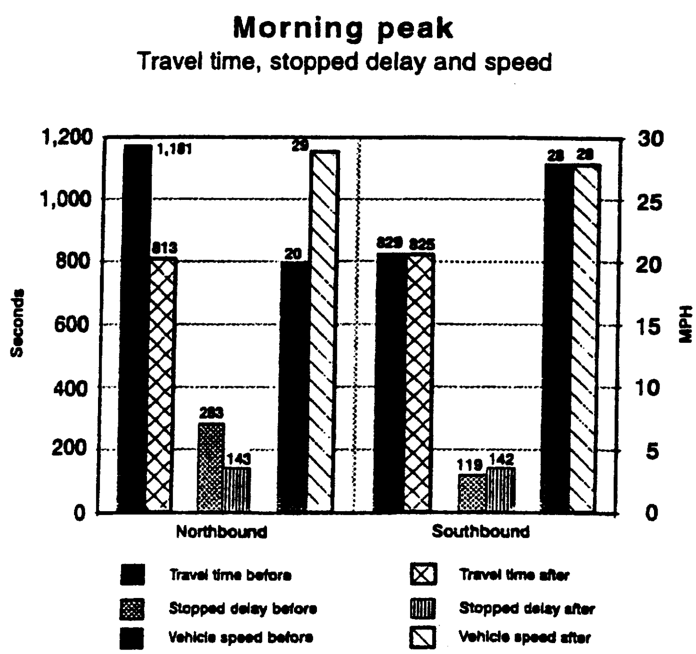
University Boulevard has four through lanes between Hampden Avenue and County Line Road, and six through lanes south of County Line Road. Double left-turn lanes are provided in the northbound approach at Hampden Avenue, both north and southbound approaches at Belleview Avenue, and both north and southbound approaches at Dry Creek Road. All other signalized locations have single left-turn lanes. University Boulevard carries approximately 44,000 vehicles per day north of Arapahoe Road and 48,000 vehicles per day south of Dry Creek Road.

The Colorado Department of Transportation operates all 12 traffic signals in the project area using Type 170 equipment with radio communications. New signal timing plans were developed for the morning peak (6-9 a.m.), the evening peak (3-7 p.m.), and the off-peak period (all other times of the day). These new plans use 120-second cycles in the morning and evening peaks and a 100-second plan during the off-peak period. Previously, University Boulevard was coordinated using a 100-second cycle length during the morning and evening peak periods, and a 90-second cycle length during the off-peak period. The new timing plans retain cross-coordination at Hampden Avenue (June 1999 project) through all three time periods.

Results

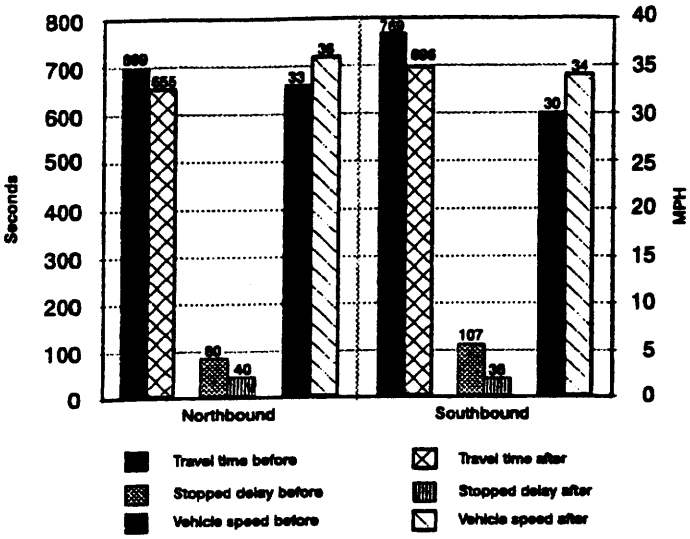
Travel improvements for this project were quantified by performing travel time and delay studies before and after the new timing plans were implemented. Fuel consumption and pollution emission levels were calculated based on these travel studies.

Travel time northbound, the major direction of travel in the morning peak, was reduced by more than six minutes, with 38 percent of this improvement due to eliminated stopped delay. Average vehicle speeds increased by 9 miles per hour (mph). The southbound direction of travel showed virtually no change in travel time or vehicle speed.



Off-peak

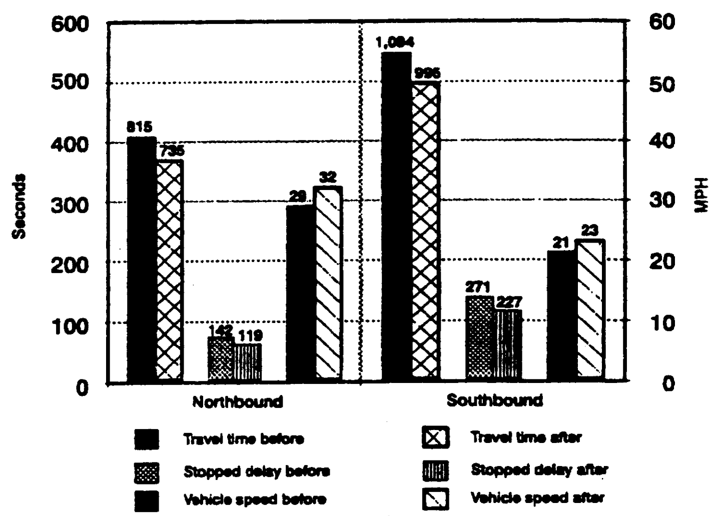
Travel time, stopped delay and speed



During the off-peak period, improvements were made in both directions of travel. Northbound travel time was reduced by nearly three-quarters of a minute and southbound travel time was reduced by about one minute and fifteen seconds. In both cases almost all of the reductions were due to eliminated stopped delay. Average vehicle speeds improved by 3 mph northbound and 4 mph southbound.

Evening peak

Travel time, stopped delay and speed



Northbound travel time during the evening peak period was reduced by about one minute and twenty seconds, of which about 25 percent was eliminated stopped delay. Travel time southbound, the major direction of evening peak travel, was decreased by more than a minute and a half, about half of which can be attributed to eliminated stopped delay. Average vehicle speeds were increased by 3 mph northbound and 2 mph southbound.

Overall Improvements

Over the course of an average weekday, the new timing plans reduced travel times by 12 percent, and average travel speeds increased by 13 percent. Most dramatic was the 31 percent reduction in travel time in the northbound direction during the morning peak period. As shown in the table below, this timing project is estimated to have reduced total travel time on University Boulevard by almost 850 vehicle hours per day. Daily fuel consumption and vehicle emissions decreased by 280 gallons and 776 pounds respectively. The value to motorists, in terms of time and fuel savings, is calculated to be $4,550 per day, or approximately $1.1 million per year.

Summary of Daily Benefits

Performance Measures	Daily Benefits
Vehicle hours of travel	844 hours reduction
Fuel consumption	280 gallons decrease
Time and fuel costs	$4,550 savings
Total pollutant emissions	776 pounds reduction

The brochure *"Why are the Signals Red"* provides an informative overview of some of the challenges involved in improving traffic signal timing and coordination. This brochure is available at no charge by calling the DRCOG Public Affairs Division at 303-455-1000.

Glossary

Arterial – A main roadway. Built primarily to serve through traffic at moderately high speeds, an arterial generally extends many miles in length and has multiple through lanes.

Controllers – The devices which operate traffic signals (making them display red, yellow, green, etc. indications). Modern controllers are microprocessor-based; they are, in essence, computers. There are two basic types of controllers; Type 170 and NEMA.

Type 170 Equipment – A control equipment approach based on hardware standardization (electronic modules, wiring harnesses, cabinet enclosures, etc.), originally developed by New York and California. Control functions are not covered by these specifications; control software is purchased separately.

NEMA Equipment – Control equipment conforming to standards published by the National Electrical Manufacturers Association (NEMA). These standards define physical and functional requirements, input and output formats, interface requirements, etc. Control software is included in NEMA equipment. Vendors such as Econolite, Eagle, Multisonics, and Peek produce equipment to NEMA specifications.

Signal Coordination – The process of making traffic signals work together, as opposed to independently. There are several ways to accomplish coordination; the two primary ones are time-based and signal system.

Time-based Coordination – This method of coordination relies on synchronizing "time clocks" installed with the controllers at individual intersections. This "time clock" may be a separate piece of equipment, called a time-based coordinator, or it may be built into the controller circuitry. A communications network is not specifically required in order to provide this form of coordination.

Signal System Coordination – Intersection signals are linked together by a communications network, and various operating functions (such as the time the signal turns green, the maximum amount of green time various movements get) are governed by a "master" controller or a centrally-located computer. System hardware, software, and communications linkages enable the automatic synchronization of the individual controllers and provide signal personnel with the ability to observe signal operations and adjust operating functions from a remote location.

Communications Network – Provides for the movement of data from local intersection controllers to the point of control (central computer, master controller, or signal engineer's personal computer) and of commands from the point of control to the local intersections. Many different communications media are used in signal systems, including: leased telephone lines, cellular telephones, radio-based communications, copper wire, and fiber optic cable.

Cycle Length – The total length of time required for the controller to serve all of the movements at the intersection. The cycle length defines how long it takes for the indications on one street to go from green to yellow to red, and back again to green.

Timing Plans – The set of signal timing parameters provided to the local intersection controllers and system control devices. Timing plans are developed with the objective of providing the most effective operations for a specific set of traffic conditions, typically focusing on minimizing the amount of stopped delay and providing progression along the arterial.

Stopped Delay – Additional time incurred by a vehicle when stopped as compared to one which does not stop.

Progression – Forward travel with a minimum of stops.

Travel Time – The amount of time it takes to drive from one location to another, including the time driving at speed, accelerating and decelerating, and stopped. In this report, it is the total time spent driving from one end of the corridor to the other.

Cross-coordination – A condition where both the main street signals and the cross-street signals are operated in a coordinated fashion.

Preparation of this report has been financed in part through grants from
the U. S. Department of Transportation

D. —"What is Traffic Calming and How Does it Work", Planning Advisory Service Report

Chapter 2. What Is Traffic Calming and How Does It Work?

Current planning techniques have not created communities that are efficient in their use of natural resources and available public monies, or that provide the best quality of life for all residents. Urban areas cannot go on indefinitely handing over more and more of their living space to cars. Many city and state planning authorities in other countries have already abandoned traditional planning methods and in their place have adopted a new planning approach. In some countries, such as Germany, this new planning approach has even been enacted into federal law.

Traffic calming is a holistic, integrated traffic planning approach that seeks to maximize mobility while reducing the undesirable effects of that mobility. Another definition of traffic calming is environmentally compatible mobility management.

This chapter discusses the nuts and bolts of how traffic calming actually works. It looks at the principles of traffic calming, the techniques used in traffic calming, and the results of employing these techniques.

THE PRINCIPLES

Principle 1. Streets are not just for cars. The function of a street is not solely to act as a corridor for traffic. Streets are also for social interaction, walking, cycling, and playing. Different roadways will serve different functions in a community—but, on a street, no one function should dominate to the exclusion of all others.

Principle 2. Residents have rights. Residents have a right to the best quality of life a city can provide. This includes the least noise possible, the least pollution possible, the safest environment possible, and an environment that fosters a rich community life in which individuals are free to reach their fullest potential.

All residents, regardless of age, financial status, or social standing, have rights to an equal share of the mobility that a city can responsibly provide for its residents. No person or group has the right to increase their mobility at the expense of another person's mobility. This means recognizing that an overemphasis on car transportation discriminates against a large section of society.

Principle 3. Maximize mobility while decreasing the costs. Trips are usually only a means to achieving a desirable end. Therefore a trip is a "cost" we must pay to enjoy a "benefit" at journey's end. That cost involves time, money, energy, and social and environmental effects. It therefore makes sense to minimize the costs a city and its residents must pay to enjoy access to a wide range of destinations.

This principle involves managing the already existing transportation resources of a city with maximum efficiency. It means maximizing the efficiency of an inefficient road and public transportation network before new infrastructure is built.

THE TECHNIQUES

Technique 1. Reduce the speed at which automobiles travel by altering roadway design. Reducing speed has the following effects:

1. Slower traffic emits less noise and fumes if traveling at an even pace.
2. There are fewer accidents.
3. Accidents that happen are less severe.
4. The capacity of the existing road space is increased.

This last point surprises many people. It is natural to think that the faster traffic is traveling, the more traffic the road would be able to handle in an hour. What is overlooked is that, as you increase speed, you must increase the safe traveling distance between each vehicle. There is an optimum speed for all roadways. At speeds below or above the optimum level, the number of vehicles the roadway can move in an hour drops.

There are two types of techniques that can be employed to reduce the speed of vehicles on roadways: active and passive controls. A comprehensive document done in 1980, *State of the Art Report: Residential Traffic Management*, by Daniel T. Smith et al. for the U.S. Department of Transportation's Federal Highway Administration discusses in detail the effects of applying various traffic control techniques to residential streets. Key points of this report's findings, in addition to those of other research on various traffic control techniques, are discussed in the following paragraphs.

Active physical controls include: speed bumps, speed tables, rumble strips, median barriers, cul-de-sacs, semi-diverters, traffic circles, chokers, interrupted sight lines, neck-downs, chicanes, changes in direction, and protected parking. Active controls change driver behavior and are therefore largely self-enforcing. They create the visual impression that a street is not meant for through traffic and that other users of the roadway, such as pedestrians, cyclists, and children playing, have an equal right to use of the street. The drawback to use of active controls is their cost, the possible negative impact on emergency and service vehicles, and the negative response of motorists who are inconvenienced by their introduction.

Passive control devices are primarily traffic signs (e.g., Stop, Yield, speed limits, turn prohibitions, one-way, "Slow, School Zone," "Do Not Enter," "Not a Through Street," "Dead End," "Local Access Only," truck restrictions, etc.). Other passive control devices include traffic signals and pavement markings, such as crosswalks and lateral bars.

Passive control devices, while using regulatory signs to inform drivers, do not physically prevent action. Thus, drivers easily violate the purpose of these devices. Their advantage lies in the fact that they can be in force during only selected time periods of the day, thus allowing full access to travelers at other times of the day. They also do not block access for emergency or service vehicles.

Passive control devices are most effective in areas where compliance can be expected to be high and enforcement is possible. In such cases, experience has shown that, even with some violations,the devices can produce a significant improvement in the level and effect of traffic. If there is little enforcement of the law and drivers resent the limits on their travel, however, compliance will be low, and the devices will be ineffective. For example, if Stop signs are used to try to reduce major traffic flow or No Through Traffic signs are installed in a neighborhood used for cut-through traffic where no better alternative exists, numerous violations can be expected.

The following sections briefly discuss the advantages and disadvantages of various active and passive traffic control devices.

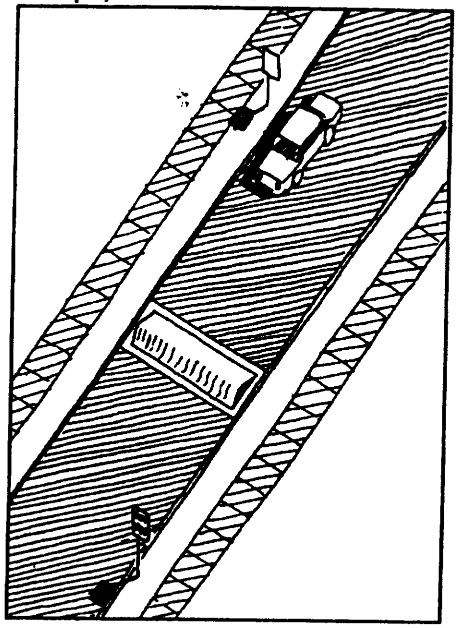
Speed Bumps and Speed Tables

Speed bumps and *speed tables* are raised humps in the paved surface of a street that extend across the roadway. Normally, they have a height of less than five inches. A speed table must be long enough for both the front and rear wheels of a car to be on top of the table at once, meaning that the table has to be 8 to 12 feet (or 2 to 4 meters) long. Speed tables can be comfortably crossed at 15 to 25 miles per hour. Speed bumps are normally less than 3 feet in length (1 meter).

Studies done in Great Britain on speed tables that were 12 feet (4 meters) long (in the direction of travel) and 4 inches (.1 meter) high showed that they not only reduce the speed of vehicles, they also reduce traffic volumes (TRRL 1976, 1977).

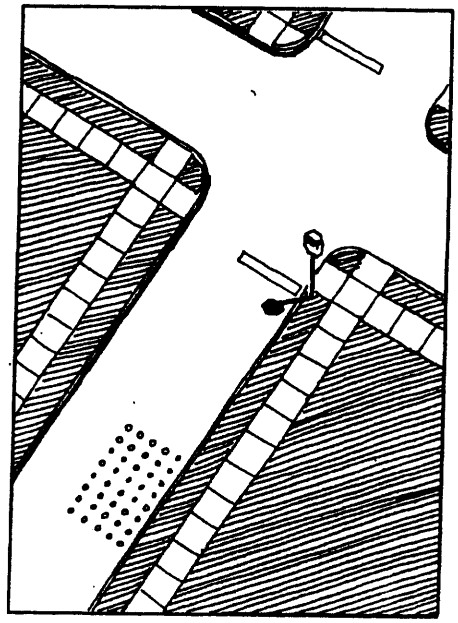
U.S. traffic engineers do not favor the use of speed bumps. In most cities in the U.S., speed bumps have been removed from public roadways where they are considered an unacceptable hazard. Speed bumps have also been reported to interfere with winter snow plowing operations. Speed tables appear less likely to cause such problems.

Bumps, Undulations



Rumble Strips or Changes in Roadway Surface

Patterned sections of rough pavement (*rumble strips*) or cobblestone strips across the road cause a slight vibration in the car, which causes the driver to become more alert and/or slow down. Studies have shown the effects of a change in road surface on speed to be mainly at the upper end of acceptable speeds in residential areas. However, studies have also shown that such strips have noticeably reduced accidents when placed in advance of stop signs (Smith et al. 1980). Changes in road surface are sometimes objected to by bicyclists, but this problem could be addressed by not altering the road surface within a designated bike lane. The noise produced by rumble strips has raised objections from nearby residents in some cases.

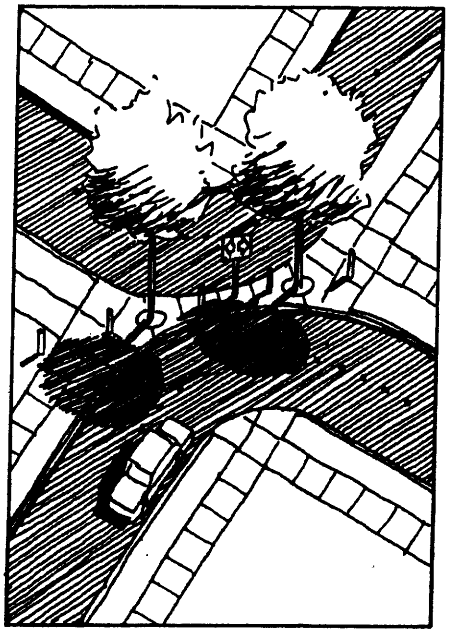


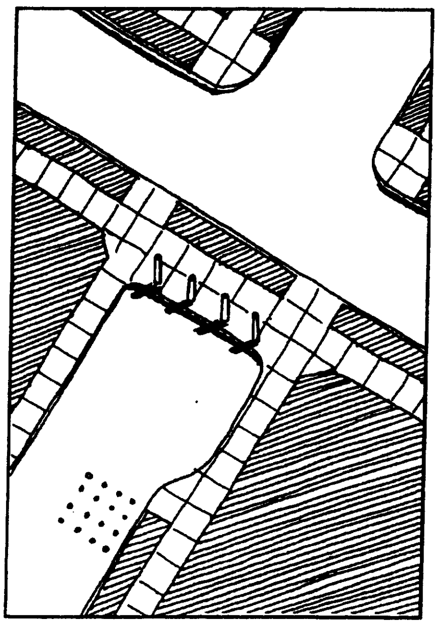
Rumble Strips

Diagonal Diverters

A *diagonal diverter* is a barrier placed diagonally across an

Diagonal Diverters





Cul-de-Sac Closures

intersection to convert the intersection into two unconnected streets, each making a sharp turn. Its primary purpose is to make travel through a neighborhood circuitous, while not preventing such travel. Used alone, the diverters will affect only the two specific streets involved. This application is most effective in reducing traffic volumes if used as part of a planned system for the neighborhood that will discourage through traffic.

Smith et al. (1980, 31) note that "In a system of devices, traffic on streets with diverters can be reduced from between 20 to 70 percent depending on the system of devices in the area." Diverters are effective in reducing traffic volumes, whereas speed is reduced only in the immediate vicinity of the diverter, within about 200-300 feet. Studies done in Seattle, Washington, and Richmond and Berkeley, California, have shown a significant reduction in the number of accidents in the neighborhoods. Usually, however, the actual number in each case was small originally (Smith et al. 1980, 31).

In order to have diverters function safely and effectively, they should incorporate the following features:

- Visibility. Devices should have painted curbs, rails, reflectors, directional signs, street lights, and elevated landscaping.
- Delineation. Centerline pavement striping and, where possible, pavement buttons are helpful in identifying the driving path.
- Emergency vehicle access. The design of the diverter should allow for passage of emergency vehicles while restricting automobile passage.
- Pedestrian, bicycle, and disabled access. Sidewalks across the diverter should allow such access.

Dead-end Streets or Cul-de-sacs

In some communities, traffic volumes in older residential areas have become so problematic that streets have been converted to *dead-ends* or *cul-de-sacs* to prevent cut-through traffic. A cul-de-sac is a complete barrier of a street at an intersection or mid-block that leaves the block open to local traffic at one end while physically restricting through traffic. Studies have shown cul-de-sacs or dead-end streets to be very effective in reducing traffic volumes.

Due to the need for adequate turning radius, retrofitting an existing street can be very expensive. On existing streets, it is often the case that only an 18- to 20-foot turning radius can be provided, whereas in new subdivisions 35 feet (10.5 m) is standard. The appropriate length of a street that can be dead-ended should be determined by traffic volume and the number of houses on the street. In general, however, cul-de-sacs should probably not be installed on streets longer than 500 feet when lots are 50 feet wide, meaning there would be approximately 20 houses on a street generating eight to 10 vehicle trips per day (NAHB 1990, 55). Streets longer than 500 feet tend to lose the advantages of installing a cul-de-sac because there are likely to be increases in traffic speeds and mid-block turnarounds, a potential safety hazard. The number of properties on a longer street also means an increase in the volume of trips on that street, again reducing the safety factor that the cul-de-sac should bring.

A cul-de-sac should be clearly identified by signs indicating that the street is not a through street. In some cases, provision for passage of emergency vehicles through the cul-de-sac may be desirable. Existing movement of pedestrians, bicyclists, and people with disabilities will need to be evaluated and accommodated by provision of through sidewalks and/or ramps.

The use of dead-end streets and cul-de-sacs to reduce traffic volumes is one of the most expensive and least desirable techniques employed for traffic calming due to issues of accessibility for emergency vehicles, buses, etc. Caution should be employed in making use of this technique.

Semi-diverters, Neck-downs, Chicanes, Chokers, and Protected Parking

A *semi-diverter* is a barrier to traffic at the intersection of two streets in which one direction of the street is blocked, but traffic from the opposite direction is allowed to pass through. A semi-diverter blocks only half of a street and is easily violated. Semi-diverters are best used when one direction on a street is used as a shortcut.

Studies have shown that semi-diverters can significantly reduce traffic volumes. Studies of a neighborhood in San Francisco, where semi-diverters were placed at opposite ends of block pairs, showed an average reduction on four streets of 40 percent to an average of 1,000 vehicles per day on those streets (San Francisco Dept. of Planning 1977). The same study in San Francisco showed a 50 percent reduction in the number of accidents over a four-month period.

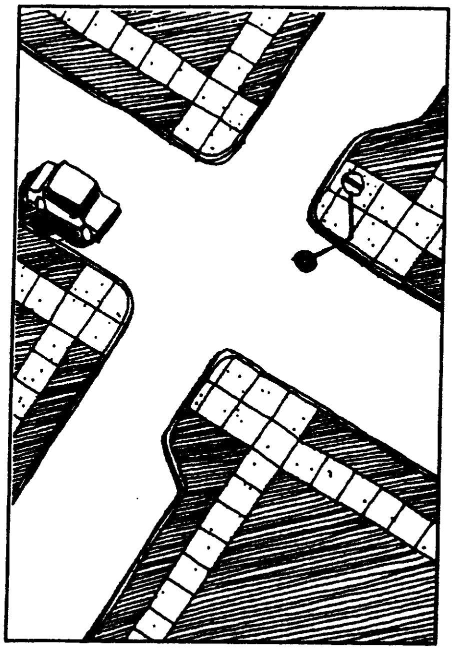
Neck-downs are the same in design as semi-diverters but are located mid-block. They allow two-way traffic for only a portion of the block.

Protected parking provides a landscaped island projecting out from the curb; the island creates protected parking bays. These devices are meant to reduce the speed of vehicles through neighborhoods rather than reduce traffic volumes, as do semi-diverters located at intersections. However, in some cases, they may also act to reduce traffic volumes.

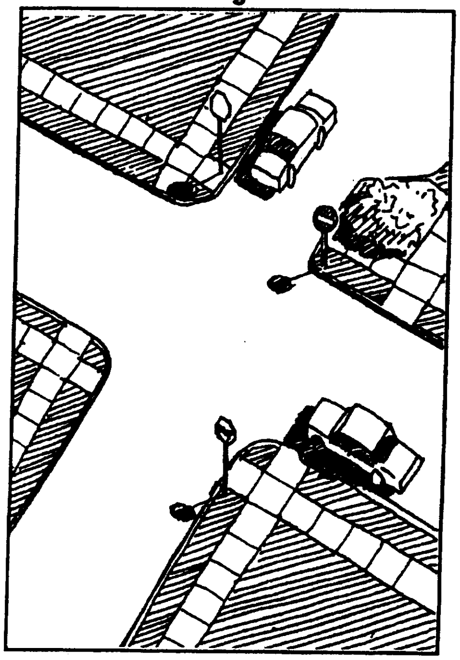
Chokers are basically the same type of device as a semi-diverter or neck-down, depending on whether they are located at the intersection or mid-block on a street. They can also be alternated from side-to-side on a street, thereby creating a chicane.

Chicanes are a form of curb extension which alternate from one side of the street to the other. A study of the use of chicanes in Seattle, Washington, done in 1988 showed varying decreases in traffic volumes ranging from six percent on very-low-volume streets to 48 percent on higher-volume streets (Seattle, Transportation Division 1988). The study also found significant reductions in vehicle speeds—a decrease of 26 percent in speed since the chicanes were installed. The authors of the study concluded that "Speeds have continued to increase on neighboring streets without chicanes. Thus chicanes have

Semi-Diverters



Chokers/Narrowing



proved to be a long-term effective means of reducing speeds in residential areas."

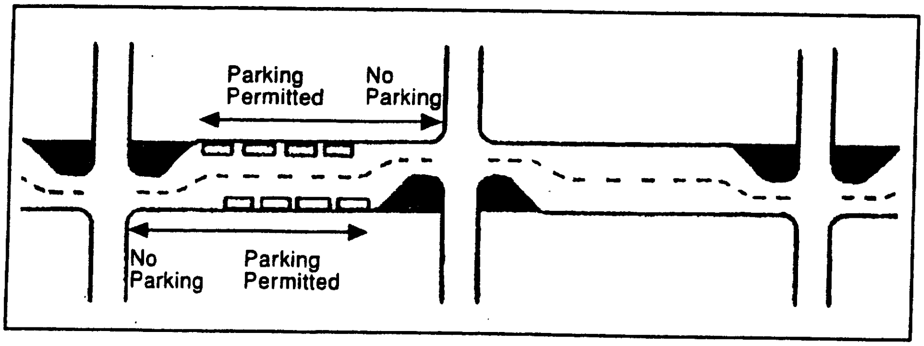
Accident rates appeared to be unaffected by chicanes. Emergency vehicles were not slowed significantly by the chicanes; however, it was recommended that the chicanes be constructed by use of curb bulbs rather than wooden barriers to allow emergency vehicles to run over the curb when opposing traffic was met. Maintenance of the wooden barriers was also problematic due to breakage.

Chicanes have the advantage of not blocking emergency vehicle access; however, drivers are also more likely to violate chicanes, especially at intersections with low traffic volumes. The devices should be made visible with signs, painted curbs, landscaping, reflectors, and street lights.

Traffic Circles or Round-abouts

A *traffic circle* or *round-about* is a raised island, which is usually landscaped and located at the intersection of two streets. The use of these devices is recommended on residential nonarterial streets where they have been found to be very effective in reducing traffic speeds and accidents without diverting traffic onto adjacent residential streets. Wallwork (1993, 240) reports that traffic circles reduce crashes by 50 to 90 percent when compared to two-way or four-way Stop signs and traffic signals by reducing the number of conflict points at intersections. He also notes that they are cheaper to maintain than traffic signals, provide equal access to intersections for all drivers, and provide a good environment for cyclists.

Chicanes



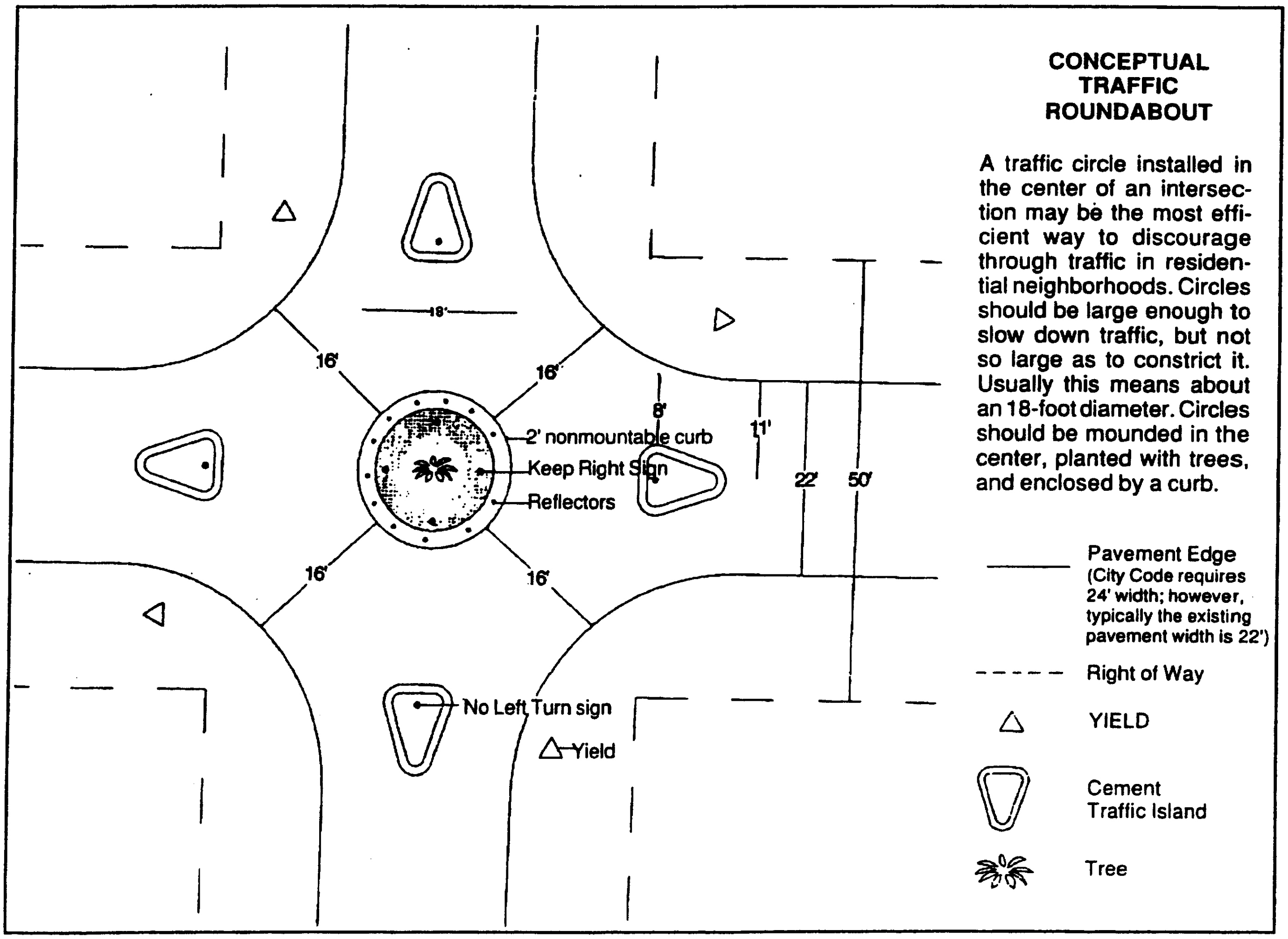
Seattle, Washington, and Portland, Oregon, have done extensive analysis on the effectiveness of traffic circles. In Seattle, the city's engineering department did a study that found the circles to be "highly effective in reducing both intersection and mid-block collisions. Intersection collisions are reduced by up to 90 percent and mid-block collisions are reduced by at least 39 percent" (von Borstel n.d., 80-81). Traffic circles were also found to significantly reduce the speed of traffic on nonarterial streets both at the intersection and mid-block (McLaughlin et al. 1987,7). While the studies did not find that traffic volumes were significantly decreased by the installation of traffic circles, residents perceived that there was a reduction in traffic volume. The explanation offered for this phenomenon was that the reduced speed of the vehicles in the neighborhood made them less noticeable and, therefore, made it seem as if there were fewer cars on the street.

Seattle has chosen to limit the use of Stop, Yield, and speed limit signs as speed or volume reduction traffic control devices because they were found to be much less effective than traffic circles. Seattle has installed 190 traffic circles with a 98 percent success rate in providing effective traffic control (von Borstel n.d., 81).

Portland, Oregon, reached similar conclusions in its study of traffic circles. That city's technical evaluation committee found that "Traffic circles are successful at reducing the number of vehicles traveling at high speeds (30-35 mph) on residential streets. . . . After traffic circles were installed, vehicles rarely exceed 35 mph" (Portland 1992, 1). Portland also found that traffic volumes on streets with traffic circles did not significantly change and that accidents had been reduced by installation of traffic circles. The report also concluded that larger radius circles appear to reduce vehicle speeds more than smaller traffic circles.

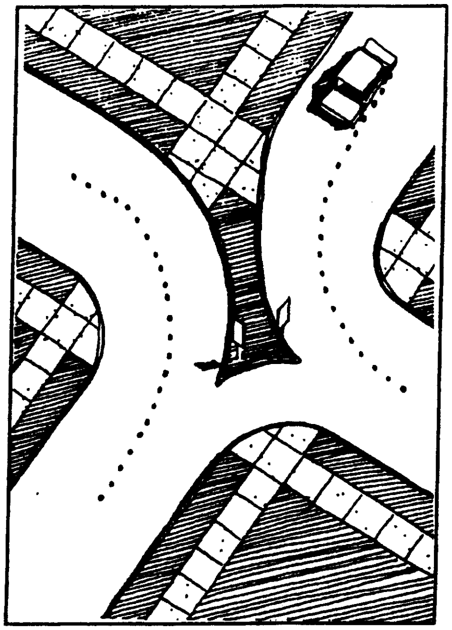
Traffic circles have been found to be a popular and effective way of providing safer and quieter neighborhoods in the view of the residents. If the traffic circles are installed strictly as speed reduction devices, they should be installed about 600 to 800 feet apart to maintain the reduced speed (von Borstel n.d., 81).

Traffic circles should be well marked with appropriate traffic signs, pavement markings, street lights, and landscaping. Traffic circles must also have adequate lane width (16 to 20 feet) to allow passage of larger vehicles like emergency and service vehicles.



Source: City of Fort Myers Planning Department

Forced Turns



Other Active Control Devices

Forced turn channelization is usually installed in the form of traffic islands that prevent traffic from executing specific movements at an intersection. These devices basically function in the same way as a diagonal diverter. They are mainly used to prevent traffic flow from one neighborhood to another at the intersection of a major and local street. In some cases, a reduction in traffic volume will likely result. These devices should be marked in the same fashion as diagonal diverters. Their design depends on the locational needs.

Median barriers are usually used to improve traffic flow on major streets. They can also be used, however, to reduce traffic flow onto residential streets by preventing left turns off a major street onto a residential one or preventing traffic from one neighborhood crossing the major street into another. Studies done in Sweden documented a 70 percent reduction in traffic volumes on streets inside a loop road around the central business district and an increase of 25 percent on the circumferential street (Elmberg 1972). Studies have shown median barriers to be effective in reducing traffic speed on small radius curves on arterial and residential streets (Smith et al. 1980, 50).

Interrupted sight lines can be created through many of the devices noted above—chicanes, semi-diverters, chokers, neck-downs, or protected parking. The same effect can be created by use of "Residential" or "Pedestrian Streets," which are discussed below. Interruption of the sight line of a street causes motorists to slow down and can also mean that they are compelled to widen their field of vision, becoming more aware that there may be pedestrians and cyclists near the traffic way. (See Figure 2–1.)

Residential or Pedestrian Streets are used extensively in European countries with great success. They were first used as part of program in Delft, Holland, and are called "woonerf." The concept is to equalize the right-of-way on the street between cars, pedestrians, bicycles, and children at play. This is accomplished through elimination of sidewalks and curbs with the entire surface being paved for pedestrians. Streets are broken up into small sections by the use of large planters, walls, benches, barriers, and mounds. The width of the street is about six feet (two meters) with a widening for passing every 100 feet (30 meters). Parking spaces are limited and designed for use by automobiles only. The "woonerf" streets are marked with signs to warn motorists that they are entering a pedestrian area. Conversion of streets into pedestrian streets is very costly and would be even more expensive on the typical American street.

Changes in direction are accomplished with the use of 45-degree bends in the roadway. Various techniques discussed above could be used to achieve this change.

Stop Signs

Stop signs are designed to assign the right-of-way at intersections

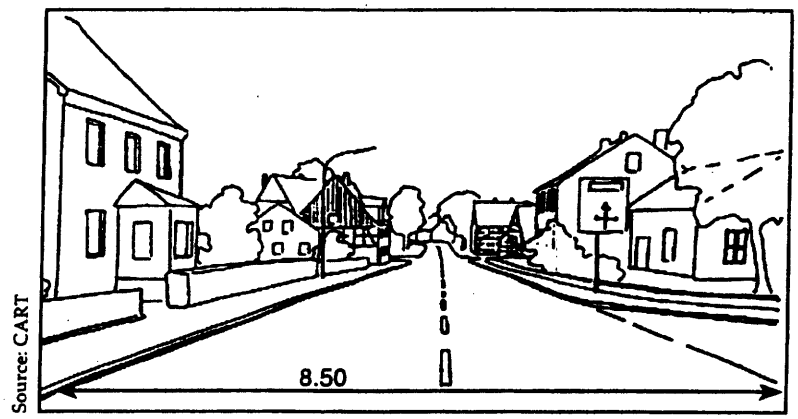
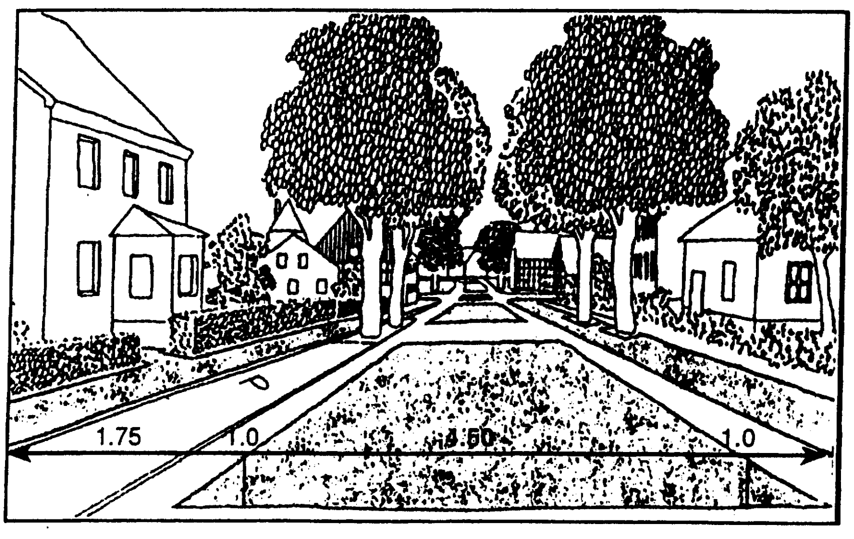


Figure 2–1. (Above) Unobstructed Sight Lines; (Below) Interrupted Sight Lines



with high traffic volumes or high accident rates. The need for a Stop sign should be clearly established. Stop signs not warranted by traffic volumes or site-specific safety concerns (e.g., inadequate sight distance) may tend to increase traffic accidents because, once drivers become aware that the sign is unwarranted, they will disregard it. The presence of several unwarranted Stop signs may, in turn, create a general disregard of all Stop signs in the neighborhood (Homburger et al. 1989, 82).

Citizens regularly request Stop signs with the misconception that they will reduce the speed of vehicles and/or reduce traffic volumes. Numerous studies have shown that Stop signs do not significantly reduce either speed or volume of traffic in neighborhoods.

Other studies have shown that Stop signs effect speed in the immediate vicinity of the sign, but, according to Smith et al. (1980, 64), "between intersections t' ey are either ineffective or prc uce the contrary effect."

Speed Limit Signs

Speed limit signs ... neant to inform drivers of ? speed limit imposed by the ' :al governing body. They are .s..ally established based on the ' ,h percentile speed on a road. (The 5th percentile speed represents ie speed at which 85 percent o .ie vehicles drive at or under.) But as Smith et al. (1980, 65) report, "In the United States, studies have shown that speed limit signs have very little impact on driver speed on surface arterials."

Various studies of speed limit signs have come to the same conclusions:

- Traffic consistently ignores posted speed limits and travels at speeds drivers consider reasonable, convenient, and safe under existing conditions.
- Drivers do not operate by the speedometer but by the conditions they meet.
- The general public pays little attention to what speed limits are posted.
- The general public has a false conception of speed.

Similarly, speed limit signs have little effect on traffic volumes or distribution. Studies have shown that, even with enforcement, little effect is seen in traffic with changes in speed limit signs.

Turn Prohibition Signs

No Right Turn or *No Left Turn* signs can be used to prevent turning movements onto residential streets with or without peak-hour limitations. It is best if they are used around the periphery of a neighborhood to prevent unwanted traffic from entering (Homburger et al. 1989, 84). Such signs can limit turning movements during specified hours of the day, which can be particularly effective in preventing shortcutting during peak traffic periods. This allows residents full access during the rest of the day.

The success of these signs depends on their acceptance by drivers. There must be voluntary compliance or heavy enforcement for these signs to be effective. One study (Welke and Keim 1976) found that peak-hour turning prohibitions reduced traffic volumes by as much as 90 percent. However, if traffic control has not been planned for the entire neighborhood, the result of such turning prohibitions can be to simply divert the traffic onto another residential street. No direct effect on traffic speed should be expected, although a reduction in traffic volume may result in the perception of reduced speed.

One-way Streets

One-way streets have been used to make travel through a neighborhood difficult, thereby discouraging through traffic. Providing limited entrances to the neighborhood and making streets that intersect with collectors or arterials one-way exits can effectively discourage traffic. This provides the advantage of allowing emergency and service vehicles access (they can even travel the "wrong" way), but it can face stiff opposition from residents. If this technique is to be used, an effective and comprehensive citizen participation program is a must to ensure neighborhood support. Another clear advantage of one-way streets is that violations tend to be very low; citizens often help enforce the restrictions by telling people travelling the wrong way on a one-way street that they are, in fact, in violation. It is also true that violating a one-way street means a violation that may last the time it takes to travel the length of the street, thereby reducing a driver's impulse to violate the law (Homburger et al. 1989, 85).

Other Passive Traffic Controls

Traffic signals can have a dramatic effect on traffic in neighborhoods. Frustration with delays at arterial signals are a major reason for shortcutting. Operating signal systems to reduce delays, especially at peak periods, can reduce through traffic in neighborhoods. Because of their expense and the need to meet warrants, traffic signals would rarely be used as a device to directly reduce traffic in neighborhoods.

Studies have shown that *Yield signs* can be effective in terms of reducing accidents at intersections. Welke (1976) reported that, given a volume of 200 to 800 vehicles per hour, "Yield signs are as effective as Stop signs in terms of accidents and are superior in terms of energy and delay costs. Above 800 vph, Stop signs are more effective."

Evidence indicates that *Slow signs* are only effective in locations in which a physical feature of the roadway makes higher speeds dangerous. Use of a Slow sign in a neighborhood simply to slow traffic will probably have no effect at all.

Adequate information is not available on the use of *Do Not Enter* and *Local Access Only signs* as traffic volume and speed reduction devices. These signs could be used in a fashion similar to semi-diverters to prevent traffic from entering a residential street from an arterial.

Flashing yellow beacons on School Zone signs have been found to be effective in reducing average speeds by 3 to 4 mph (5 to 6 kph) (Welke 1976, 24). However, the use of signs and flashers timed to periods when children are present appears to be important in achieving compliance from drivers. Signs that are continuously present are not as effective.

Bars can be painted laterally across a roadway with the space between them growing shorter and shorter to give a driver the illusion that there is an increase in speed. The bars are usually painted over a distance of a quarter mile or so. The bars might also make a driver believe that some change in road feature is coming up, causing a decrease in speed and an increase in awareness. Applications of this measure have been limited, and it is regarded as an experimental device (Homburger et al. 1989, 90).

Marked crosswalks do attract pedestrian use, but, unfortunately, driver reaction and accident rates are not usually effected. A study done in San Diego, California, found that marked crosswalks attracted 75 percent of the pedestrians crossing the streets, but 85 percent of the accidents occurred at the marked crosswalks. The study concluded that "pedestrians showed less caution in using marked crosswalks than shown at unmarked locations. . . . Limited sample studies at the University of California showed that the painting of a crosswalk did increase the percentage of drivers who would yield to a pedestrian; however, the majority of drivers still failed to yield" (Welke 1976, 76).

For these reasons, the use of lateral bars and painted crosswalks by themselves should not be expected to provide greater pedestrian safety. Additional active control devices should be considered at or in the area approaching the crosswalk to provide a safer crossing.

Technique 2. Change the psychological feel of the street through design or redesign. Wide and straight stretches of paved streets say to a motorist, "This is your turf." Streets that use paved strips, landscaping, and narrowed lanes have a relaxed, pedestrian feel that says to the driver, "Beware, this is shared space."

Homburger et al. (1989) and Appleyard and Bosselman (1982) have described a series of ways to use design to influence driver behavior. They emphasize the number of ways that changes in the physical environment can alter the ways that drivers and all other users of the street "experience" the street. Most importantly, they stress the necessity to create a sense of place on streets, much as one tries to create a sense of place in a neighborhood and a community. Recognizing the street as a place rather than as a channel designed for the benefit of the car and driver will change the psychological feel of the street for all users.

To create this sense of place, Homburger et al. (1989, 61-63) recommend a number of measures that community transportation planners and citizens might consider when designing or redesigning neighborhood streets. Those "policies for street design" are summarized here.

1. *Traffic management devices and changes to the street design should be compatible with the character of the neighborhood.* Using materials that are in harmony with the colors and textures of the streetscape signal a change in environment. A visible change from asphalt, for example, to colors that are in character with the surrounding residences immediately tells a driver that he or she is entering a different space. The changes also mark the street as more clearly belonging to the residents of the adjacent houses than to the driver.
2. *Traffic control devices and street designs should be easy to maintain.* Allowing for easy maintenance of traffic calming devices means that they will remain attractive and effective. Residents may feel a pride of ownership in the landscaping used to define the street space or in their local traffic circle. Neglect of such devices gives a signal to both residents and drivers that the devices are not important, which may lead to drivers ignoring them.
3. *The landscaping used for street design should be safe for pedestrians.* A landscape architect might be consulted to help planners and citizens choose landscaping that, when mature, will allow both pedestrians and drivers clear lines of sight while still creating a sense of place.
4. *Street trees should be planted to enhance the image of a street as a place with which residents can identify.* Some of the traffic calming devices described in this chapter can give the space needed for large trees to grow that is not provided for in typical three-foot-wide (one-meter-wide) sidewalks. Homburger et al. (1989, 62) note that in typical street design plans:

> To prevent sidewalk cracking and interference with utility lines, public works officials favor smaller "lollipop" trees. These provide little shade and tend to be petty and ornamental. They fail to impart a truly dignified character to the neighborhood.

As Duerksen and Richman (1993, 9-16) describe, large trees not only provide shade, enhance property values, and contribute to sense of place, they act as very effective buffers to traffic noise and create visual and psychological barriers between parked cars and residential spaces.

Planners and designers should never forget that all residential streets are not the same. Traffic volumes and the behavior of the users of the street will need to be documented. Homburger et al. (1989, 65-77) describe six different scenarios for street design based on different periods and styles of development. In general, observations of various activities on the street, including travel speeds, pedestrian circulation, and cyclist behavior, may be necessary to determine what designs will truly change the psychological feel of the street. Eye-level perspectives taken through the windshield of a moving car and from various pedestrian and cyclist crossing points may help designers. A variety of visual simulation tools, like those described in Duerksen and Richman (1993, Appendix A), may be useful, effective, and efficient in producing these perspectives. Presenting citizens with these perspectives throughout the planning and decision-making process can help get feedback that ensures that safety, mobility, resident access, and sense of place are all enhanced and politically acceptable.

Technique 3. Increase incentives to use public transport. If our society's goals are to increase energy efficiency, improve air quality, and reduce traffic congestion while increasing mobility options, we must address the efficiency and compactness of our land-use patterns. Private automobiles take 30 times more road space to move each person than buses. In many cases, expanding our streets has not led to moving more people, but moving more cars.

Studies have shown that efforts to ease traffic congestion by expanding road capacity and improving vehicle flow discourage the development of housing and small commercial uses and result in further migration, longer commuter trips, and even more congestion.

The dramatic differences in energy usage between most U.S. cities and European and Asian cities is a result of more compact land-use patterns. "The biggest factor accounting for these difference in energy use appears to be not the size of cars or the price of gasoline, but the efficiency and compactness of land-use patterns" (Reglogle 1990). As was made clear in the seminal study on sprawl more than 20 years ago, "sprawl is the most expensive form of residential development in terms of economic costs, environmental costs, natural resource consumption, and many types of personal costs. . . . This cost difference is particularly significant for that proportion of total costs which is likely to be borne by local governments" (Real Estate Research Corporation 1974).

To make public transit more attractive, automobile users will have to be made to bear more of the costs of providing the infrastructure cars require (Moore and Thorsnes 1994, Appendix B). More of the money spent on expanding streets should be spent to upgrade transit systems, especially buses since they appear to be the most efficient system in US cities. "Improving bus systems appears to be a cheaper and more efficient way of increasing mass transit ridership. . .because of their relatively low capital cost and because bus routes can be easily shifted to meet changing demands" (Highway Users Federation 1986, 29). Increasing the efficiency of public transit by giving it time advantage over cars and offering attractive fares can encourage mass transit use.

Technique 4. Discourage use of private motor vehicles. Discouraging the use of private motor vehicles is usually used in tandem with incentives for using public transit. Measures that can be used include parking restrictions in the CBD, higher parking fees, or banning cars from the CBD and other "congestion pricing" policies (Moore and Thorsnes 1994).

The enormous success of German pedestrian areas in which cars are often banned altogether can be accounted for by such a combination of techniques. In Nurenburg, for example, the city council wanted the pedestrian system expanded in 1971. The city planners were opposed to the expansion for fear of overloading surrounding streets. The feared overloading of parallel streets did not occur. Several strategies were employed to make the pedestrian areas succeed. First, parking is restricted on the central city streets to residents only, and parking spaces in garages are limited. Second, the mass transit system was upgraded along with the bicycle and pedestrian systems. One lane on a street was often converted to bike lanes. Third, commercial establishments in the central business districts are encouraged, and new outlying development was discouraged through rigid land-use control provisions.

> *The [Los Angeles] CBD provides the best illustration of the embarrassments of successful traffic engineering. Over the years, the flows have been improved, but the primary result has been more cars, not people. The number of people entering downtown has only increased five percent since 1955, but the number of autos entering has increased 23 percent. (Joel Woodhull, "Calmer, Not Faster")*

Technique 5. Encourage people to organize their own travel more efficiently. Through the combination of a public education campaign, introduction of traffic restraint measures, and better mixed-use planning, authorities can encourage people to organize their own travel more efficiently. This may mean providing a better mix of land uses to allow people to find jobs close a to home or, when buying a home, to buy one which is close to number of high-use activity centers (job, school, and shops). It may mean combining a number of trips into one, or using public transportation for work instead of buying a second car, or organizing a car pool.

Technique 6. Create strong viable local communities. Rather than building large roads to large centralized facilities, the facilities can be brought to the people. Strong, compact communities are created with a wide range of facilities at hand. This policy reduces the amount of traffic on the road because:

- People can drive shorter distances to get to where they want to go.
- Trips which had to be made by car can now be made by walking, cycling, or public transportation.
- Children and the elderly are given independent mobility through walking and cycling, resulting in less chauffeuring.
- A strong local economy leads to a higher level of localized employment.
- Measures that can be taken include making local shopping centers more attractive places to shop, grouping of activity centers, and encouragement of

local festivals and entertainment. Most important is the need for long-term commitment to avoid carving up existing, viable communities with large roads.

THE RESULTS

Based on research from Denmark, Holland, Sweden, Japan, Italy, Switzerland, Germany, America, England, Canada, and Australia, where these planning techniques have been tried in various degrees or combinations, the following results can be expected:

- Noise and pollution reduce by 50 percent
- The top speed of traffic down by 50 percent (Even though speed is dropped by 50 percent, journey time is only increased by 11 percent because there is less stop-start driving.)
- Less heavy traffic and less cut-through traffic
- Smaller roads move the same number of people. The extra space created by closing lanes or narrowing existing lanes is transformed into tree-lined avenues, bike-ways, walkways, mini-parks, or squares
- Greater safety for drivers, pedestrians, cyclists, and children playing in the street
- A 43 to 60 percent less chance of being killed or seriously injured in an accident involving a car
- Up to 30 to 50 percent less traffic on the roads in peak hours
- Greater choice of travel methods for everyone, particularly for those who don't have access to a car
- Increased viability of community life
- Less stop-start driving
- Enhancement of neighborhoods with an increase in greenery and a decrease in the visual intrusiveness of the roads and parked cars; also a decrease in the number of traffic lights and signs

In sum, traffic calming aims to give you the best of both worlds—mobility and a better quality of life. Clearly, traffic calming is not a narrow concept. It involves cars, streets, roads, public transport, layout of the city, and the education of residents. It is a holistic planning approach that is aimed at improving the quality of life. It involves a whole new attitude and outlook.

Chapter 3. Community Involvement

In most communities, the impetus for instituting traffic calming measures comes from the requests or complaints of residents. The success or failure of traffic calming techniques depends on the effective involvement of the community.

Engineers and planners may develop the best technical solutions to the problems they identify, but their proposed solutions may not address the real problems as seen by the residents. Community input allows the professionals to see the problems from the residents' point of view, and the interaction between planning staff and citizens can help residents understand the legal, physical, and financial constraints of any system.

Local traffic issues arouse powerful emotions. Neighborhood traffic management is controversial because some people gain and some lose. If the negative effects of a neighborhood traffic management system are not understood in advance, it can discredit the entire process because it will appear that there will always be "unforseen" adverse impacts.

> *An effective, well-organized planning process is the single most important element in the creation of a successful neighborhood traffic management program. It seems overemphasizing the point to say the planning process is more important than selection of the "right" device; more important than design; or more important than implementation technique. Yet experiences reported in cities . . . feature some successful efforts and numerous failures. In virtually every case, the failure of a program can be traced directly to either a breakdown in the planning process or the failure to have a structured process at all. (Daniel T. Smith, Jr., et al.,* State of the Art Report: Residential Traffic Management*)*

A variety of models exist that can be used in designing the planning process and community involvement. Which model is chosen will depend upon the size of the area (e.g., a neighborhood, a small town, a quadrant of a large city, etc.) and the scope of planning being done (i.e., whether it is to be just a traffic control or management system or a comprehensive community transportation plan). Ideally, planning for the transportation needs of a neighborhood or community should be done comprehensively, taking into account the overall quality of life residents want to achieve.

In general, the planning process should involve the following steps:

1. Problem Identification and Needs Assessment
2. Identifying Alternatives and Techniques
3. Selection of a Plan or Vision
4. Implementation
5. Evaluation
6. Modification and Reapplication

Portland, Oregon, has a Neighborhood Traffic Management Program (NTMP). The process to have a neighborhood traffic calming project considered, as described in a citizens advisory committee report (City of Portland, Bureau of Traffic Management 1991, 41), involves nine steps:

1. Preliminary staff review of requested projects to determine if they meet the minimum criteria for inclusion in the NTMP.
2. Priority ranking of projects to determine the order in which they are undertaken. The number of projects initiated each year is dependent on Bureau of Traffic Management resources.
3. Petitioning of the neighborhood. Signatures representing a majority of the households and businesses within the project area are required for further consideration of the project.
4. Plan development. This step involves formation of a citizen traffic committee to develop and evaluate possible solutions, neighborhood meetings for review and comment, and selection of a plan to test.
5. Test installation. A petition to test the selected plan is circulated in the project area. If signatures are obtained from a majority of households and businesses, a temporary test project is installed.
6. Test evaluation, where the city and area residents evaluate how well the test performed in terms of the previously defined problems.
7. Neighborhood vote to construct a permanent installation. For projects that include traffic diversion, a majority of eligible voters in the project area must respond favorably.

8. City Council action, based on a review of the project evaluation and neighborhood vote.
9. Construction of the permanent installation.

PROBLEM IDENTIFICATION AND NEEDS ASSESSMENT

As stated above, in most cases, the process begins with citizen requests, which usually come from residents of an area in which traffic is perceived to have become a problem. There are two points of view: resident and transportation user. The transportation users are those people who want to have access to or through an area.

A variety of techniques can be used to collect information to help define the problems in the area. According to Smith et al. (1980), these techniques fall into five main categories:

1. Citizen inputs: resident needs/values; satisfaction/disturbance; suggested improvements; traffic needs/values
2. Traffic/service observations: traffic volumes; speed; parking; safety; access
3. Environmental concerns: noise; safety conditions; access for pedestrians, cyclists, and people with disabilities; space analysis; visual quality
4. Observations of resident activities: street activities, including pedestrian activity, cycling, and the way that people with disabilities negotiate the street; parking
5. Records: accident and crime statistics; traffic counts; census data; land-use data; real estate assessment data

There are basically two ways to get citizen input on the traffic calming system. First, the staff of the agency responsible for instituting the plan of action can begin to collect the complaints of citizens about traffic problems. It is important to have an organized method of logging and analyzing this input so that each complaint is fairly dealt with and problem areas can be identified early from repeat requests. Second, to determine the needs of the citizens, formal surveys should be initiated. These surveys are best proceeded by broad public notification that they are being distributed, collected, and analyzed for formulation of a transportation or traffic calming system.

One option for collecting community input that has proven very successful is the Visual Preference Survey (VPS), pioneered by Anton Nelessen.

The process involves asking residents of a community to numerically rate pictures of their town and other places as acceptable or unacceptable. Participants rank images of spaces, places, and land uses. The common vision developed from this process allows the planning process to work more smoothly. Nelessen recommends that community surveys also be done that ask specific questions and can include maps of the area asking people to identify traffic problems, pedestrian flow patterns, and other problem areas. (See, for example, the neighborhood survey in Martz 1995, Appendix A).

This process could be adapted and used to show residents how various traffic control devices like traffic circles or diverters would look when installed in their neighborhoods. The negative appearance of many traffic control devices has led to the failure of traffic calming techniques, especially when temporary devices have been installed for a trial period.

As noted in category 2, traffic/service operations, staff will need to collect data about such things as the average number of vehicles per day for specified streets, estimates of through traffic, traffic speeds, traffic composition (used to confirm the presence of trucks, buses, and motorcycles), traffic capacity studies, traffic safety, service and emergency vehicle access, and resident access.

When gathering data, staff must remember that resident demands for transportation planning are often based not on traffic volumes but from situations in which the conditions on the street differ from the resident's expectations of what the conditions on their street should be (Smith et al. 1980, 96). For example, accident data for neighborhoods rarely show measurable accident rates. However, on-site observation can verify whether resident fears of accidents are based on the potential for accidents (i.e., incidents that occur but do not result in a accidents) rather than actual accidents. In Britain and Holland, counts of vehicles/pedestrian "conflicts" are used as indicators. Field observations, such as sight lines at intersections, visibility of traffic, presence or absence of sidewalks, and absence of needed signs and/or street markings are included in a safety assessment. Some cities have included maps in surveys that ask respondents to locate and describe accidents or incidents in which they were involved or witnessed (Smith et al. 1980, 102).

Addressing environmental concerns means that staff will need to measure noise and air pollution, to assess visual quality (again, perhaps, Nelessen's visual survey process can be used, here with staff as well as citizens), and to analyze how the street space is being used (i.e., area devoted to traffic, parking, sidewalks, yards, gardens, parks, and play space.) Many of the computer image processing programs

> *The Visual Preference Survey is a research and visioning technique consisting of photographic images, evaluation forms, optional questionnaires, and evaluation/analysis techniques to understand and present the results. The purpose of the VPS is to articulate the resident's impression of the present community image and to build consensus for its future character. The conclusion of the process is called a vision plan. (Anton C. Nelessen, Vision for a New American Dream).*

make it easier for planners to put together simulations of changes in street design and their effects. These tools can be particularly effective in communicating with citizens concerned about how traffic calming devices might change the character of their street and neighborhood.

Observations of residents' activities means having staff go out on the street to actually observe the street activities of pedestrians, bicyclists, and people with disabilities, and parking conditions. Observational studies are sometimes the only way to collect needed data. This is especially true in determining hazards to children playing. Notations of where children play along with traffic counts can indicate areas of potential conflict. The same is true for parking. Only observation can tell who is using parking spaces—residents or others.

Gathering the records suggested in the list is self-explanatory. Once the data has been collected and analyzed, however, the staff and community must determine if a problem exists, where the problem is located, and whether traffic calming will solve the problem. The following questions may be a useful guide (Smith et al. 1980, 106, 107):

- Does the technical data confirm the community's perception? If not, which is more important, the perception or the technical data? If there is not a "confirmed problem," can the situation be improved?
- Is the problem site-specific or does it cover the entire neighborhood? Will application of traffic calming techniques cure the problem or merely shift it to another location? Does the problem require a systemic solution?
- Is the problem occurring throughout the day or at specific times?
- Are the complaints actually symptoms of other problems, such as crime, dirty streets, no play areas, etc.? Will traffic calming address these problems or is it irrelevant?
- Is the community united in its view of the problem or are there internal conflicts? Have all points of view been elicited adequately to define the problems?

IDENTIFYING ALTERNATIVES AND TECHNIQUES

Once the needed information has been collected and analyzed, it needs to be presented to the community in an understandable format. This can be done in a number of ways, but it should be done in graphic forms (e.g., charts, graphs, maps with overlays, etc.) so that the majority of people can understand what the plan entails. (For example, see Figure 3–1 below.) In Berkeley, California, a system of overlay plots was used to show citizen complaints, accidents, traffic volumes, speed studies, citations, public transit routes, congestion points, neighborhood boundaries, site inspection field notes, community analysis, land use, and activity generators (Smith et al. 1980, 110).

The development of alternative scenarios for a transportation or traffic calming system can be done by the staff and presented to the community for consideration, or residents may want to take responsibility for developing alternatives and present them to the jurisdiction's planning and transportation staff and governing bodies. Whichever method of developing the alternatives is chosen, it should be clear to everyone involved what roles the staff and the community groups will play in the process.

Planners need to make sure that the entire range of possible alternatives is known and that the technical possibilities and trade-offs between benefits and disadvantages are discussed with the residents of the community. After a specific set of alternatives has been selected for consideration, the process of discussing the potential effects or each alternative should be repeated.

Staff must pay close attention to design when evaluating and choosing alternatives. Poor design in traffic calming techniques will result in dissatisfaction with their implementation and, in some cases, dismantling of the entire project. Nelessen (1994) offers some design principles to keep in mind when evaluating alternatives.

1. *Design for the human scale.* Traffic calming techniques must enhance the human experience and accommodate cars, trucks, and transit.
2. *Design in harmony with nature not against it.* Complement the natural environment with indigenous vegetation and colors; preserve important features of the landscape; be responsive to noise impacts; and provide for walking to jobs, transit, and community facilities.
3. *Design for pedestrians.* Provide ground texture and sidewalks of adequate width, separated from the street by a parkway; create security; provide pedestrian-scale lighting and other street fixtures like benches and trash receptacles where appropriate; ensure that there is proper and adequate signage; provide for bike paths and access for people with disabilities
4. *Design in harmony with the existing character of the community.* The design of signs, traffic control devices, benches, planters, streetlights, pavement materials and textures, curb treatments, street lights, should complement the architectural style and characteristics of the community.

SELECTION OF A PLAN OR VISION

The final selection process for a traffic calming system includes evaluation of the technical information, and, most importantly, consideration of the social and political values of the community. While technical analyses can make clear the variety of effects that each alternative traffic calming scenario or device might have, there will always be the business of making the necessary trade offs to secure political approval. The ultimate authority for making the selection resides with the city council or other elected bodies.

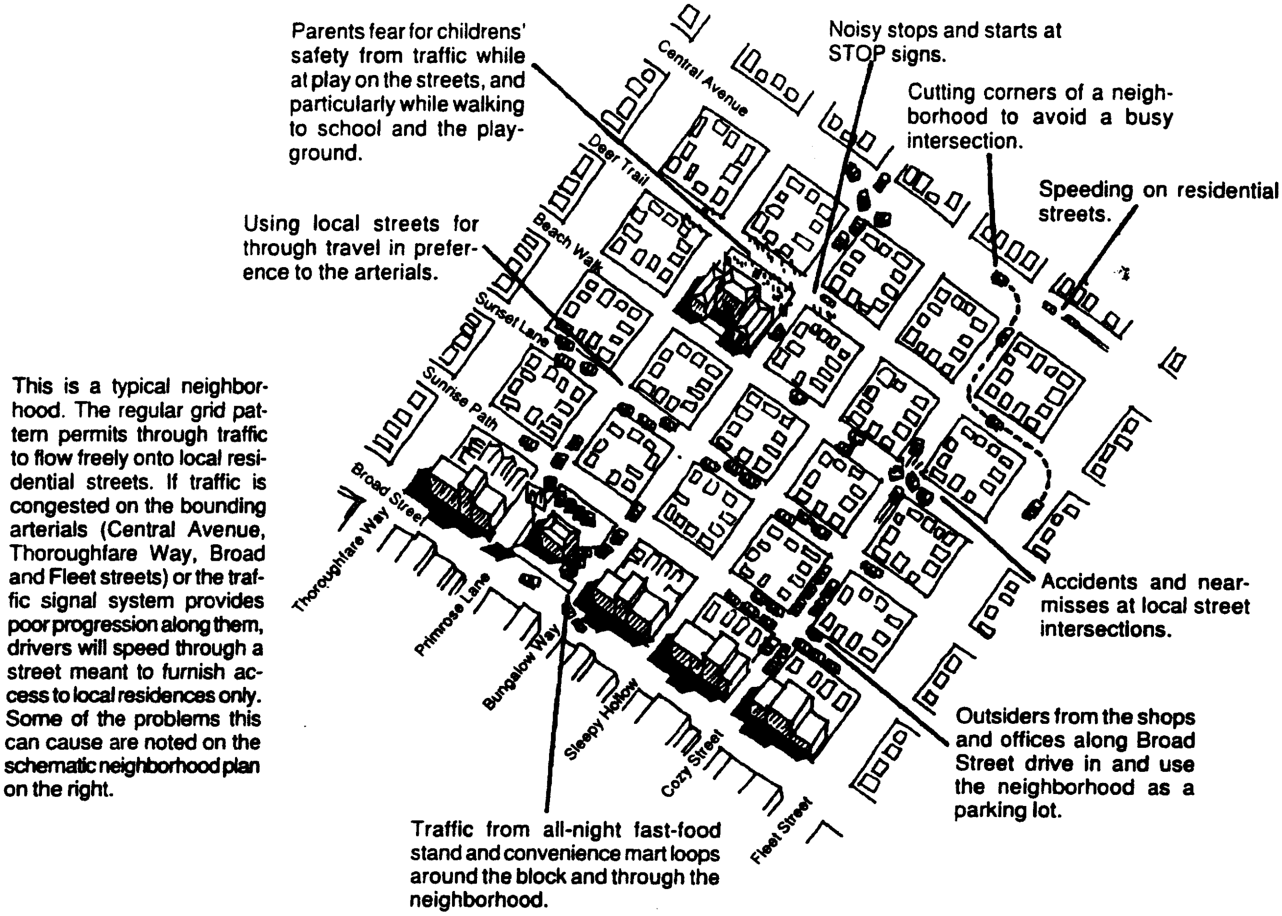
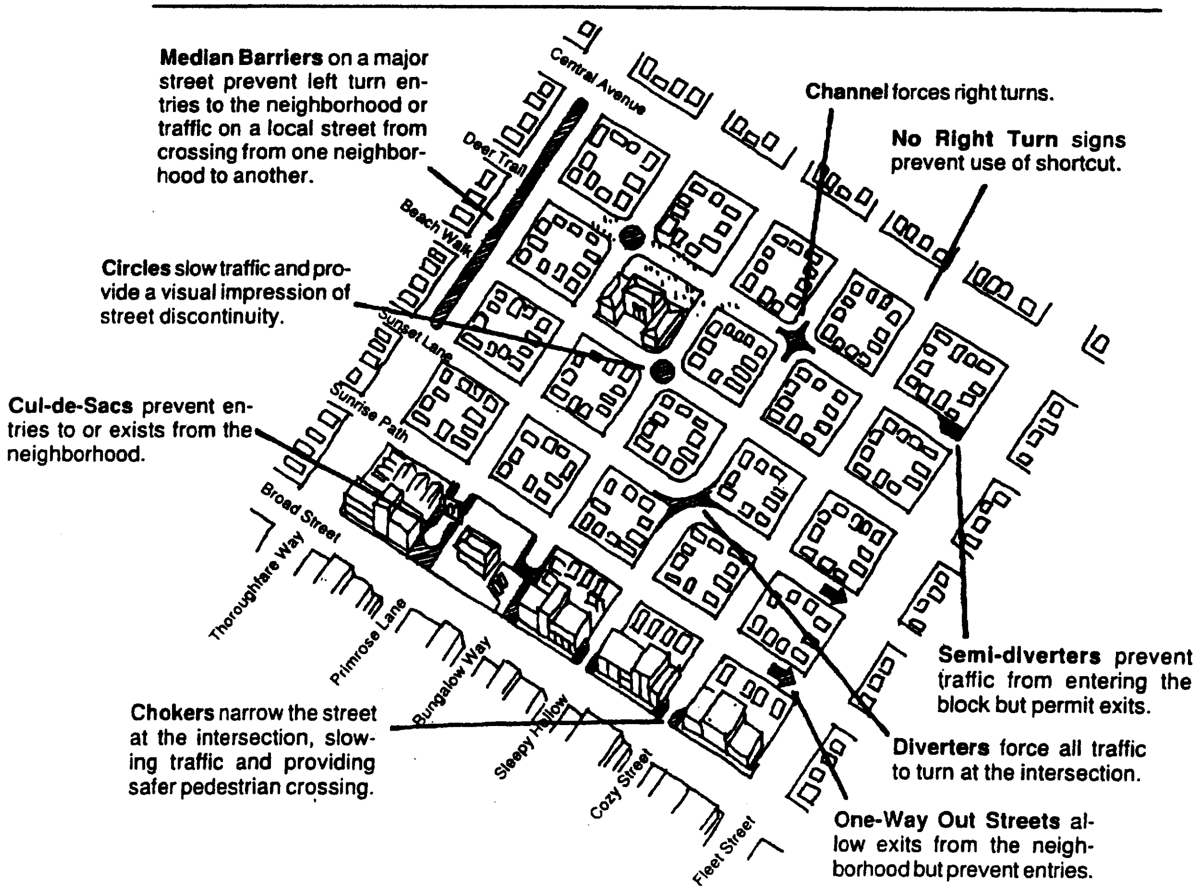


Figure 3.1 (Above) Typical neighborhood with traffic-related problems. (Below) Proposed solutions to typical neighborhood traffic problems.



Source: Daniel T. Smith, Jr., et al., *State of the Art Report: Residential Traffic Management* (Washington, D.C.: U.S. Dept. of Transportation, Federal Highway Administration, December 1980), 11, 16.

The selection process can take several forms. Traffic calming systems work best when a consensus of citizens and staff has been reached. The following checklist of technical information might be used to determine which issues will be most important to the decision-making process:

- traffic volumes
- traffic speed
- traffic composition
- safety
- noise
- visual quality
- accessibility
- parking
- level of expected violation
- impact on bicyclists
- impact on pedestrians
- impact on people with disabilities
- construction costs
- maintenance costs
- added driving time/fuel costs
- number of people affected.

The public should always have a voice when the final decision is made. Communities use various methods to involve the public in that process depending on the scope of the plan, organizational structure of the governing body, and other factors. These methods range from citizen review boards to referenda.

IMPLEMENTATION

Once the plan has been selected and adopted by the governing body, care must be taken in how it is implemented. Portland, Oregon, for example, requires that temporary traffic calming devices be installed before permanent devices are installed. The city council may then change the plan, if necessary, after the trial with temporary devices.

> ***Where temporary devices are selected, careful attention to their attractiveness is a must, and a future commitment to make permanent those devices which prove themselves should be made clear. (Daniel T. Smith, Jr., et al., State of the Art Report: Residential Traffic Management)***

There are a number of advantages and disadvantages to using temporary devices. In the event that modification is necessary, temporary devices are much easier to alter and considerably less expensive to install and change. However, they can be unattractive and lead citizens to decide to oppose permanent installations.

Prior to installation of any traffic control devices, most especially those that divert traffic, public notice of pending construction should be widespread. Lack of notification has lead in some cases to angry motorists who have resorted to illegal maneuvers and, in some cases, vandalism and destruction of the devices. This reaction can be minimized and often averted by placement of warning signs, distribution of notices throughout the neighborhood to be affected, notices being posted at neighborhood entry points, and distribution of notices to affected commuters at their places of employment. Notices should also appear in local newspapers and newsletters. Of course, all service providers (e.g., police, fire, utility companies, ambulance services, postal and delivery services) should be involved in the planning process and receive detailed maps of the final adopted form of the traffic plan prior to construction.

Every effort should be made to make sure installation is attractive from the start. Scrimping on the landscaping budget will not pay in the long run.

> ***Efforts to present an attractive appearance even with low budget temporary devices [illegible] rewarded. The extra cost of minimal landscaping may be money well spent. A plan [illegible] with trees or shrubs may look very nice in the [illegible] rendering, but in the field it may look like [illegible] tied to a large stake [illegible] if the community scrimps on the landscape budget. (Daniel T. Smith, Jr., et al., State of the Art Report: Residential Traffic Management)***

Even with the best planning and community outreach efforts, there are inevitably negative reactions to installation of new traffic control devices. Increased surveillance during the first two weeks after installation by staff and police can help to discourage illegal behavior.

EVALUATION

The "calendar" for evaluating the effect of traffic calming devices will vary according to each community's needs. However, the initial evaluation should be done long enough after the installation so that traffic and residents have had time to adjust to the new traffic patterns and initial adverse reactions have cooled off. This will allow for a thorough evaluation based on the actual performance of the traffic calming system. According to Smith et al. (1994, 126), "in conducting the evaluation, three to six months after the implementation should be allowed before "after" data measures are taken."

Only a few cities in the U.S. have done thorough studies of the effects of traffic calming devices. Seattle, Washington, and Portland, Oregon, in particular, have provided much needed data on the actual effectiveness of such devices. Their experience has shown that, in order to do a thorough evaluation, there must be "before" and "after" data so that comparisons are quantified. Staff must take care that all important measures of "before" conditions are recorded, even if the data is not needed in the initial program planning.

If a community does not carefully plan for the evaluation and modification of its traffic management scheme, it runs the risk that the entire scheme will be abandoned due to minority opposition that may not reflect the actual facts of the situation. Evaluation allows for modification of a scheme to make it perform its intended function better or to lessen its adverse impacts.

Public involvement in the evaluation should be maintained by having public hearings or ongoing contact with citizen review boards. Ideally, a community should do a follow-up survey of public perception of the traffic management scheme and conduct neighborhood meetings within the affected areas to receive input from residents and provide them with information gathered by staff.

> *If traffic management opponents' allegations regarding traffic safety and congestion impacts were not countered by hard evaluation, Berkeley might well have abandoned its neighborhood traffic plan at an early date (Daniel T. Smith, Jr., et al., State of the Art Report: Residential Traffic Management).*

MODIFICATION AND REAPPLICATION

In most cases, the modifications to traffic calming systems are quite minor. After installation, it becomes clear that additional signs are needed, a crosswalk should be installed, or additional reflectors are needed to increase visibility. Such alterations help the traffic calming devices work more effectively and reduce any dangerous conditions that may result from their installation. Generally, this type of modification occurs as a result of the staff observation, before the public is given input to modifications.

Care should be taken in making anything other than minor alterations to traffic calming devices after their installation and prior to scheduled evaluations. Such changes should be done with careful evaluation and planning in the same way that the original system was constructed. Large-scale modifications to such systems can create as much confusion and opposition as they were intended to cure.

If a scheme is considered unworkable and has been unpopular with the community, an attempt should be made to go back and reconsider alternatives that were not chosen in the earlier stages of the process. In some communities, calls for modification or elimination of a traffic calming system continue for years after its implementation. For instance, Smith et al. (1980, 130) report that, in Berkeley, three years after implementation, opponents were still attempting to eliminate some or all of the traffic diverters installed there, while supporters wanted numerous modifications. And, in Barnsbury, London, the traffic calming scheme was substantially recycled over a four-year period and two evaluation sequences.

In Seattle and Portland, neighborhood demand for evaluation and installation of traffic calming devices has exceeded the community's available funding. The devices, such as traffic circles, are very popular, and the cities have now developed systems for application, review, and selection, subject to available funding levels. In Portland, the city undertook an extensive citizen involvement program called the Community Traffic Safety Initiative: Reclaiming Our Streets. The idea was to "design a community-based action plan to address traffic mitigation and safety" (Portland, Office of Transportation 1991, 1). All this activity was guided by a community-based committee or task force.