# Step-3 Report on

# 784 Memorial Drive

Includes a Calculation and Assessment of Queues,

as well as Traffic Mitigation Proposals and

Signal Warrant Study Results

prepared by Stephen H. Kaiser
191 Hamilton Street
Cambridge, Mass. 02139

*for submission to the Cambridge Planning Board*

*and the Cambridgeport Neighborhood Initiative*

* A review of existing Traffic Congestion and Queues
* City of Cambridge IPOP Requirements
* Alternate Plans for Transportation Demand Management

*February 25, 1999*

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# STEP-THREE REPORT ON CAMBRIDGEPORT TRAFFIC

# 1 INTRODUCTION AND PURPOSE

The purpose of this community traffic report is to provide a final assessment of the traffic impacts associated with the proposed development at 784 Memorial Drive, as currently proposed by the joint venture of Polaroid and Spaulding and Slye. The key remaining issues are the presentation of the traffic queuing near the site in peak hours, the application of the five IPOP criteria to the 784 Memorial project, and an assessment of the effectiveness of the Parking & Transportation Demand Management plans as proposed by the developer. In addition, the need for alternate PDTM proposals arises from the very limited proposals received from the developer and City officials to date. The proposed relocation of the driveways needs a critical review.

One consequence of the added traffic is considerable congestion on Pleasant Street itself, in addition to existing congestion on Memorial Drive and Putnam Avenue. The Polaroid site proposal has grown to include 310,622 s.f. of office space, plus 30 units of row housing and 607 parking spaces (including a 577-car parking garage). Today, there have been four traffic reports or reviews dealing with the proposed project :

- A traffic study prepared by Vanasse Associates for Spaulding and Slye (November 1997)
- A Step-One traffic study prepared by Stephen Kaiser for the Cambridgeport Neighborhood Initiative (December 1997)
- A traffic review report prepared by Rizzo Associates (Barry Pell) for the City of Cambridge (February 1998)
- A Step-Two traffic study prepared by Stephen Kaiser for the Cambridgeport Neighborhood Initiative (October 1998)
- *THIS REPORT* A Step-Three traffic study prepared by Stephen Kaiser for the Cambridgeport Neighborhood Initiative (February 1999)

In the Spring of 1997, the Cambridge City Council passed an Order requesting that the City Manager should prepare a traffic study on the effects of the development at 784 Memorial Drive. The City Manger first turned to the Community Development Department, but CDD determined that the private developer -- Spaulding and Slye -- should do the study.

On May 30, 1997, the CDD issued a draft scope covering those issues which the study should contain. However, the developer responded in August and agreed to do only certain parts of the scope. CNI, in response to any potential "analysis monopoly" of a traffic study by a private developer, offered to complete its own community study – which also would not deal with the full CDD scope but would cover the issues with a different perspective and emphasis. (All scopes are contained in Appendix A of the Step-One Report). The general strategy was that the City would review both reports, and the Rizzo submission of February 1998 represented that review effort.

The CNI reports have been submitted in three steps because new information keeps arising about traffic issues in the neighborhood and because of the need to better understand queues, safety, mitigation and the implications of IPOP permit decisions. The Step-One report dealt with the adequacy of the study area and traffic counts, including trip generation and resulting congestion. We identified issues of parking alternatives and safety concerns, as well as alternate travel routes through the neighborhood and specific proposals for a series of mitigation actions to protect the neighborhood from being overwhelmed by traffic impacts. The Step-Two report was primarily a report on the extensive traffic counting done in June 1998. Additional discussion covered PTDM plans and driveway safety.

This Step-Three report will concentrate on queuing impacts and implications for the IPOP assessment process. The inadequacy of the PTDM proposals and the need for a new parking strategy will be presented. Finally, the appendices will contain the proposals for Memorial Drive mitigation and the analysis of traffic signal warrants – which were developed independently of the formal reports.

## 2 Project Size and Traffic Generation

Since the beginnings of the project almost two years ago, the site has grown from 285,000 s.f. with "500-plus" parking spaces to 311,000 s.f. with a total of 607 parking spaces – including a 577-car parking garage. The developer has calculated 1,941 daily vehicle trips associated with the two office towers, but CNI has specifically criticized the numerical methods that Vanasse used in making the estimate and communicated these concerns to MEPA. The daily trips from the site, including the front building and its expansion is 3,320 total, using more credible ITE trip generation data.

There are numerous instances where I would have small disagreements with the numbers included in the 1997 Vanasse report. However, the larger impacts of the development are of a much larger scale than these technical differences over comparatively small variations in numbers. Therefore, unless we find more serious technical differences in the traffic analysis, we should best proceed by using the traffic projections and calculations from the Vanasse report. We can agree to use the same data and see what they mean for queues and congestion.

The essence of the historical traffic problem has been know for many years and is readily apparent to any observer during the afternoon peak hour. In my letter of May 1997 to CDD, I noted that

> *"The proposed 500-car garage can be expected to release about 250 cars an hour onto Pleasant Street during the afternoon peak hour, with 70-75% of it headed towards the Turnpike and other points to the West. The resulting 175 cars would encounter long vehicle queues on both Memorial Drive and Putnam Avenue. Currently, there is no space for more traffic and no traffic mitigation plan. Since today's queues regularly extend to Strawberry's and often back to Magazine Street, the queuing problem should be obvious."*

Stated another way, the existing long queues are visible evidence of the inadequacy of the transportation infrastructure to handle the traffic demands, and more new traffic would simply overload an already overloaded system. Despite this obvious nature of the queue problem in the area of 784 Memorial Drive, neither the City of Cambridge nor the developer's traffic consultant have adequately focused on the queuing problem and its significance. The focus of IPOP on traffic impacts is a significant step forward for the City, as is the inclusion of an evaluation criterion dealing with queues.

## 3 Projections of Traffic Queues

The citizen's complaint that the "traffic is all backed up" is a layman's perspective on what the traffic engineers measure as *queues*. Through various mathematical and computer techniques, it becomes possible to calculate the length of traffic queues for various conditions -- such as existing traffic and future conditions with-and-without a new development project. State highway officials and MEPA have approved computer methods for evaluating intersection congestion.

For *unsignalized* intersections, the common method is to use the HCS computer software, which calculates level of service, delay and queue length. The queue length is

given in the number of vehicles which queue after an hour, for a 95th percentile probability. Because traffic often comes in uneven bunches, queues are not always constant and their lengths will vary. Rather than take an "average" queue or a "worst case," the accepted procedure is to consider a 95th percentile queue. This means that we make a list of all queues that occur during the hour, from the longest to the shortest. The longest 5% of the queues are discarded, and we say the 95th percentile queue occurs right at that 5% break. Queue lengths are measured in *numbers* of vehicles, so to obtain a physical length for the queue, we must multiply by the spacing per car in a queue (25 feet) and divide by the number of lanes.

For *signalized* intersections, the procedure is different. The calculation of Level-Of-Service is made first, and then the queues are calculated using a simple spreadsheet. The result is both the average queue and 95th percentile queue for the busiest 15-minute period during the peak hour. Normally with minimal congestion, a 15-minute period would be satisfactory, but when there is severe congestion (as occurs on Memorial Drive and Putnam Avenue) we would obviously benefit from knowing the one-hour queue. Alas, MassHighway's spreadsheet does not yet allow for such an adjustment. The best we can do for consistency is to use the 95th percentile queues for 15-minutes of signal operation and for 60-minutes of unsignalized operation.

The #4 IPOP criteria refers generally to queues growth greater than 6 cars in the peak hour. How should we measure queues? The City's *Guidelines for Transportation Impact Study* of December 21, 1998, specify the use of the MassHighway Queue length model. In their traffic study, Vanasse used the HCS model to consider intersection capacity and used the MHD spreadsheet for queue lengths at signals. Unfortunately, the VAI report did not summarize this raw data, assimilate it or seek to assess its implications.

CNI has taken the Vanasse-HCS computer model and has made its own queue length calculations, using the MHD spreadsheet. In every instance, we duplicated the calculations of the VAI report (Appendix A). The next step was to calculate the physical length of unsignalized queues as measured in feet. The final presentation step is to show a color diagram of the queues for the morning and afternoon peak hours, which are contained in Figures 1 and 2. The consistent color scheme has been to use *Blue* for existing conditions, *Yellow* for added traffic for the future No-Build, and *Red* for the increment of new traffic from the full development.

We can see from Figures 1 & 2 that the primary congestion problem occurs in the afternoon, as many citizens observe today. Long queues on Memorial Drive and Putnam Avenue are shown to grow significantly in the future. With the site fully developed, all of the queue segments (*blue, yellow and red*) should be the focus of our attention, and we can see clearly that the queues wrap themselves completely around the 784 Memorial Drive site -- on Memorial Drive and Putnam Avenue as they do today, but also in both directions of Pleasant Street.

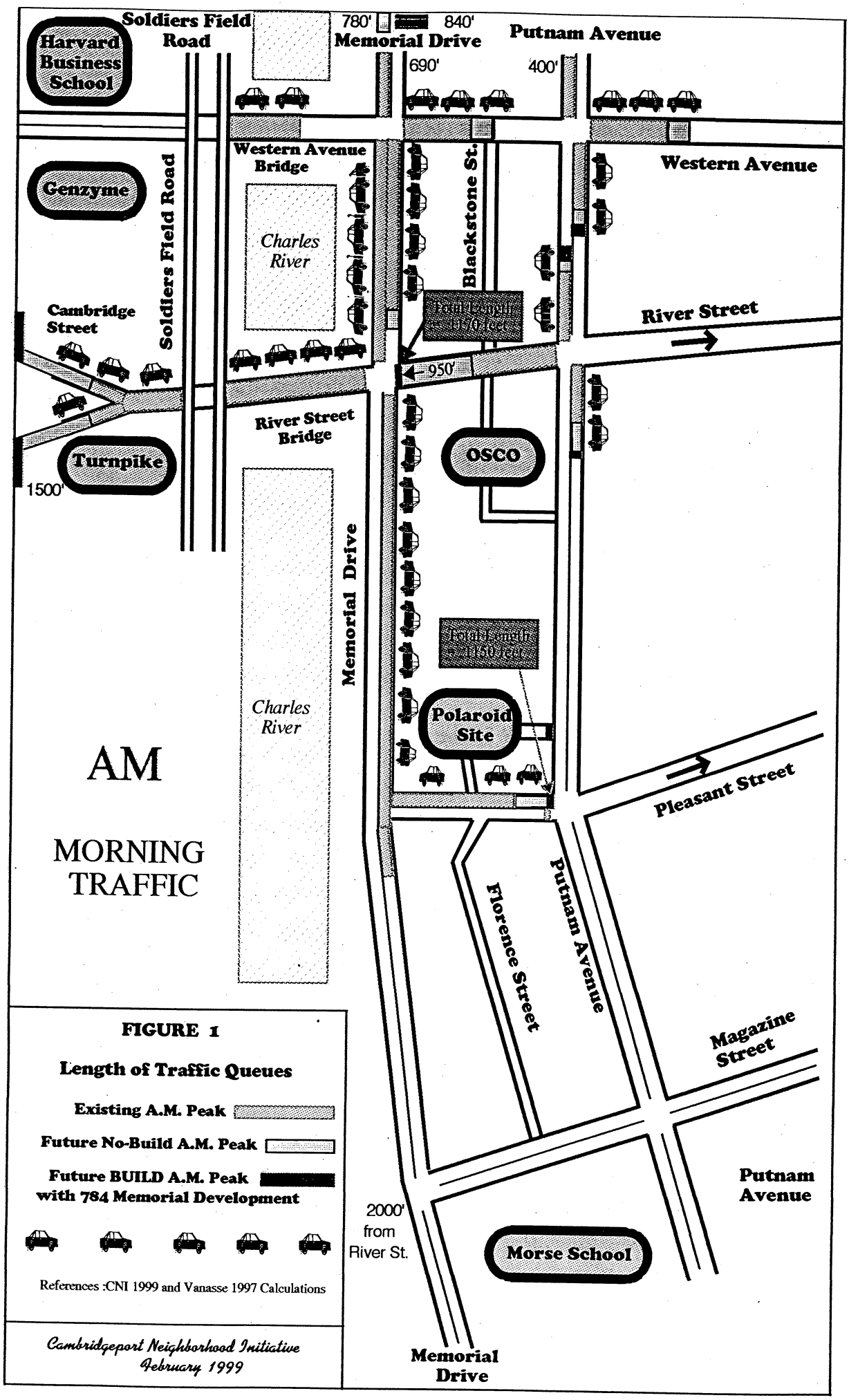
The severity of the traffic queuing problem should be obvious to any observer. We should be aware that there is no disagreement between CNI and the developer over the actual projected queue lengths. The only difference is that CNI has taken the data and presented it, first in tabular form (Appendix A) and in the graphical form of Figures 1 and 2. If Vanasse & Associates were to go through the same exercise, I would expect them to come up with the same results and product. There is no disagreement on the traffic calculations -- only in its completeness of presentation. Spaulding and Slye might even agree on the desirability of the CNI presentation method -- if the results were not so indicative of traffic problems associated with their development proposals.

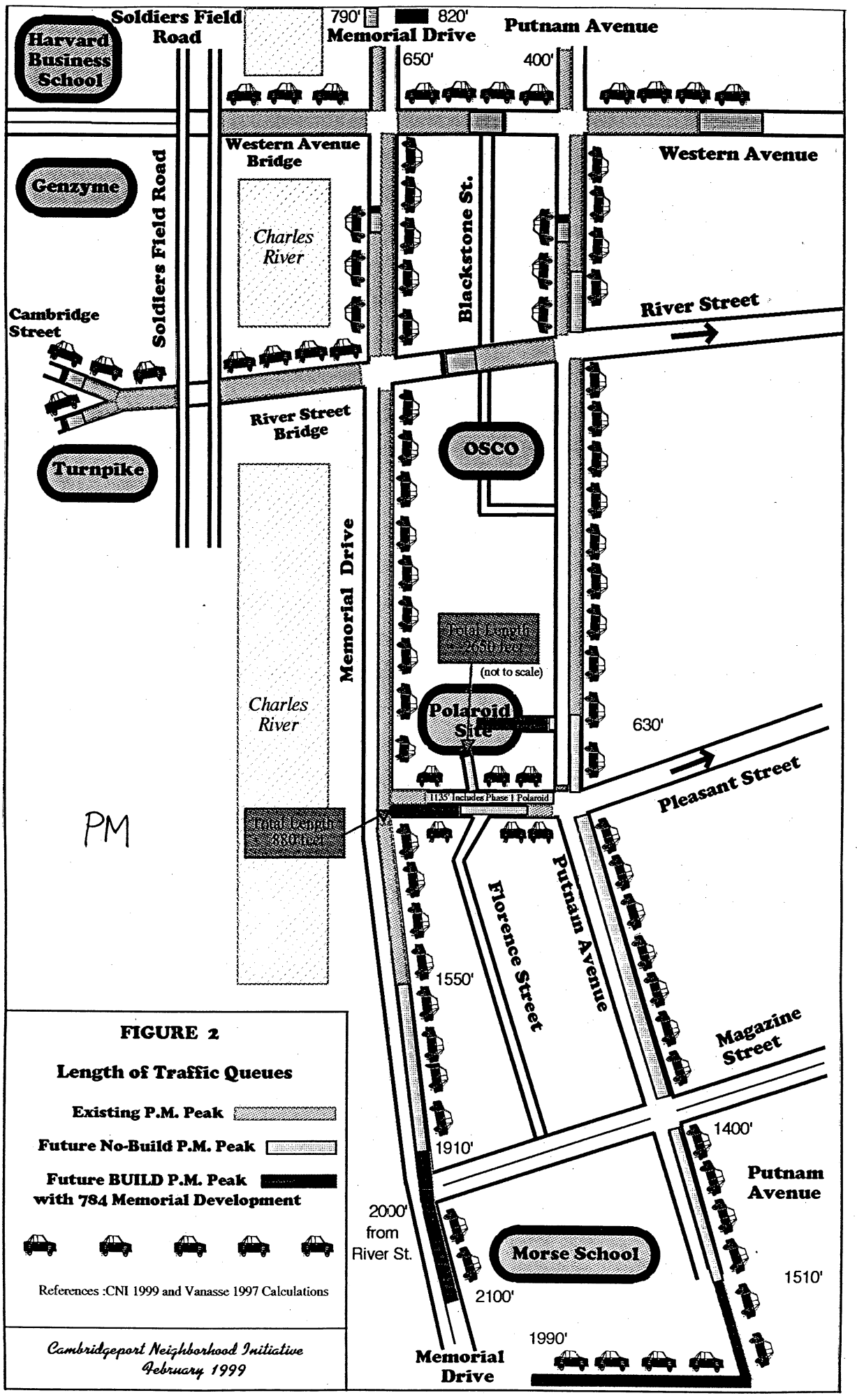
## 4 IPOP Requirements

On September 28, 1998, the City Council passed an amendment to the Zoning Ordinance, section 11.500 for special Planning Overlay Requirements, more commonly known as IPOP. (See Appendix E) Responsibilities for issuance of the special permit were delegated by the Council to the Planning Board, and the permit generally involved information and procedural steps (11.511 and 11.512) which include compliance with four growth policy goals as well as preparation of a traffic report and making a finding of "no substantial adverse impact on city traffic."

Section 11.511 (a) requires submittals to be in compliance with Large Project Submittal Requirements of para. 11.45 of the Zoning Ordinance. There are no clear traffic information requirements here.

Section 11.511 (b) requires that a traffic study be certified by Traffic & Parking Department as being "done in a complete and reliable manner," as to methodology. It shall also include "information on Parking & Transportation Demand Management measures," without specifying the actual approval of a specific plan or set of actions.


Harvard Business School
Soldiers Field Road
780'
840'
Memorial Drive
Putnam Avenue
690'
400'
Western Avenue Bridge
Blackstone St.
Western Avenue
Genzyme
Soldiers Field Road
Charles River
Cambridge Street
River Street
950'
River Street Bridge
Turnpike
1500'
OSCO
Memorial Drive
Charles River
Polaroid Site
AM
MORNING TRAFFIC
Pleasant Street
Florence Street
Putnam Avenue
Magazine Street
Putnam Avenue
2000' from River St.
Morse School
Memorial Drive
FIGURE 1
Length of Traffic Queues
Existing A.M. Peak
Future No-Build A.M. Peak
Future BUILD A.M. Peak with 784 Memorial Development
References :CNI 1999 and Vanasse 1997 Calculations
Cambridgeport Neighborhood Initiative
February 1999


Harvard Business School
Soldiers Field Road
790'
820'
Memorial Drive
Putnam Avenue
650'
400'
Western Avenue Bridge
Western Avenue
Genzyme
Soldiers Field Road
Charles River
Blackstone St.
Cambridge Street
River Street
River Street Bridge
OSCO
Turnpike
Memorial Drive
Total Length = 2650 feet
(not to scale)
Polaroid Site
630'
Charles River
1135' Includes Phase I Polaroid
Pleasant Street
PM
Total Length = 880 feet
Florence Street
Putnam Avenue
1550'
Magazine Street
1910'
1400'
Putnam Avenue
2000' from River St.
Morse School
2100'
1510'
1990'
Memorial Drive
FIGURE 2
Length of Traffic Queues
Existing P.M. Peak
Future No-Build P.M. Peak
Future BUILD P.M. Peak with 784 Memorial Development
References :CNI 1999 and Vanasse 1997 Calculations
Cambridgeport Neighborhood Initiative
February 1999

Section 11.511 (c) requires a certification that all special permits and variances have been granted. CNI believes that this section does apply to the 784 Memorial Drive site because the current building permit for the parking garage (now under appeal) is based on use of the existing Pleasant Street driveway, which is contrary to City Zoning, section 6.43.4(b), for driveways located closer than 25 feet of an intersection. The only legal way for the developers to secure a building permit for the garage when the driveway is in violation of zoning is to seek a zoning variance -- which they did not do, so they do not have a legal parking garage which the two office towers would use. Thus, they do not have all of their necessary variances, unless they abandon their current garage building permit and instead base their development on a plan with legal and conforming driveways that do not require variances.

The criteria for the Planning Board's approval of the special permit include a requirement that the Board "will ensure that the project conforms" with four growth policies from the Cambridge Growth Policy Document, c. 1994. Growth Policy #13 states that a pace of development *"should be encouraged"* which *"does not unreasonably disrupt the daily activities of the city's neighborhoods and residents..."* Since severe traffic congestion could provide such a disruption, the Planning Board would need to provide specific "encouragement" by a recommendation that the project could or must not provide a traffic disruption which is "unreasonable." Technically, the Board could simply make a general recommendation to encourage actions which do not unreasonably disrupt neighborhood activities through traffic congestion .... and leave it at that. Growth Policy #13 is not a very strong one with regard to traffic, but it does involve a specific action by the Board.

Growth Policy #27 deals with housing, not commercial development.

Growth Policy #39 requires a finding by the Board that development patterns *"must be planned to minimize negative impact on abutting residential neighborhoods."* What is a development pattern and who does the planning? This policy is also ambiguous because of the dual meaning of the word *"minimize."* For example, to minimize impacts has traditionally meant finding ways to reduce damage, but "minimizing impacts" can also imply spin control, denial and down-playing of impacts. We have seen considerable evidence of consultant traffic studies which minimize impacts not by providing traffic reduction or mitigation, but instead saying that key intersections will be congested before and after the project : *it was LOS F before and it will remain LOS F in the future.*

Growth Policy #66 appears to be limited to new open space areas.

Criterion 11.512(b) is clearly the most challenging action for the Board, because it requires a finding that *"the project will have no substantial adverse impact on city traffic."* The word "substantial" requires definition and has specifically been recognized in the five "Criteria to Guide Project Evaluation" as *"indicative of substantial impact."* Adverse impact can mean more traffic, increased congestion, higher speeds or safety problems -- and these appear to have been covered at least in part by the five criteria.

The reference to *"city traffic"* has caused some puzzlement, since one interpretation is that *"city traffic"* would mean everywhere in the City of Cambridge. By this interpretation, developments in East Cambridge would be assessed by impacts on traffic in North and West Cambridge. This interpretation is unreasonable on several grounds : the traffic study referred to in section 11.511(b) always involves impacts on only a relatively small study area of the city. For example, the 784 Memorial traffic analysis does not include East Cambridge. Therefore, there would be no basis for the Board to reach a conclusion about city-wide traffic impacts, if this were the interpretation of *"city traffic."*

I prefer to interpret *"city traffic"* to mean "City of Cambridge traffic" -- as opposed to traffic in Boston, Belmont, Arlington or Somerville. Unfortunately, I interpret this to mean that IPOP is not intended to worry about anyone else than Cambridge. In the 784 Memorial Drive case, we would not be worried about congestion in Boston -- for the purposes of IPOP.

The developer has requested an IPOP approval for two new office buildings at 784 Memorial Drive, and specifically excludes the parking garage and the initial phase of the 40,000 s.f. front building and the 20,000 s.f addition. Spaulding and Slye claims that *"the garage is not subject to the Planning Overlay Special Permit requirements."* Clearly, both zoning and IPOP as currently written offer an inducement for developers to build the parking garage first and then seek approvals for office or other commercial space later.

An awkwardness here is that Section 11.511(b) requires the submission of information on Parking & Transportation Demand Management, which includes information on encouraging transit and shared rides -- actions which would hopefully reduce traffic and also the need for parking. How can a good PTDM plan not look at the need for the total number of parking spaces?

Indeed, in the November 13, 1998 application letter to the City, Spaulding and Slye indicated that their response to the finding that "the project will have no substantial adverse impact" refers to the mitigation program for Western Avenue, which was implemented in June 1998 (see Appendix D). These proposals evolved out of the initial CNI proposal for traffic mitigation (Appendix C), but changes implemented at Western Avenue were not as effective as hoped, because of congestion at River Street. Our mitigation effort remains only a small part of the original traffic signal concepts for MDC roads and is an even smaller element of the original CNI mitigation proposal. Spaulding and Slue's contribution to the group effort was significant in terms of off-site mitigation and if the *entire* group effort (if successful) were credited to the 784 Memorial Drive site alone, there is a logic which would conclude that a maximum size of parking garage of 300 spaces could be handled by the mitigation provided.

The developer states it is "through the implementation of this program that we intend to avoid substantial adverse impacts on City traffic." A careful reading of this letter indicates that the program includes both the signal timing mitigation and the PTDM programs. The signal mitigation program has not been fully implemented, and the PTDM program is very weak – currently it includes a commitment of only 10 shared ride parking spaces in a 577-car garage. The fraction of single-vehicle-occupant cars would be reduced from 83% of all trips to a target of 80%. While these specifics are better than for the developers of the ComEnergy site or at Alewife, they are of pitiful insignificance in terms of having a substantial effort on traffic congestion or queues.

The logic of the developer is that without the mitigation program they will not be able to avoid adverse traffic impacts, but through this program they "intend" to avoid such impacts. Clearly, the developer has a concept of what are "substantial adverse impacts" to traffic, but the letter is not specific. By implication the mitigation program must have some effect at reducing traffic impacts. The developer should indicate what are these impacts and how were the estimates calculated.

The developer also wishes to use Section 10.43 for the granting of traditional special permits, whereby special permits *"will normally be granted ..... except when particulars of the location or use, not generally true of the district or of the uses permitted in it, would cause granting of such permit to be to the detriment of the public interest."* However, IPOP is a unique permit process, without a timeline, and with findings of no substantial adverse impact on traffic. An IPOP is quite different from a PUD special permit.

## 5 Application of the Five IPOP Criteria

There is an important difference between all four previous traffic reports and the IPOP requirements. Previous traffic studies have followed a pattern similar to a MEPA analysis, where counts are made of existing traffic, and then traffic is projected into the future, typically for five years. Thus, Vanasse considered a No-Build case of future traffic in the year 2002 -- including the effects of University Park -- and a Build case which adds in the full development of 784 Memorial Drive.

For IPOP the only specified comparison is between existing and future growth : there is no background growth factor which includes developments such as University Park. Thus the ground rules of the traffic analysis have shifted under IPOP. I believe it is still important to consider the complete future traffic conditions with University Park and with/without the 784 Memorial Drive and the IPOP structure does not say we should ignore other development such as University Park. The most logical way I read the IPOP rules is that a full and complete traffic analysis is performed, but the criteria are based on comparing the *growth* in traffic from 784 Memorial development with *existing* traffic volumes and queue growth.

For example, the queue lengths remain the same as previously calculated for future conditions. But under IPOP, the queues shown in Figures 1 and 2 would be a comparison of the existing (*blue*) with the growth (*red*). The background traffic growth shown in yellow is still there -- it just does not enter directly into the IPOP criteria.

On November 25, 1998, the Planning Board adopted five traffic criteria which were intended to assist in determining what is a substantial traffic impact.

### 1. *Project Vehicle Trip Generation*

CNI contends that the trips generated from the entire project is approximately 3,300 daily vehicle trips, and the traffic from the two towers is about 2,600 ADT. Although Spaulding & Slye in their original driveway withdrawal had indicated that new tenants with lower trip generation rates were being contacted, I am unaware of any information from the developers showing any traffic reduction. The IPOP criterion #1 of 2,000 daily vehicle trips is exceeded. Similar, the 352 peak hour trips exceeds the IPOP level of 240 trips per hour by 47%.

In the February 25, 1999 letter of Traffic and Parking to Spaulding & Slye, Director Susan Clippinger indicates that the estimated new traffic from the site should not be based on 100% of standard rates but on 77% based on Census tract information. Instead of the 352 peak hour trips shown in the 1997 Vanasse study, the new trip total would be 23% less or 271 trips, which I feel is too low. As a good rule of thumb for office development, half of the parking spaces empty in the peak hour. For 607 on-site spaces, the peak hour traffic would be expected to be about 300 trips. Currently, I do not know where the 77% figure came from and whether it applies to all of Cambridgeport and whether it would include locations closer to Central Square which would have better pedestrian and transit access.

*2. Traffic on Residential Streets -*

The IPOP criterion says in effect that development traffic should be less in cases where streets are increasingly residential or where traffic on these streets is less -- reflecting the more tranquil residential streets of today. Table 1 shows instances of excessive traffic on residential streets for two instances in the morning and four in the afternoon, with one less in each case if we do not count the hotel as residential. Memorial Drive is less than 1/3 residential today, so there is no maximum limit on new traffic under this criterion.

Pleasant Street between Memorial Drive and Putnam Avenue is at least 1/2 residential between Memorial Drive and River Street, but the first block is "residential" only because of the Howard Johnson Hotel. Only in this block is there a traffic growth of more than 40 vehicles in the peak hour. It would not appear that land uses such as a commercial hotel were included in the original intent of the City Council in providing residential protections from traffic.

Putnam Avenue between Pleasant and Western Avenue is at least half residential between Magazine and Allston Street (2 blocks) and between River and Hingham Streets. In Pleasant to Allston block during the morning, new development traffic exceeds the IPOP criteria by 70% in the AM peak and by 120% in the PM peak. In the afternoon, there is also a violation of 40% in the block of Putnam Avenue between Pleasant and Magazine Street. Another PM excess of 20% occurs between River and Western Ave.

### 3. *Level of Service (LOS) and Traffic Growth*

The IPOP criteria allow traffic to degrade from LOS A to LOS C and from LOS B, C and D to LOS D, and more congested location allow for the growth in total intersection traffic of 5 to 7% maximum. If we take existing LOS and traffic volumes from the Vanasse study, we can apply the IPOP criteria and compare it with the estimates of traffic increase due to 784 Memorial Drive :

| AM Peak Hour | Existing LOS | Existing Traffic Volume | IPOP Allowed Volume Increase | 784 Mem.Dr Increase With Development |
|---|---|---|---|---|
| Memorial Drive and Pleasant Street | F | 3,195 | 5% or 160 | 147 |
| Memorial Drive and River Street | E | 4,385 | 7% or 307 | 142 |
| Memorial Drive and Western Avenue | D | 3,637 | 7% or 255 | 76 |
| Putnam Avenue and Pleasant Street | B | - | D or better | B |
| Putnam Avenue and River Street | C | - | D or better | C |
| Putnam Avenue and Western Avenue | C | - | D or better | C |

| PM Peak Hour | Existing LOS | Existing Traffic Volume | IPOP Allowed Volume Increase | 784 Mem.Dr Increase With Development |
|---|---|---|---|---|
| Memorial Drive and Pleasant Street | F | 2,929 | 5% or 146 | 115 |
| Memorial Drive and River Street | E | 4,335 | 7% or 303 | 85 |
| Memorial Drive and Western Avenue | E | 4,097 | 7% or 287 | 160 |
| Putnam Avenue and Pleasant Street | E | 1,031 | 7% or 72 | 96 |
| Putnam Avenue and River Street | C | - | D or better | F |
| Putnam Avenue and Western Avenue | D | 1,780 | 7% or 125 | 96 |

An IPOP exceedance occurs at the intersection of Putnam Avenue and Pleasant Street in the afternoon peak hour. This location is immediately adjacent to Elie Yarden's apartment. The intersection of Putnam Avenue at Western shows a decline in

# *Table 1*

# 784 Memorial Drive – Traffic Growth on Local Streets

*AM .... Morning Peak Hour*

AM

| Street | Block | Direction | AM Volumes | TOTAL | Resid Percent | Number of Lanes | Development Volumes Max.Poss | New Traffic | | Devel# vs. Max | IPOP STATUS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pleasant Street | Block 1 | Eastbound | 31 | 88 | Half | 1 | 40 | 133 | 147 | 107 | VIOLATION |
| *(between* | | Westbound | 57 | | (Hotel) | 1 | (2-way) | 14 | Total | | |
| *Memorial &* | Block 2 | Eastbound | 46 | 106 | Half | 1 | 40 | 0 | 0 | -40 | OK |
| Putnam Ave) | | Westbound | 60 | | (Houses) | 1 | (2-way) | 0 | Total | | |
| Florence Street | Block 1 | Northbound | 13 | 49 | All | 1 | 40 | 0 | 5 | -35 | OK |
| *(Between* | | Southbound | 36 | | (Hotel) | 1 | (2-way) | 5 | Total | | |
| *Pleasant &* | Block 2 | Northbound | 10 | 20 | All | 1 | 20 | 0 | 0 | -20 | OK |
| Magazine St.) | | Southbound | 10 | | (Houses) | 0 | (2-way) | 0 | Total | | |
| Putnam Avenue | Block 1 | Northbound | 181 | 446 | All | 1 | 80 | 26 | 36 | -44 | OK |
| *(Between* | | Southbound | 265 | | (Houses) | 1 | (2-way) | 10 | Total | | |
| *Magazine &* | Block 2 | Northbound | 180 | 478 | Half | 1 | 80 | 40 | 135 | 55 | VIOLATION |
| *Allston)* | | Southbound | 298 | | (Houses) | 1 | (2-way) | 95 | Total | | |
| Putnam Avenue | Block 1 | Northbound | 241 | 475 | Half | 1 | 80 | 14 | 40 | -40 | OK |
| *(Between* | | Southbound | 234 | | (Houses) | 1 | (2-way) | 26 | Total | | |
| *River and* | Block 2 | Northbound | 191 | 526 | 3/4 | 1 | 80 | 0 | 0 | -80 | OK |
| *Hingham St)* | | Southbound | 335 | | (Houses) | 1 | (2-way) | 0 | Total | | |

AM

*PM .... Afternoon Peak Hour*

PM

| Street | Block | Direction | PM Volumes | TOTAL | Resid Percent | Number of Lanes | Development Volumes Max.Poss | New Traffic | | Devel# vs. Max | IPOP STATUS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pleasant Street | Block 1 | Eastbound | 30 | 55 | Half | 1 | 40 | 25 | 115 | 75 | VIOLATION |
| *(between* | | Westbound | 25 | | (Hotel) | 1 | (2-way) | 90 | Total | | |
| *Memorial &* | Block 2 | Eastbound | 170 | 240 | Half | 1 | 60 | 0 | 0 | -60 | OK |
| Putnam Ave) | | Westbound | 70 | | (Houses) | 1 | (2-way) | 0 | Total | | |
| Florence Street | Block 1 | Northbound | 120 | 165 | All | 1 | 60 | 0 | 30 | -30 | OK |
| *(Between* | | Southbound | 45 | | (Hotel) | 1 | (2-way) | 30 | Total | | |
| *Pleasant &* | Block 2 | Northbound | 10 | 20 | All | 1 | 20 | 0 | 0 | -20 | OK |
| Magazine St.) | | Southbound | 10 | | (Houses) | 0 | (2-way) | 0 | Total | | |
| Putnam Avenue | Block 1 | Northbound | 585 | 795 | All | 1 | 80 | 95 | 177 | 97 | VIOLATION |
| *(Between* | | Southbound | 210 | | (Houses) | 1 | (2-way) | 82 | Total | | |
| *Magazine &* | Block 2 | Northbound | 520 | 795 | Half | 1 | 80 | 90 | 111 | 31 | VIOLATION |
| *Allston)* | | Southbound | 275 | | (Houses) | 1 | (2-way) | 21 | Total | | |
| Putnam Avenue | Block 1 | Northbound | 585 | 845 | Half | 1 | 80 | 90 | 96 | 16 | VIOLATION |
| *(Between* | | Southbound | 260 | | (Houses) | 1 | (2-way) | 6 | Total | | |
| *River and* | Block 2 | Northbound | 320 | 585 | 3/4 | 1 | 80 | 0 | 0 | -80 | OK |
| *Hingham St)* | | Southbound | 265 | | (Houses) | 1 | (2-way) | 0 | Total | | |

S. Kaiser **February 24, 1999**

# Table 2

## Traffic Queues in Violation of IPOP Criterion :
### : Maximum Queue Growth of 6 cars due to development

## As applied to Polaroid Site development, 784 Memorial Drive

## Morning Peak Hour : 3 Violations

| | Queues on CambridgePort Streets : | | | AM MORNING PEAK HOUR NUMBER OF CARS | | | AM LENGTH OF QUEUE | | | IPOP Criteria | This Project | Comply with IPOP? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Traffic Queue* | Direction | *Starting At :* | Existing | No Build | BUILD | Existing | No Build | BUILD | QUEUE GROWTH LIMITS | | |
| Unsignal | Pleasant Street | *Westbound* | Memorial Drive | 26.8 | 34.8 | 46.1 | 670 | 870 | 1153 | 6.0 | 11.3 | Violation |
| | River Street | *Eastbound* | Memorial Drive | 99.6 | 144.4 | 162.9 | 910 | 1320 | 1490 | 18.0 | 18.5 | Violation |
| | River Street | *Eastbound* | Putnam Avenue | 39.0 | 72.3 | 89.3 | 510 | 950 | 1170 | 12.0 | 17.0 | Violation |

Total Violations : 3

## Afternoon Peak Hour : 6 Violations

| | Queues on CambridgePort Streets : | | | PM MORNING PEAK HOUR NUMBER OF CARS | | | PM LENGTH OF QUEUE | | | IPOP Criteria | This Project | Comply with IPOP? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Traffic Queue* | Direction | *Starting At :* | Existing | No Build | BUILD | Existing | No Build | BUILD | QUEUE GROWTH LIMITS | | |
| Unsignal | Pleasant Street | *Westbound* | Memorial Drive | 5.1 | 45.4 | 105.7 | 128 | 1135 | 2643 | 6.0 | 60.3 | Violation |
| | Memorial Drive | *Northbound* | River Street | 118.1 | 145.4 | 160.2 | 1550 | 1910 | 2100 | 12.0 | 14.8 | Violation |
| Unsignal | Pleasant Street | *Eastbound* | Putnam Avenue | 5.5 | 21.6 | 35.2 | 138 | 540 | 880 | 6.0 | 13.6 | Violation |
| Unsignal | Site Driveway | *Eastbound* | Putnam Avenue | 0.2 | 0.8 | 15.4 | 5 | 20 | 385 | 6.0 | 14.6 | Violation |
| | Putnam Avenue | *Northbound* | River Street | 25.1 | 60.5 | 79.6 | 630 | 1510 | 1990 | 6.0 | 19.1 | Violation |
| | Putnam Avenue | *Northbound* | Western Avenue | 33.0 | 74.7 | 94.5 | 830 | 1870 | 2360 | 6.0 | 19.8 | Violation |

S. Kaiser February 24, 1999

Total Violations : 6

*NOTE :* Of the 8 intersections shown, four are signalized and four are unsignalized.
In all cases, the 95th percentile queues are shown. With signalized intersections, the queuing period is for the busiest 15-minutes of the peak hour, while for unsignalized intersections the queuing period is for the peak hour (60 minutes).

LOS from C to F, when the criteria is a decline to D. In fairness, much of this decline is due to University Park traffic.

In general I find the Level-of-Service criteria to be of little use. There is too much incentive for traffic engineers to do what some readily admit is now occurring -- that numbers will be "fudged," that conditions will be shown to change from a "High D to a Low D," and that these engineers will now claim there is no change in LOS. The worst examples occur when traffic conditions are already LOS F or fully congested. Now the standard refrain from traffic consultants becomes that conditions are LOS F and they will remain so in the future, as if nothing has changed and nothing has gotten worse. The most egregious example of this logic occurs in the Vanasse report : *"By the year 2002, with or without the project, the projected volume increases result in level-of-service (LOS) F conditions."* (p.3)

This experience with poor results for Level-Of-Service as an evaluation method should stress the importance of using better indicators of congestion, such as queues, rather than LOS for assessing traffic impact. Indeed, we should abandon the method of trying to judge traffic impacts by making estimates of changes in Level-Of-Service.

### *4. Lane Queue*

Generally, this criterion is established for any queue growth in a lane exceeding 6 cars in the peak hour. For simplicity, I have applied this general criterion in all cases.

There are nine instances where queues exceed the IPOP criterion and these are listed in Table 2. In two instances, the excess is fairly small, but the queuing problems are severe at four locations in the afternoon. With new 784 Memorial Drive traffic, Pleasant Street would back up from Memorial Drive .... and from Putnam Avenue in the opposite direction. The site driveway has a 15-car queue of cars waiting to get out onto Putnam Avenue. Meanwhile, Putnam Avenue outbound has a notably longer queue from both River Street and Western Avenue.

The computer model is fairly accurate in many cases, but it is unable to account for the full extent of congestion at Memorial Drive and Western Avenue, including queues which extend back from the Boston side and the unavoidably inefficient use of the four lanes on Western Avenue. However, this model is the most common application of the

methods of the *Highway Capacity Manual,* and is in use by both Vanasse and Rizzo and has been certified as acceptable by the City of Cambridge.

The extent of the queuing is reflected in Figures 1 and 2. In the afternoon, the queues extend past the 784 Memorial site on Memorial Drive and Putnam Avenue and along Pleasant Street in both directions. These queuing calculations are contained in Appendix A and agree entirely with the queue calculation of the 1997 Vanasse report.

Neither of the Pleasant Street intersections is signalized, and considerable analysis was given to the prospect of signalization of the Pleasant Street intersection with Memorial Drive. The Engineers' Committee did review the MUTCD standards for signal warrants, and we generally agreed with the Vanasse finding that two of the 11 possible signal warrants were justified with the development in place (See Appendix E). In the absence of a signal, it appears that both directions of Pleasant Street would be severely congested with very long queues affecting circulation on Putnam Avenue as well, and likely causing traffic to divert along Florence Street and the MicroCenter driveway.

A traffic signal at Pleasant Street and Memorial Drive would help reduce these excessive queues which are almost entirely caused by the development at 784 Memorial Drive. Any signal installation would be on MDC land and would need their approval.

The concerns of the MDC have been generally expressed in their letter of June 1997, which noted that *"The development of this site can be expected to have a significant impact on Memorial Drive and the adjacent River Street and Western Avenue intersections. Each of these areas is a marginal traffic facility at this time due to peak hour volumes and resulting lengthy queues. ... it would seem that there is a significant new traffic burden on a road of the Commonwealth and that an evaluation of this burden and a program for traffic mitigation would be appropriate. "*

### 5. *Traffic Accidents*

The IPOP criteria indicate that if there are more than 5 accidents a year at any location, the "developer must propose safety mitigation." From the Cambridge Police data reported in the Vanasse Report, none of the six intersections studied had an average of more than 5 accidents a year. Unfortunately, data from the state police for the three Memorial Drive intersections were not available, except for some historical 1971 MDC

data. In 1971, there were 29 accidents at Western and Memorial and 9 accidents at River and Memorial. Currently, we have insufficient accident information, which is unfortunate because criterion #5 is the only one dealing specifically with safety.

The current proposal for the relocation of two driveways would result in a vast improvement on Pleasant Street -- compared to the extremely awkward -- indeed scandalous -- design for the intersection which is inherent in the single driveway plan associated with the February 1998 building permit for the garage. The simple T-intersection on Pleasant Street would be closer to Memorial Drive, less likely to direct traffic onto the neighborhood and avoids dangerous hairpin turns.

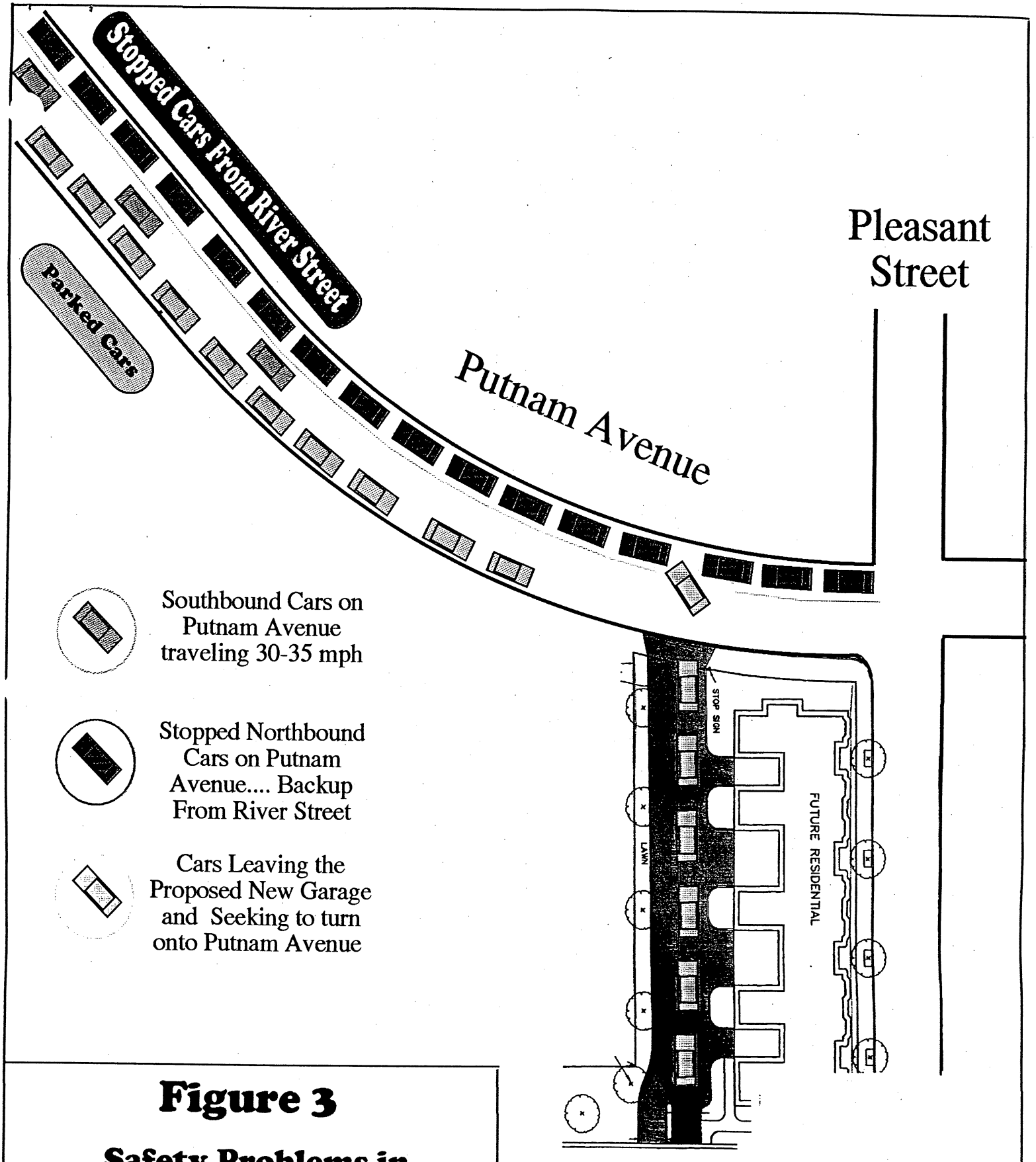
Unfortunately, the shifting of the Putnam Avenue driveway does not deserve the City's redesignation of an *"unsafe"* driveway into a *"safe"* one. There is a problem of visibility for drivers coming out of the Putnam Avenue driveway during the afternoon peak hour, with a line of backed-up cars on Putnam Avenue obscuring a clear view of on-coming cars.

In addition, the queue will not provide easy gaps for exiting cars to get into. These drivers will need to do some "butting in." This action will likely cause some stopped cars to occupy part of the southbound lane of Putnam Avenue -- using a fairly common "Boston driver" practice as shown in Figure 3. There is a more severe visibility problem for drivers traveling south -- because the line of queued cars obstructs the view of any car which is partially blocking the lane. With southbound cars on Putnam Avenue traveling at 30-35 mph, there might not be sufficient time to stop, especially in conditions of inclement weather.

The safety concerns can be significant because of the use of Putnam Avenue at River and Pleasant Street for school crossings and bus stops.

## 6 Reductions in Significant Impacts

The November 13, 1998 letter of Spaulding and Slye quotes from the Rizzo Interim Report of February 1998 that *"a commitment to a comprehensive and rigorously applied mitigation program by the developer in coordination with the City would avoid adverse traffic and safety impacts of the project."* The developer makes specific reference to the signal changes for MDC roadways and the Transportation Demand Management Program, but both of these efforts are incomplete. The traffic signal timing changes




# Figure 3

## Safety Problems in Afternoon Peak Hour at Putnam Avenue Driveway

Drawn by S. Kaiser for CNI February 1999

planned with the MDC were applied as a first phase for Western Avenue, without all the desired pedestrian enhancements. The second major phase of signal changes at River Street has yet to be addressed, and the Engineers' Committee has met this past February 10 for the first time since last June -- and this time without the participation of the developer -- and discussed some initial concepts for River Street.

I would amend the Rizzo position to urge that more than a mere commitment to mitigation is important -- we need the successful implementation of an effective mitigation program. In this sense, implementation of a successful off-site mitigation program is quite less than half-way done. The developer's proposal is entitled "Transportation Demand Management" and was assembled from informal early discussions with the City. It does not reflect the current City Ordinance 10.18 relating to "Parking and Transportation Demand Management; Parking Space Registration."

What is sadly lacking in the developer's TDM proposal is any major reference to Parking. The only specifics I could find relative to parking was a commitment to providing 10 spaces for carpools and vanpools and a monitoring program to keep out illegal parkers. The paucity of commitment can be seen in the designation of only 10 spaces in a 577-car garage for ride sharing. This means up to 567 spaces for use by single-occupant vehicles, which represents a most unwise and inappropriate parking policy in such a congested city as Cambridge. The developer's TDM plan may have some nice words in it and in the hands of a conscientious building manager, there might be some benefits from lesser traffic impacts, but the overall program is so squishy soft, so vague, so lacking in specifics as to be moldable into almost anything -- including nothing. Developers and real estate salesmen, being as aggressive as they are, are likely to follow their natural incentives -- which is to get away with as much as they can and do nothing if possible. There is nothing in the Chamber of Commerce response to PDTM and IPOP proposals which indicates that there is any civic conscience alive in the business community with regard to dealing with traffic impacts. Spaulding and Slye would have to be a most radically different real estate developer in order to make a PTDM plan work well at this site, and I have seen no evidence of any such difference.

The City of Cambridge has made some tentative proposals for alternate PTDM plans for the site, and the ideas are so recent that we have not been able to evaluate them fully. The positive aspects are that the City has taken the initiative to challenge the developer to designate 10% of the spaces (58) for shared ride vehicles, and has set a goal

of a maximum SOV (Single Occupant Vehicle or Drive-Alone) of 66%, rather than the previously used 80% figure. The developer had previously set himself the somewhat less than daunting challenge of shifting SOV use from an initial 83% to 80% "after mitigation." While it seems that City officials have finally broken out of the box of mitigation trivia, their efforts appear to still be inadequate. There is a clear need for a more comprehensive, effective and radical alternative which would have a significant effect on traffic congestion.

IPOP has as its goal to demonstrate that adequate infrastructure exists to support potential increases in traffic. What do we do in a congested area such as Memorial Drive and Putnam Avenue where there is inadequate infrastructure to begin with, even before any new development? The best policy is to do no harm, to not make matters any worse. When developers say they are not changing the level of service from existing LOS F, they are recognizing the importance of this value -- *not to make things worse.* Therefore, in any congested situation, they should seek to have fully effective mitigation, not fluff and not 5% mitigation. The neighborhood cannot be reasonably expected to have traffic dumped on their streets and then accept some paltry crumbs of "mitigation" which clean up only a tiny fraction of the impact. The proper policy for the Planning Board, for the City, for the neighborhood and for the developers is -- whenever there is a congested situation to begin with -- there should be 100% effective mitigation for any traffic impacts.

On this basis, the early traffic mitigation efforts by the Engineers' Committee indicated that there was a significant potential for traffic circulation improvements at the key intersections on both sides of the Charles River. CNI estimates were that vital pedestrian improvements could be made, as well as a residual benefit for vehicle travel. If all of these benefits were assigned solely to the 784 Memorial Drive project, there was the potential for 150 new peak hour trips from the site or the equivalent of about 300 parking spaces.

This presumption may be questioned because Spaulding and Slye did not participate in all of the 1998 meetings and is no longer attending the meetings of the Engineers' Committee. The River Street mitigation is still incomplete. However, just for the sake of argument, let us generously assume that all the mitigation credits go to 784 Memorial Drive.

The first implication is that the parking garage should be limited to 300 spaces, not the currently proposed 577 spaces. To reduce the currently proposed 352 peak hour drips down to 150, there would need to be a 33% SOV, 67% non-HOV split, plus a significant amount (about 20%) of major off-peak work activity, such as 7AM to 3PM work shifts or 11 AM to 7PM. Because Memorial Drive congestion can extend from 4PM to 7 PM on busy days, large changes in work shifts would be required to spread the traffic peak and be effective.

Naturally, there will be loud squeals of protest from the planning and corporate community that such proposals are infeasible, because managers have such inflated egos and are so perk-conscious that they would never consent to ride-sharing. I would respond that what is needed is a new corporate culture and conscience – an alternative to avarice, selfishness, bullying, and one-upmanship. If Microsoft represents the Future, we have seen the Future and we think it stinks. Their mindless anti-competitive, anti-consumer, greed-is-everything view of the world is most definitely not to be emulated, and Spaulding and Slye, Polaroid, MIT, ComEnergy and a host of other entities associated with aggressive traffic expansion should simply make a decision that they will lead in another, more responsible and less obnoxious direction – with or without the leadership of the Chamber of Commerce.

I believe that executives riding in the same car would be a good thing for modern corporate culture and communication. Among the denizens of DilbertLand who spend their days locked into the isolation of their cubicles, a little companionship might be a good thing. And if the net benefit is less damage to the local community and less congestion, so that they all spend less time stuck in traffic, how could they not say yes?

## 7 Conclusions

We should not be surprised by the evidence that a severely congested area of Cambridgeport will be even more congested in the future, with longer queues. The lessons for the Planning Board are very clear : 784 Memorial Drive is a classic example *overzoned* parcels located in the middle of traffic congestion. Conventional zoning provides us with no protection from the traffic consequences.

This project for developing on a C-3 parcel with less than as-of-right intensity demonstrates how *floor-area-ratios* are inadequate measures for limiting the intensity of

development. The IPOP procedures allow the Planning Board to appreciate the traffic impacts from intense development, the need for traffic mitigation (including smaller parking garages), and the extent to which land development is traffic-limited, not FAR limited, in most areas of Cambridge.

Our on-going IPOP review process is a learning experience, not only in how to deal with the traffic impacts of large projects but also to plan for the period after IPOP expires in October of this year. The inability of developers to provide adequate traffic mitigation (although the 784 Memorial developers have achieved *some* mitigation) and the timidity of the political forces within the city to prevent the worsening of the traffic situation should be a lesson to us all.

The purpose of the IPOP Ordinance is remarkably specific with respect to traffic : to "guarantee that the city infrastructure can support potential increases in traffic." This goal is far more exacting and specific even that the very tough finding of "no substantial adverse impact on city traffic." No one has dealt with the problem of how do we deal with developers if there is insufficient traffic infrastructure to handle their traffic increases. The Planning Board has not dealt at all with that question.

If the problem were inadequate sewer systems, the answer would be obvious – the public health officials would step in and impose a sewer ban until the sewer capacity problem was resolved. In recent decades, fewer local governments have been willing to make such sacrifices and surrender the benefits of lucrative development, so it has usually been the state DEP or Federal EPA which have stepped in to impose sewer bans. The traffic analogy here would be the MassHighway Department or the MDC holding up City building permits because of inadequate traffic capacity in the Cambridge street system.

The obligations for specifying mitigation all too often are dependent on the approval of the developers. For this reason, too much mitigation is either fluff or is only partially effective. If someone spilled a truckload of gravel in the middle of Harvard Square, would we find it acceptable if those responsible only cleared up 5% of the spill? Yet we regularly accept such traffic "mitigation" claims from developers.

The incentive for the developers is to save money by doing minimal mitigation and to pass the traffic burdens from the private sphere (the parking garage) onto the public entities (City of Cambridge or the MDC) through what I not very graciously term a

dumping operation. Economists employ a more sophisticated terminology -- "externalizing the costs." Simply put, one party simply dumps the burdens onto someone else, in this case the public. Under no circumstances should such uncontrolled and unmitigated dumping be allowed to occur -- whether it is sewerage or traffic.

The single largest problem for the developer of 784 Memorial Drive is the unassailable evidence of severe queuing impacts, and a site which is virtually inaccessible in the PM peak hour. The queuing impacts should also be of primary concern to the Planning Board in assess their IPOP obligations. On the basis of the evidence, the queuing impacts alone should constitute a substantial adverse impact on traffic and represent an unreasonable disruption of the daily activities of the Cambridgeport neighborhood.

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# Appendices

A. CALCULATIONS OF QUEUE LENGTHS

B. IPOP ORDINANCE and CRITERIA

C. CNI MITIGATION PROPOSALS from September 1997

D. JOINT SIGNAL TIMING PROPOSALS TO THE MDC

E. SIGNAL WARRANT ANALYSIS at Pleasant Street

## LENGTH OF PEAK HOUR QUEUES and IPOP Compliance : 784 Memorial Drive

| | Queues on CambridgePort Streets : | | | AM MORNING PEAK HOUR NUMBER OF CARS | | | AM LENGTH OF QUEUE | | | IPOP Criteria | This Project | Comply with IPOP? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Traffic Queue* | Direction | *Starting At :* | Existing | No Build | BUILD | Existing | No Build | BUILD | QUEUE GROWTH LIMITS | | |
| Unsignal | Memorial Drive | *Northbound* | Pleasant Street | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 12.0 | 0.0 | OK |
| Unsignal | Memorial Drive | *Southbound* | Pleasant Street | 0.0 | 0.1 | 1.0 | 0 | 3 | 25 | 12.0 | 0.9 | OK |
| Unsignal | Pleasant Street | *Westbound* | Memorial Drive | 26.8 | 34.8 | 46.1 | 670 | 870 | 1153 | 6.0 | 11.3 | Violation |
| | Memorial Drive | *Northbound* | River Street | 92.1 | 80.3 | 82.0 | 1210 | 1050 | 1080 | 12.0 | 1.7 | OK |
| | Memorial Drive | *Southbound* | River Street | 85.9 | 106.7 | 117.4 | 1130 | 1400 | 1540 | 12.0 | 10.7 | OK |
| | River Street | *Eastbound* | Memorial Drive | 99.6 | 144.4 | 162.9 | 910 | 1320 | 1490 | 18.0 | 18.5 | Violation |
| | Memorial Drive | *Northbound* | Western Avenue | 33.0 | 37.6 | 37.3 | 820 | 940 | 930 | 12.0 | -0.3 | OK |
| | Memorial Drive | *Southbound* | Western Avenue | 52.8 | 59.2 | 63.7 | 690 | 780 | 840 | 12.0 | 4.5 | OK |
| | Western Avenue | *Westbound* | Memorial Drive | 44.8 | 54.1 | 55.2 | 310 | 370 | 380 | 24.0 | 1.1 | OK |
| Unsignal | Pleasant Street | *Eastbound* | Site Drive/Florence | 0.0 | 0.0 | 0.4 | 0 | 0 | 10 | 6.0 | 0.4 | OK |
| Unsignal | Pleasant Street | *Westbound* | Site Drive/Florence | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 6.0 | 0.0 | OK |
| Unsignal | Site Drive | *Southbound* | Pleasant Street | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 6.0 | 0.0 | OK |
| Unsignal | Pleasant Street | *Eastbound* | Putnam Avenue | 0.2 | 0.4 | 0.4 | 5 | 10 | 10 | 6.0 | 0.0 | OK |
| Unsignal | Putnam Avenue | *Northbound* | Pleasant Street | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 6.0 | 0.0 | OK |
| Unsignal | Putnam Avenue | *Southbound* | Pleasant Street | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 6.0 | 0.0 | OK |
| Unsignal | Putnam Avenue | *Northbound* | Site Driveway | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 6.0 | 0.0 | OK |
| Unsignal | Putnam Avenue | *Southbound* | Site Driveway | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 6.0 | 0.0 | OK |
| Unsignal | Site Driveway | *Eastbound* | Putnam Avenue | 0.0 | 0.2 | 0.8 | 0 | 5 | 20 | 6.0 | 0.6 | OK |
| | Putnam Avenue | *Northbound* | River Street | 7.7 | 10.4 | 11.1 | 190 | 260 | 280 | 6.0 | 0.7 | OK |
| | Putnam Avenue | *Southbound* | River Street | 10.3 | 11.7 | 13.2 | 260 | 290 | 330 | 6.0 | 1.5 | OK |
| | River Street | *Eastbound* | Putnam Avenue | 39.0 | 72.3 | 89.3 | 510 | 950 | 1170 | 12.0 | 17.0 | Violation |
| | Putnam Avenue | *Northbound* | Western Avenue | 10.9 | 13.8 | 14.4 | 270 | 340 | 360 | 6.0 | 0.6 | OK |
| | Putnam Avenue | *Southbound* | Western Avenue | 14.5 | 15.6 | 15.6 | 360 | 390 | 390 | 6.0 | 0.0 | OK |
| | Western Avenue | *Westbound* | Putnam Avenue | 34.7 | 41.2 | 42.3 | 460 | 540 | 560 | 12.0 | 1.1 | OK |

AM AM AM AM

S. Kaiser February 23, 1999

**Total Violations : 3**

*NOTE :* Of the 8 intersections shown, four are signalized and four are unsignalized.
In all cases, the 95th percentile queues are shown. With signalized intersections, the queuing period is for the busiest 15-minutes of the peak hour, while for unsignalized intersections the queuing period is for the peak hour (60 minutes).

# LENGTH OF PEAK HOUR QUEUES and IPOP Compliance : 784 Memorial Drive

PM

| | Queues on CambridgePort Streets : | | | PM NUMBER OF CARS | MORNING PEAK HOUR NUMBER OF CARS | | PM LENGTH OF QUEUE | MORNING PEAK HOUR LENGTH OF QUEUE | | IPOP Criteria | This Project | Comply with IPOP? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Traffic Queue* | Direction | *Starting At :* | Existing | No Build | BUILD | Existing | No Build | BUILD | QUEUE GROWTH LIMITS | | |
| Unsignal | Memorial Drive | *Northbound* | Pleasant Street | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 12.0 | 0.0 | OK |
| Unsignal | Memorial Drive | *Southbound* | Pleasant Street | 0.2 | 0.4 | 0.6 | 5 | 10 | 15 | 12.0 | 0.2 | OK |
| Unsignal | Pleasant Street | *Westbound* | Memorial Drive | 5.1 | 45.4 | 105.7 | 128 | 1135 | 2643 | 6.0 | 60.3 | Violation |
| | Memorial Drive | *Northbound* | River Street | 118.1 | 145.4 | 160.2 | 1550 | 1910 | 2100 | 12.0 | 14.8 | Violation |
| | Memorial Drive | *Southbound* | River Street | 44.8 | 50.0 | 50.8 | 590 | 660 | 670 | 12.0 | 0.8 | OK |
| | River Street | *Eastbound* | Memorial Drive | 96.1 | 111.3 | 112.7 | 880 | 1020 | 1030 | 18.0 | 1.4 | OK |
| | Memorial Drive | *Northbound* | Western Avenue | 43.9 | 50.1 | 59.7 | 1100 | 1250 | 1250 | 12.0 | 9.6 | OK |
| | Memorial Drive | *Southbound* | Western Avenue | 49.6 | 60.2 | 62.1 | 650 | 790 | 820 | 12.0 | 1.9 | OK |
| | Western Avenue | *Westbound* | Memorial Drive | 53.2 | 77.5 | 82.9 | 370 | 530 | 570 | 24.0 | 5.4 | OK |
| Unsignal | Pleasant Street | *Eastbound* | Site Drive/Florence | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 6.0 | 0.0 | OK |
| Unsignal | Pleasant Street | *Westbound* | Site Drive/Florence | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 6.0 | 0.0 | OK |
| Unsignal | Site Drive | *Southbound* | Pleasant Street | 0.0 | 0.0 | 0.5 | 0 | 0 | 13 | 6.0 | 0.5 | OK |
| Unsignal | Pleasant Street | *Eastbound* | Putnam Avenue | 5.5 | 21.6 | 35.2 | 138 | 540 | 880 | 6.0 | 13.6 | Violation |
| Unsignal | Putnam Avenue | *Northbound* | Pleasant Street | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 6.0 | 0.0 | OK |
| Unsignal | Putnam Avenue | *Southbound* | Pleasant Street | 0.0 | 0.0 | 0.3 | 0 | 0 | 8 | 6.0 | 0.3 | OK |
| Unsignal | Putnam Avenue | *Northbound* | Site Driveway | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 6.0 | 0.0 | OK |
| Unsignal | Putnam Avenue | *Southbound* | Site Driveway | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 6.0 | 0.0 | OK |
| Unsignal | Site Driveway | *Eastbound* | Putnam Avenue | 0.2 | 0.8 | 15.4 | 5 | 20 | 385 | 6.0 | 14.6 | Violation |
| | Putnam Avenue | *Northbound* | River Street | 25.1 | 60.5 | 79.6 | 630 | 1510 | 1990 | 6.0 | 19.1 | Violation |
| | Putnam Avenue | *Southbound* | River Street | 11.3 | 12.8 | 13.1 | 280 | 320 | 330 | 6.0 | 0.3 | OK |
| | River Street | *Eastbound* | Putnam Avenue | 42.5 | 52.5 | 54.4 | 560 | 690 | 710 | 12.0 | 1.9 | OK |
| | Putnam Avenue | *Northbound* | Western Avenue | 33.0 | 74.7 | 94.5 | 830 | 1870 | 2360 | 6.0 | 19.8 | Violation |
| | Putnam Avenue | *Southbound* | Western Avenue | 15.5 | 17.6 | 17.6 | 390 | 440 | 440 | 6.0 | 0.0 | OK |
| | Western Avenue | *Westbound* | Putnam Avenue | 32.0 | 47.2 | 47.6 | 420 | 620 | 620 | 12.0 | 0.4 | OK |

PM PM

PM

S. Kaiser February 23, 1999

**Total Violations : 6**

PM

*NOTE :* Of the 8 intersections shown, four are signalized and four are unsignalized.
In all cases, the 95th percentile queues are shown. With signalized intersections, the queuing period is for the busiest 15-minutes of the peak hour, while for unsignalized intersections the queuing period is for the peak hour (60 minutes).

AM

# QUEUE LENGTH ANALYSIS

Based on MassHighway Spreadsheet Template 1996

Results Rounded to 2-Place Accuracy

Time Period Tp added by S. Kaiser February 1999

AM

| | |
|---|---|
| ANALYST | S. Kaiser |
| CHECKED BY : | SHK |
| PROJECT: | 784 Memorial Drive Development |
| LOCATION: | River Street and Memorial Drive |
| SCENARIO: | Weekday AM Peak Hour - existing 1997 |
| FILE: | W92 River & Memorial 1997 AM PEAK |
| DATE: | February 19, 1999 |

INPUT PARAMETERS

| | | |
|---|---|---|
| Time Period Tp = | 0.25 | hours |
| Cycle Length = | 140 | sec. |
| Veh. Spacing = | 25 | (ft.) |
| Units : English (E) Metric (M) = | E | |

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 1832 | 3 | 0.95 | 5232 | 2242 | 0.37 | 60 | 0.81 |
| NB TR | 1314 | 2 | 0.95 | 3150 | 1328 | 0.44 | 59 | 0.91 |
| SB L | 1365 | 2 | 0.95 | 2752 | 1455 | 0.52 | 74 | 0.91 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.98 | 0.86 | 0.0 | 71.0 | 71.0 | 99.6 | 650 | 910 |
| NB TR | 0.88 | 1.04 | 8.6 | 57.0 | 65.6 | 92.1 | 860 | 1210 |
| SB L | 0.90 | 0.99 | 2.1 | 59.0 | 61.1 | 85.9 | 800 | 1130 |

| | |
|---|---|
| PROJECT: | 784 Memorial Drive Development |
| LOCATION: | River Street and Memorial Drive |
| SCENARIO: | Weekday AM Peak Hour - Year 2002 NoBuild |
| FILE: | W92 River & Memorial 1997 AM PEAK |
| DATE: | February 19, 1999 |

INPUT PARAMETERS

| | | |
|---|---|---|
| Time Period Tp = | 0.25 | hours |
| Cycle Length = | 140 | sec. |
| Veh. Spacing = | 25 | (ft.) |
| Units : English (E) Metric (M) = | E | |

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 2199 | 3 | 0.95 | 5261 | 2255 | 0.44 | 60 | 0.77 |
| NB TR | 1255 | 2 | 0.95 | 3148 | 1327 | 0.42 | 59 | 0.91 |
| SB L | 1456 | 2 | 0.95 | 2737 | 1447 | 0.56 | 74 | 0.90 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.98 | 1.03 | 8.4 | 94.8 | 103.2 | 144.4 | 950 | 1320 |
| NB TR | 0.88 | 1.00 | 2.9 | 54.1 | 57.0 | 80.3 | 750 | 1050 |
| SB L | 0.90 | 1.06 | 12.1 | 64.1 | 76.1 | 106.7 | 1000 | 1400 |

| | |
|---|---|
| PROJECT: | 784 Memorial Drive Development |
| LOCATION: | River Street and Memorial Drive |
| SCENARIO: | Weekday AM Peak Hour - Year 2002 BUILD |
| FILE: | W92 River & Memorial 1997 AM PEAK |
| DATE: | February 19, 1999 |

INPUT PARAMETERS

| | | |
|---|---|---|
| Time Period Tp = | 0.25 | hours |
| Cycle Length = | 140 | sec. |
| Veh. Spacing = | 25 | (ft.) |
| Units : English (E) Metric (M) = | E | |

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 2279 | 3 | 0.95 | 5275 | 2261 | 0.45 | 60 | 0.77 |
| NB TR | 1264 | 2 | 0.95 | 3148 | 1327 | 0.42 | 59 | 0.91 |
| SB L | 1509 | 2 | 0.95 | 2760 | 1459 | 0.58 | 74 | 0.90 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.98 | 1.06 | 18.0 | 98.4 | 116.3 | 162.9 | 1070 | 1490 |
| NB TR | 0.88 | 1.00 | 3.6 | 54.7 | 58.3 | 82.0 | 760 | 1080 |
| SB L | 0.90 | 1.09 | 17.3 | 66.5 | 83.8 | 117.4 | 1100 | 1540 |

| | | | | | |
|---|---|---|---|---|---|
| EB LTR | Queue Growth = | 18.4 | cars ..... or | 170 | ft |
| NB TR | Queue Growth = | 1.7 | cars ..... or | 30 | ft |
| SB L | Queue Growth = | 10.7 | cars ..... or | 140 | ft |

PM

# QUEUE LENGTH ANALYSIS

Based on MassHighway Spreadsheet Template 1996

Results Rounded to 2-Place Accuracy

Time Period Tp added by S. Kaiser February 1999

PM

| | |
|---|---|
| ANALYST | S. Kaiser |
| CHECKED BY : | SHK |
| PROJECT: | 784 Memorial Drive Development |
| LOCATION: | River Street and Memorial Drive |
| SCENARIO: | Weekday PM Peak Hour - existing 1997 |
| FILE: | W92 River & Memorial 1997 PM PEAK |
| DATE: | February 19, 1999 |

INPUT PARAMETERS

| | | |
|---|---|---|
| Time Period Tp = | 0.25 | hours |
| Cycle Length = | 140 | sec. |
| Veh. Spacing = | 25 | (ft.) |
| Units : English (E) Metric (M) = | E | |

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 1812 | 3 | 0.95 | 5394 | 2312 | 0.35 | 60 | 0.81 |
| NB TR | 1608 | 2 | 0.95 | 3530 | 1588 | 0.48 | 63 | 0.89 |
| SB L | 915 | 2 | 0.95 | 2480 | 1311 | 0.39 | 74 | 0.94 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.98 | 0.82 | 0.0 | 68.5 | 68.5 | 96.1 | 630 | 880 |
| NB TR | 0.91 | 1.07 | 14.3 | 70.1 | 84.3 | 118.1 | 1110 | 1550 |
| SB L | 0.88 | 0.73 | 0.0 | 30.4 | 30.4 | 44.8 | 400 | 590 |

| | |
|---|---|
| PROJECT: | 784 Memorial Drive Development |
| LOCATION: | River Street and Memorial Drive |
| SCENARIO: | Weekday PM Peak Hour - Year 2002 NoBuild |
| FILE: | W92 River & Memorial 1997 PM PEAK |
| DATE: | February 19, 1999 |

INPUT PARAMETERS

| | | |
|---|---|---|
| Time Period Tp = | 0.25 | hours |
| Cycle Length = | 140 | sec. |
| Veh. Spacing = | 25 | (ft.) |
| Units : English (E) Metric (M) = | E | |

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 1986 | 3 | 0.95 | 5400 | 2314 | 0.39 | 60 | 0.79 |
| NB TR | 1719 | 2 | 0.95 | 3526 | 1587 | 0.51 | 63 | 0.88 |
| SB L | 973 | 2 | 0.95 | 2416 | 1277 | 0.42 | 74 | 0.93 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.98 | 0.90 | 0.0 | 79.5 | 79.5 | 111.3 | 730 | 1020 |
| NB TR | 0.91 | 1.14 | 28.7 | 75.2 | 103.9 | 145.4 | 1360 | 1910 |
| SB L | 0.87 | 0.80 | 0.0 | 34.5 | 34.5 | 50.0 | 450 | 660 |

| | |
|---|---|
| PROJECT: | 784 Memorial Drive Development |
| LOCATION: | River Street and Memorial Drive |
| SCENARIO: | Weekday PM Peak Hour - Year 2002 BUILD |
| FILE: | W92 River & Memorial 1997 PM PEAK |
| DATE: | February 19, 1999 |

INPUT PARAMETERS

| | | |
|---|---|---|
| Time Period Tp = | 0.25 | hours |
| Cycle Length = | 140 | sec. |
| Veh. Spacing = | 25 | (ft.) |
| Units : English (E) Metric (M) = | E | |

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 2001 | 3 | 0.95 | 5402 | 2315 | 0.39 | 60 | 0.79 |
| NB TR | 1779 | 2 | 0.95 | 3527 | 1587 | 0.53 | 63 | 0.88 |
| SB L | 983 | 2 | 0.95 | 2423 | 1281 | 0.43 | 74 | 0.93 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.98 | 0.91 | 0.0 | 80.4 | 80.4 | 112.7 | 740 | 1030 |
| NB TR | 0.91 | 1.18 | 36.5 | 78.0 | 114.5 | 160.2 | 1500 | 2100 |
| SB L | 0.87 | 0.81 | 0.0 | 35.0 | 35.0 | 50.8 | 460 | 670 |

| | | | | | |
|---|---|---|---|---|---|
| EB LTR | Queue Growth = | 1.4 | cars ..... or | 10 | ft |
| NB TR | Queue Growth = | 14.8 | cars ..... or | 190 | ft |
| SB L | Queue Growth = | 0.7 | cars ..... or | 10 | ft |

AM

# QUEUE LENGTH ANALYSIS

Results Rounded to 2-Place Accuracy

**Based on MassHighway Spreadsheet Template 1996**

Time Period Tp added by S. Kaiser
February 1999

AM

ANALYST: S. Kaiser  CHECKED BY : SHK
PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Memorial Drive
SCENARIO: Weekday AM Peak Hour - existing 1997
FILE: W92 Western & Memorial 1997 AM
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 100 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 1064 | 4 | 0.95 | 6804 | 1361 | 0.16 | 20 | 0.88 |
| NB L | 567 | 1 | 1.00 | 1767 | 549 | 0.32 | 31 | 0.87 |
| NB T | 672 | 1 | 0.95 | 1742 | 1289 | 0.41 | 74 | 0.84 |
| SB TR | 1334 | 2 | 0.95 | 3468 | 1630 | 0.40 | 47 | 0.91 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.83 | 0.82 | 0.0 | 30.4 | 30.4 | 44.8 | 210 | 310 |
| NB L | 0.69 | 1.03 | 4.9 | 16.3 | 21.2 | 33.0 | 530 | 820 |
| NB T | 0.82 | 0.55 | 0.0 | 9.0 | 9.0 | 16.5 | 230 | 410 |
| SB TR | 0.86 | 0.86 | 0.0 | 36.6 | 36.6 | 52.8 | 480 | 690 |

PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Memorial Drive
SCENARIO: Weekday AM Peak Hour - Year 2002 NoBuild
FILE: W92 Western & Memorial 1997 AM
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 100 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 1232 | 4 | 0.95 | 6829 | 1366 | 0.19 | 20 | 0.87 |
| NB L | 595 | 1 | 1.00 | 1767 | 549 | 0.34 | 31 | 0.86 |
| NB T | 708 | 1 | 0.95 | 1742 | 1289 | 0.43 | 74 | 0.83 |
| SB TR | 1423 | 2 | 0.95 | 3469 | 1630 | 0.43 | 47 | 0.90 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.83 | 0.95 | 1.2 | 36.4 | 37.6 | 54.1 | 260 | 370 |
| NB L | 0.69 | 1.08 | 7.7 | 17.2 | 24.8 | 37.6 | 620 | 940 |
| NB T | 0.82 | 0.58 | 0.0 | 9.9 | 9.9 | 17.7 | 250 | 440 |
| SB TR | 0.86 | 0.92 | 0.4 | 41.0 | 41.4 | 59.2 | 540 | 780 |

PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Memorial Drive
SCENARIO: Weekday AM Peak Hour - Year 2002 BUILD
FILE: W92 Western & Memorial 1997 AM
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 100 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 1246 | 4 | 0.95 | 6832 | 1366 | 0.19 | 20 | 0.86 |
| NB L | 595 | 1 | 1.00 | 1773 | 551 | 0.34 | 31 | 0.86 |
| NB T | 717 | 1 | 0.95 | 1742 | 1289 | 0.43 | 74 | 0.83 |
| SB TR | 1476 | 2 | 0.95 | 3472 | 1632 | 0.45 | 47 | 0.90 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.83 | 0.96 | 1.5 | 36.9 | 38.4 | 55.2 | 260 | 380 |
| NB L | 0.69 | 1.08 | 7.5 | 17.2 | 24.6 | 37.3 | 620 | 930 |
| NB T | 0.82 | 0.59 | 0.0 | 10.1 | 10.1 | 18.1 | 250 | 450 |
| SB TR | 0.86 | 0.95 | 1.0 | 43.8 | 44.8 | 63.7 | 590 | 840 |

| | | | | | |
|---|---|---|---|---|---|
| WB LTR | Queue Growth = | 1.1 | cars ..... or | 10 | ft |
| NB L | Queue Growth = | -0.3 | cars ..... or | -10 | ft |
| NB T | Queue Growth = | 0.3 | cars ..... or | 10 | ft |
| SB TR | Queue Growth = | 4.5 | cars ..... or | 60 | ft |

PM

# QUEUE LENGTH ANALYSIS

**Based on MassHighway Spreadsheet Template 1996**

Results Rounded to 2-Place Accuracy

Time Period Tp added by S. Kaiser
February 1999

PM

ANALYST: S. Kaiser — CHECKED BY: SHK
PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Memorial Drive
SCENARIO: Weekday PM Peak Hour - existing 1997
FILE: W92 Western & Memorial 1997 PM
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 100 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 1417 | 4 | 0.95 | 6911 | 2212 | 0.22 | 32 | 0.85 |
| NB L | 718 | 1 | 1.00 | 1900 | 661 | 0.38 | 35 | 0.84 |
| NB T | 958 | 1 | 0.96 | 1742 | 1080 | 0.57 | 62 | 0.78 |
| SB TR | 1004 | 2 | 0.95 | 3422 | 1061 | 0.31 | 31 | 0.93 |

AKCELIK METHOD

| Approach | Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.91 | 0.67 | 0.0 | 36.9 | 36.9 | 53.2 | 250 | 370 |
| NB L | 0.72 | 1.09 | 9.0 | 20.8 | 29.8 | 43.9 | 740 | 1100 |
| NB T | 0.79 | 0.92 | 0.9 | 26.2 | 27.1 | 40.5 | 680 | 1010 |
| SB TR | 0.79 | 1.00 | 3.7 | 30.5 | 34.1 | 49.6 | 450 | 650 |

PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Memorial Drive
SCENARIO: Weekday PM Peak Hour - Year 2002 NoBuild
FILE: W92 Western & Memorial 1997 PM
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 100 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 1903 | 4 | 0.95 | 6958 | 2227 | 0.29 | 32 | 0.80 |
| NB L | 754 | 1 | 1.00 | 1900 | 665 | 0.40 | 35 | 0.83 |
| NB T | 1023 | 1 | 0.96 | 1742 | 1080 | 0.61 | 62 | 0.77 |
| SB TR | 1066 | 2 | 0.95 | 3423 | 1061 | 0.33 | 31 | 0.93 |

AKCELIK METHOD

| Approach | Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.91 | 0.90 | 0.0 | 55.0 | 55.0 | 77.5 | 380 | 530 |
| NB L | 0.72 | 1.13 | 12.6 | 21.9 | 34.5 | 50.1 | 860 | 1250 |
| NB T | 0.79 | 0.99 | 3.0 | 30.9 | 33.9 | 49.3 | 850 | 1230 |
| SB TR | 0.79 | 1.06 | 9.7 | 32.5 | 42.2 | 60.2 | 550 | 790 |

PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Memorial Drive
SCENARIO: Weekday PM Peak Hour - Year 2002 BUILD
FILE: W92 Western & Memorial 1997 PM
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 100 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 1992 | 4 | 0.95 | 6966 | 2229 | 0.30 | 32 | 0.79 |
| NB L | 754 | 1 | 1.00 | 1900 | 665 | 0.40 | 35 | 0.83 |
| NB T | 1083 | 1 | 0.96 | 1742 | 1080 | 0.65 | 62 | 0.75 |
| SB TR | 1076 | 2 | 0.95 | 3424 | 1061 | 0.33 | 31 | 0.92 |

AKCELIK METHOD

| Approach | Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.91 | 0.94 | 0.3 | 58.7 | 59.0 | 82.9 | 410 | 570 |
| NB L | 0.72 | 1.13 | 12.6 | 21.9 | 34.5 | 50.1 | 860 | 1250 |
| NB T | 0.79 | 1.04 | 8.3 | 33.5 | 41.8 | 59.7 | 1040 | 1490 |
| SB TR | 0.79 | 1.07 | 10.8 | 32.8 | 43.7 | 62.1 | 570 | 820 |

| | | | | | |
|---|---|---|---|---|---|
| WB LTR | Queue Growth = | 5.5 | cars ..... or | 40 | ft |
| NB L | Queue Growth = | 0.0 | cars ..... or | 0 | ft |
| NB T | Queue Growth = | 10.4 | cars ..... or | 260 | ft |
| SB TR | Queue Growth = | 2.0 | cars ..... or | 30 | ft |

AM

# QUEUE LENGTH ANALYSIS

Results Rounded to 2-Place Accuracy

**Based on MassHighway Spreadsheet Template 1996**

Time Period Tp added by S. Kaiser
February 1999

AM

| | | | |
|---|---|---|---|
| ANALYST | S. Kaiser | CHECKED BY : | SHK |
| PROJECT: | 784 Memorial Drive Development | | |
| LOCATION: | River Street and Putnam Avenue, Cambridge | | |
| SCENARIO: | Weekday AM Peak Hour - 1997 Existing | | |
| FILE: | W92 River & Putnam AM PEAK | | |
| DATE: | February 19, 1999 | | |

INPUT PARAMETERS

| | | |
|---|---|---|
| Time Period Tp = | 0.25 | hours |
| Cycle Length = | 90 | sec. |
| Veh. Spacing = | 25 | (ft.) |
| Units : English (E) Metric (M) = | E | |

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 1026 | 2 | 0.95 | 3155 | 1262 | 0.34 | 36 | 0.93 |
| NB TR | 180 | 1 | 0.95 | 1234 | 425 | 0.15 | 31 | 0.95 |
| SB LT | 234 | 1 | 0.95 | 1232 | 424 | 0.20 | 31 | 0.94 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.80 | 0.86 | 0.2 | 25.7 | 26.0 | 39.0 | 340 | 510 |
| NB TR | 0.64 | 0.45 | 0.0 | 3.7 | 3.7 | 7.7 | 90 | 190 |
| SB LT | 0.64 | 0.58 | 0.0 | 5.2 | 5.2 | 10.3 | 130 | 260 |

| | | | |
|---|---|---|---|
| PROJECT: | 784 Memorial Drive Development | | |
| LOCATION: | River Street and Putnam Avenue, Cambridge | | |
| SCENARIO: | Weekday AM Peak Hour - Future NoBuild | | |
| FILE: | W92 River & Putnam AM PEAK | | |
| DATE: | February 19, 1999 | | |

INPUT PARAMETERS

| | | |
|---|---|---|
| Time Period Tp = | 0.25 | hours |
| Cycle Length = | 90 | sec. |
| Veh. Spacing = | 25 | (ft.) |
| Units : English (E) Metric (M) = | E | |

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 1295 | 2 | 0.95 | 3137 | 1255 | 0.43 | 36 | 0.91 |
| NB TR | 237 | 1 | 0.95 | 1236 | 426 | 0.20 | 31 | 0.94 |
| SB LT | 262 | 1 | 0.95 | 1230 | 424 | 0.22 | 31 | 0.93 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.80 | 1.09 | 15.2 | 36.0 | 51.1 | 72.3 | 670 | 950 |
| NB TR | 0.64 | 0.59 | 0.0 | 5.2 | 5.2 | 10.4 | 130 | 260 |
| SB LT | 0.64 | 0.65 | 0.0 | 6.0 | 6.0 | 11.7 | 150 | 290 |

| | | | |
|---|---|---|---|
| PROJECT: | 784 Memorial Drive Development | | |
| LOCATION: | River Street and Putnam Avenue, Cambridge | | |
| SCENARIO: | Weekday AM Peak Hour - Future BUILD | | |
| FILE: | W92 River & Putnam AM PEAK | | |
| DATE: | February 19, 1999 | | |

INPUT PARAMETERS

| | | |
|---|---|---|
| Time Period Tp = | 0.25 | hours |
| Cycle Length = | 90 | sec. |
| Veh. Spacing = | 25 | (ft.) |
| Units : English (E) Metric (M) = | E | |

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 1375 | 2 | 0.95 | 3137 | 1255 | 0.46 | 36 | 0.90 |
| NB TR | 251 | 1 | 0.95 | 1236 | 426 | 0.21 | 31 | 0.94 |
| SB LT | 288 | 1 | 0.95 | 1230 | 424 | 0.25 | 31 | 0.93 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.80 | 1.15 | 25.3 | 38.3 | 63.6 | 89.3 | 830 | 1170 |
| NB TR | 0.64 | 0.62 | 0.0 | 5.6 | 5.6 | 11.1 | 140 | 280 |
| SB LT | 0.64 | 0.71 | 0.1 | 6.8 | 6.9 | 13.2 | 170 | 330 |

| | | | | | |
|---|---|---|---|---|---|
| EB LTR | Queue Growth = | 17.0 | cars ..... or | 220 | ft |
| NB TR | Queue Growth = | 0.7 | cars ..... or | 20 | ft |
| SB LT | Queue Growth = | 1.5 | cars ..... or | 40 | ft |

PM

# QUEUE LENGTH ANALYSIS

Based on MassHighway Spreadsheet Template 1996

Results Rounded to 2-Place Accuracy

Time Period Tp added by S. Kaiser February 1999

PM

ANALYST: S. Kaiser CHECKED BY : SHK
PROJECT: 784 Memorial Drive Development
LOCATION: River Street and Putnam Avenue, Cambridge
SCENARIO: Weekday PM Peak Hour - 1997 Existing
FILE: W92 River & Putnam PM PEAK
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 90 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 1132 | 2 | 0.95 | 3464 | 1386 | 0.34 | 36 | 0.92 |
| NB TR | 521 | 1 | 0.95 | 1714 | 590 | 0.32 | 31 | 0.87 |
| SB LT | 262 | 1 | 0.95 | 1398 | 482 | 0.20 | 31 | 0.93 |

AKCELIK METHOD

| Approach | Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.81 | 0.86 | 0.2 | 28.5 | 28.7 | 42.5 | 380 | 560 |
| NB TR | 0.69 | 0.93 | 1.5 | 13.7 | 15.2 | 25.1 | 380 | 630 |
| SB LT | 0.66 | 0.57 | 0.0 | 5.8 | 5.8 | 11.3 | 140 | 280 |

PROJECT: 784 Memorial Drive Development
LOCATION: River Street and Putnam Avenue, Cambridge
SCENARIO: Weekday PM Peak Hour - Future NoBuild
FILE: W92 River & Putnam PM PEAK
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 90 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 1272 | 2 | 0.95 | 3457 | 1383 | 0.39 | 36 | 0.91 |
| NB TR | 724 | 1 | 0.95 | 1717 | 591 | 0.44 | 31 | 0.83 |
| SB LT | 295 | 1 | 0.95 | 1398 | 482 | 0.22 | 31 | 0.93 |

AKCELIK METHOD

| Approach | Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.81 | 0.97 | 2.0 | 34.4 | 36.4 | 52.5 | 480 | 690 |
| NB TR | 0.69 | 1.29 | 22.5 | 20.0 | 42.4 | 60.5 | 1060 | 1510 |
| SB LT | 0.66 | 0.64 | 0.0 | 6.7 | 6.7 | 12.8 | 170 | 320 |

PROJECT: 784 Memorial Drive Development
LOCATION: River Street and Putnam Avenue, Cambridge
SCENARIO: Weekday PM Peak Hour - Future BUILD
FILE: W92 River & Putnam PM PEAK
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 90 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 1287 | 2 | 0.95 | 3452 | 1381 | 0.39 | 36 | 0.91 |
| NB TR | 814 | 1 | 0.95 | 1719 | 592 | 0.50 | 31 | 0.81 |
| SB LT | 301 | 1 | 0.95 | 1398 | 482 | 0.23 | 31 | 0.92 |

AKCELIK METHOD

| Approach | Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| EB LTR | 0.81 | 0.98 | 2.7 | 35.1 | 37.8 | 54.4 | 500 | 710 |
| NB TR | 0.69 | 1.45 | 34.0 | 22.5 | 56.6 | 79.6 | 1410 | 1990 |
| SB LT | 0.66 | 0.66 | 0.0 | 6.9 | 6.9 | 13.1 | 170 | 330 |

| | | | | | |
|---|---|---|---|---|---|
| EB LTR | Queue Growth = | 1.9 | cars ..... or | 20 | ft |
| NB TR | Queue Growth = | 19.1 | cars ..... or | 480 | ft |
| SB LT | Queue Growth = | 0.3 | cars ..... or | 10 | ft |

AM

# QUEUE LENGTH ANALYSIS

Results Rounded to 2-Place Accuracy

**Based on MassHighway Spreadsheet Template 1996**

Time Period Tp added by S. Kaiser
February 1999

AM

ANALYST: S. Kaiser CHECKED BY : SHK
PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Putnam Ave, Cambridge
SCENARIO: Weekday AM Peak Hour - 1997 Existing
FILE: W92 Western & Putnam AM PEAK
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 90 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 981 | 2 | 0.95 | 3581 | 1432 | 0.29 | 36 | 0.93 |
| NB LT | 260 | 1 | 0.95 | 1585 | 546 | 0.17 | 31 | 0.93 |
| SB TR | 335 | 1 | 0.95 | 1513 | 521 | 0.23 | 31 | 0.92 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.82 | 0.72 | 0.0 | 22.6 | 22.6 | 34.7 | 300 | 460 |
| NB LT | 0.67 | 0.50 | 0.0 | 5.5 | 5.5 | 10.9 | 140 | 270 |
| SB TR | 0.67 | 0.68 | 0.0 | 7.7 | 7.8 | 14.5 | 190 | 360 |

PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Putnam Ave, Cambridge
SCENARIO: Weekday AM Peak Hour - Future NoBuild
FILE: W92 Western & Putnam AM PEAK
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 90 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 1117 | 2 | 0.95 | 3578 | 1413 | 0.33 | 36 | 0.92 |
| NB LT | 323 | 1 | 0.95 | 1585 | 546 | 0.21 | 31 | 0.92 |
| SB TR | 355 | 1 | 0.95 | 1513 | 521 | 0.25 | 31 | 0.91 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.82 | 0.83 | 0.1 | 27.6 | 27.7 | 41.2 | 360 | 540 |
| NB LT | 0.67 | 0.62 | 0.0 | 7.3 | 7.3 | 13.8 | 180 | 340 |
| SB TR | 0.67 | 0.72 | 0.1 | 8.4 | 8.5 | 15.6 | 210 | 390 |

PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Putnam Ave, Cambridge
SCENARIO: Weekday AM Peak Hour - Future BUILD
FILE: W92 Western & Putnam AM PEAK
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 90 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 1143 | 2 | 0.95 | 3566 | 1426 | 0.34 | 36 | 0.92 |
| NB LT | 337 | 1 | 0.95 | 1585 | 546 | 0.22 | 31 | 0.92 |
| SB TR | 355 | 1 | 0.95 | 1513 | 521 | 0.25 | 31 | 0.91 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.82 | 0.84 | 0.1 | 28.5 | 28.5 | 42.3 | 370 | 560 |
| NB LT | 0.67 | 0.65 | 0.0 | 7.7 | 7.7 | 14.4 | 190 | 360 |
| SB TR | 0.67 | 0.72 | 0.1 | 8.4 | 8.5 | 15.6 | 210 | 390 |

| | | | | | |
|---|---|---|---|---|---|
| WB LTR | Queue Growth = | 1.1 | cars ..... or | 20 | ft |
| NB LT | Queue Growth = | 0.7 | cars ..... or | 20 | ft |
| SB TR | Queue Growth = | 0.0 | cars ..... or | 0 | ft |

PM

# QUEUE LENGTH ANALYSIS

Based on MassHighway Spreadsheet Template 1996

Results Rounded to 2-Place Accuracy

Time Period Tp added by S. Kaiser February 1999

PM

ANALYST: S. Kaiser CHECKED BY : SHK
PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Putnam Ave, Cambridge
SCENARIO: Weekday PM Peak Hour - 1997 Existing
FILE: W92 Western & Putnam PM PEAK
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 90 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 944 | 2 | 0.96 | 3855 | 1542 | 0.26 | 36 | 0.93 |
| NB LT | 570 | 1 | 0.95 | 1669 | 575 | 0.36 | 31 | 0.86 |
| SB TR | 366 | 1 | 0.95 | 1717 | 591 | 0.22 | 31 | 0.91 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.83 | 0.64 | 0.0 | 20.5 | 20.5 | 32.0 | 270 | 420 |
| NB LT | 0.68 | 1.04 | 5.7 | 15.6 | 21.3 | 33.0 | 530 | 830 |
| SB TR | 0.69 | 0.65 | 0.0 | 8.4 | 8.4 | 15.5 | 210 | 390 |

PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Putnam Ave, Cambridge
SCENARIO: Weekday PM Peak Hour - Future NoBuild
FILE: W92 Western & Putnam PM PEAK
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 90 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 1256 | 2 | 0.96 | 3665 | 1466 | 0.36 | 36 | 0.91 |
| NB LT | 778 | 1 | 0.95 | 1669 | 575 | 0.49 | 31 | 0.81 |
| SB TR | 393 | 1 | 0.95 | 1550 | 534 | 0.27 | 31 | 0.90 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.82 | 0.89 | 0.4 | 31.9 | 32.3 | 47.2 | 420 | 620 |
| NB LT | 0.68 | 1.42 | 31.4 | 21.5 | 53.0 | 74.7 | 1320 | 1870 |
| SB TR | 0.67 | 0.77 | 0.2 | 9.5 | 9.8 | 17.6 | 240 | 440 |

PROJECT: 784 Memorial Drive Development
LOCATION: Western Avenue and Putnam Ave, Cambridge
SCENARIO: Weekday PM Peak Hour - Future BUILD
FILE: W92 Western & Putnam PM PEAK
DATE: February 19, 1999

INPUT PARAMETERS
Time Period Tp = 0.25 hours
Cycle Length = 90 sec.
Veh. Spacing = 25 (ft.)
Units : English (E) Metric (M) = E

| Approach | qe Lane Group Vol. (vph) | L Number Lanes | PHF Peak Hour Factor | S Saturation Flow | Qe Capacity (vph) | Flow Ratio (qe/S) | Ge Effective Green (sec.) | Unbunched Lane Factor |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 1262 | 2 | 0.96 | 3663 | 1465 | 0.36 | 36 | 0.91 |
| NB LT | 868 | 1 | 0.95 | 1669 | 575 | 0.55 | 31 | 0.80 |
| SB TR | 393 | 1 | 0.95 | 1550 | 534 | 0.27 | 31 | 0.90 |

| Approach | AKCELIK METHOD Eq. Xo | Eq. X | Eq. No (veh.) | Eq. Nu (veh.) | Max. Back of Queue Nb (veh.) | 95th% Queue (veh.) | Average QueueLength Per Lane (ft.) | 95th% QueueLength Per Lane (ft.) |
|---|---|---|---|---|---|---|---|---|
| WB LTR | 0.82 | 0.90 | 0.4 | 32.2 | 32.6 | 47.6 | 430 | 620 |
| NB LT | 0.68 | 1.59 | 43.2 | 24.1 | 67.3 | 94.5 | 1680 | 2360 |
| SB TR | 0.67 | 0.77 | 0.2 | 9.5 | 9.8 | 17.6 | 240 | 440 |

| | | | | | |
|---|---|---|---|---|---|
| WB LTR | Queue Growth = | 0.4 | cars ..... or | 0 | ft |
| NB LT | Queue Growth = | 19.7 | cars ..... or | 490 | ft |
| SB TR | Queue Growth = | 0.0 | cars ..... or | 0 | ft |

ORDINANCE #1209

Final Publication Number 2806. First Publication in the Chronicle on July 30, 1998.

# City of Cambridge

In the Year One Thousand, Nine Hundred Ninety Eight.

## AN ORDINANCE

In amendment to the "Zoning Ordinance" of the City of Cambridge.

*Be it ordained by the City Council of the City of Cambridge as follows:*

Amend the text of the Zoning Ordinance of the City of Cambridge by adding the following Section 11.500:

11.500 PLANNING OVERLAY REQUIREMENTS

Purpose. The purpose of this section is to provide temporarily for the review of large-scale development in order to ensure conformance with the Cambridge Growth Policy Document, 'Towards a Sustainable Future' and guarantee that the city infrastructure can support potential increases in traffic.

11.501 Term of Effect. The provisions of this Section 11.500 apply to any building permit granted between Wednesday, July 1, 1998, and Friday, October 1, 1999, inclusive.

11.502 Applicability. The provisions of this Section 11.500 apply to all new construction of 50,000 square feet or more gross floor area; and to all renovations and rehabilitations of 50,000 square feet or more gross floor area involving a change of category of use, such categories being defined as those numbered and bolded in Section 4.30 of this Ordinance. The provisions of this section also apply to any project that will bring the total construction on the lot, or any abutting lot or lots that are or have been in common ownership at any time since May 1, 1998, to 50,000 square feet or more gross floor area during the effective period of this section. This section shall not apply to any housing projects with a substantial component of affordable units (defined as more than 25% of units affordable by households making 110% or less of median income). The provisions of this section apply to all zoning districts in the city without exception.

11.510 The Planning Overlay Special Permit

11.511 A Planning Overlay Special Permit shall be required from the Planning Board for all projects subject to this Section 11.502. The Planning Board may request reports from the Community Development Department, Conservation Commission, Historical Commission or other pertinent boards and commissions regarding compliance with Growth Policies 13, 27, 39 and 66 as set forth in Section 11.512. Before a building permit for a project to which paragraph 11.502 applies can be issued, the project must receive a "Planning Overlay Special Permit." No application for this permit will be accepted unless it is accompanied, at a minimum, by the following documents:

(a) the information required by the Large Project Submittal Requirements as described in paragraph 11.45 of this Ordinance.

(b) a traffic study certified as being done in a complete and reliable manner by the Traffic and Parking Department. The required traffic study shall include information on Parking Transportation Demand Management measures which may mitigate projected traffic impacts. Such certification must be issued or denied within ten (10) days of the request and must only certify the methodology used, not necessarily the accuracy of the data.

(c) a certification from the Superintendent of Buildings that all other special permits and variances required for the issuance of a building permit have been granted.

11.512 Criteria for Special Permit.

(a) In granting a planning overlay special permit the Planning Board will ensure that the project conforms with the following growth policies as set forth in the Cambridge Growth Policy Document, "Towards a Sustainable Future":

Growth Policy #13. A pace of development or redevelopment should be encouraged that permits the maintenance of a healthy tax base, allows for adjustment and adaptation to changing economic conditions, and is consistent with the City's urban design and other physical development objectives yet does not unreasonably disrupt the daily activities of the city's neighborhoods and residents or overburden the city's water and sewer infrastructure.

**Growth Policy #27.** Where possible, construct new affordable housing that fits neighborhood character. In existing residential neighborhoods housing should be built at a scale, density, and character consistent with existing development patterns. Permit reconstruction of affordable housing (defined as more than 50% of units rented or owned by households at 80% or less than median income) that serves a wide range of incomes and groups at previous non-conforming density where reconstruction is less expensive than rehabilitation. Emphasize construction of affordable housing designed for families with children.

**Growth Policy #39.** Development patterns in all non-residential areas must be planned to minimize negative impact on abutting residential neighborhoods.

**Growth Policy #66.** New open space facilities, including larger ones for organized activities, should be considered for those private developments where the size of the development, the amount of land area and/or the ownership patterns provide the flexibility to accommodate such a facility without loss of economic value for other uses.

(b) Additionally, the Planning Board shall, before issuing a special permit, find that the project will have no substantial adverse impact on city traffic. In determining whether there is a substantial adverse impact, the Planning Board shall apply criteria for measuring traffic impact based on the best available measures of traffic volumes and level of service, as recommended by the Traffic, Transportation and Parking Department. These criteria shall be updated as new data on existing traffic volumes and level of service are compiled.

11.513 Enforcement. The Superintendent of Buildings will require certification from the Planning Board that it has issued a special permit to the applicant to which paragraph 11.502 applies before issuing a building permit to that applicant.

11.514 Expiration. A Planning Overlay Special Permit will expire after one (1) year if construction on the project has not begun and no extension has been granted by the Planning Board. Such extension may only be granted for good cause. If expiration takes place the Superintendent of Buildings will revoke any building permit granted under the special permit effective the date of expiration.

In City Council September 28, 1998.
Passed to be ordained as amended
by a yea and nay vote:-
Yeas 8; Nays 1; Absent 0.

ATTEST:-

D. Margaret Drury

## Criteria to Guide Project Evaluation

The following measures of impact shall be considered by the Planning Board as they evaluate projects with respect to traffic and when exceeded, will be indicative of substantial impact. In addition, the Planning Board may consider any additional mitigation efforts and other supplemental information which addresses efforts by the proponent to limit traffic impacts and which the Board may use in making its determination.

### *1. Project Vehicle Trip Generation*

Project based trip generation in excess of:
2,000 weekday or weekend (24-hour)
240 peak hour (A.M., P.M. or Saturday midday)

### *2. Traffic on Residential Streets*

| | Current Peak Hour Street Volume (two-way vehicles) | | |
|---|---|---|---|
| Amount of Residential | < 150 | 150 – 400 | > 400 |
| 1/2 or more | 20 | 30 | 40 |
| >1/3 but <1/2 | 30 | 45 | 60 |
| 1/3 or less | no max | no max | no max |

Notes:
1. Amount of residential for each adjacent two blocks and determined by first floor frontage.
2. Additional project vehicle trip generation in vehicles per lane.

### *3. Level of Service (LOS)*

| | Existing | With Project |
|---|---|---|
| Level of Service | A | C or better |
| | B | D or better |
| | C | D or better |
| | D | D or 7% volume increase, whichever is greater |
| | E | 7% volume increase maximum |
| | F | 5% volume increase maximum |

### *4. Lane Queue*

| Existing | With Project |
|---|---|
| Under 15 vehicles | Under 15 vehicles or increase of 6 vehicles maximum, whichever is greater |
| 15 or more vehicles | Increase of 6 vehicles maximum |

### *5. Traffic Accidents*

If 5 or more per year average, developer must propose mitigation to reduce the accident rate.

Stephen H. Kaiser
191 Hamilton Street
Cambridge, Mass. 02139

To : Cambridgeport Neighborhood Initiative
Cambridge Community Development Department
Traffic Consultant : Rizzo Associates
Spaulding and Slye
Traffic Consultant : Vanasse Associates

From : Stephen Kaiser , Traffic Engineer, CNI

*SUBJECT:* **Existing Traffic Mitigation Potentials**
**Memorial Drive at River and Western**



## 1.0 FOUR INTERSECTIONS AT RIVER AND WESTERN

This preliminary report considers the traffic flow at four MDC traffic signals at River Street and Western Avenue for existing peak PM traffic operations. The goal is to identify possible traffic mitigation for safety and efficiency :

1. Soldiers Field Road and Western Avenue (HBS) - now 3 phase, 100-second cycle
2. Memorial Drive and Western Avenue - now 3 phase, 100-second cycle
3. Memorial Drive and River Street - now 2 phase with lead, 140-second cycle
4. Soldiers Field Road and Cambridge St./Turnpike - 4 phase, 140-second cycle

(Intersection #1 above is a new addition to the CNI scope, and like #4 is located in Boston. )

Historically, these intersections have been major congestion points. Memorial Drive was constructed c.1920, with the River and Western Avenue Bridges being of 1925 to 1930 vintage. Soldiers Field Road and the underpasses were constructed about 1960, and the turnpike exit and reconstructed Cambridge Street were introduced in 1965. About this time River and Western were made one-way in their present arrangement.

As recently as the 1970s, three of the four (excluding #1) were controlled in peak hours by MDC policemen, and as recently as 3-4 years ago State Police would periodically operate the signals on both sides of the River Street Bridge, running cycle times of about 7 minutes. My observations and those of others were that police operation did not appear to offer any traffic flow advantages. In the last few years, the signals have been controlled as pairs on River and on Western Avenue. The cycle length was expanded from 100-seconds to its current 140-seconds. A new span-wire system was installed at Soldiers Field Road and Western Avenue a year ago. This last site includes a pedestrian pushbutton to call a concurrent WALK phase, but the other three have no pedestrian indications whatsoever.

For decades, traffic has backed up on Memorial Drive typically to the Shell Station, and at the Turnpike exit there commonly are queues on several exit ramps. These queues have not been recognized or described in previous traffic studies.

## 2.0 ALTERNATE ROUTES AROUND CONGESTION

Commuters will try several routes around any traffic backups :

* Memorial to River to Blackstone to Western

This route is commonly used by drivers who become boxed into the right lane and wish to make a left turn at Western. Rather than force an awkward lane change on Memorial Drive, they will instead follow this local "jughandle" pattern.

* Memorial to Magazine to Putnam to Western

This route is used by commuters who become impatient with long waits on Memorial Drive and seek to use Putnam Avenue as a congestion bypass. However, Putnam Avenue is frequently congested as well. Drivers seeking to head north towards Central Square will also use Magazine or Pleasant Street to reach River Street, rather than waiting through the Memorial Drive delay.

* Putnam to Osco Parking Lot to Blackstone to Western Avenue

This route is available today but is somewhat circuitous and includes an unsignalized crossing of River Street. It would bypass queues along Putnam Avenue and Part of Western Avenue.

## 3.0 OBSERVATIONS OF FLOWS AND CONGESTION

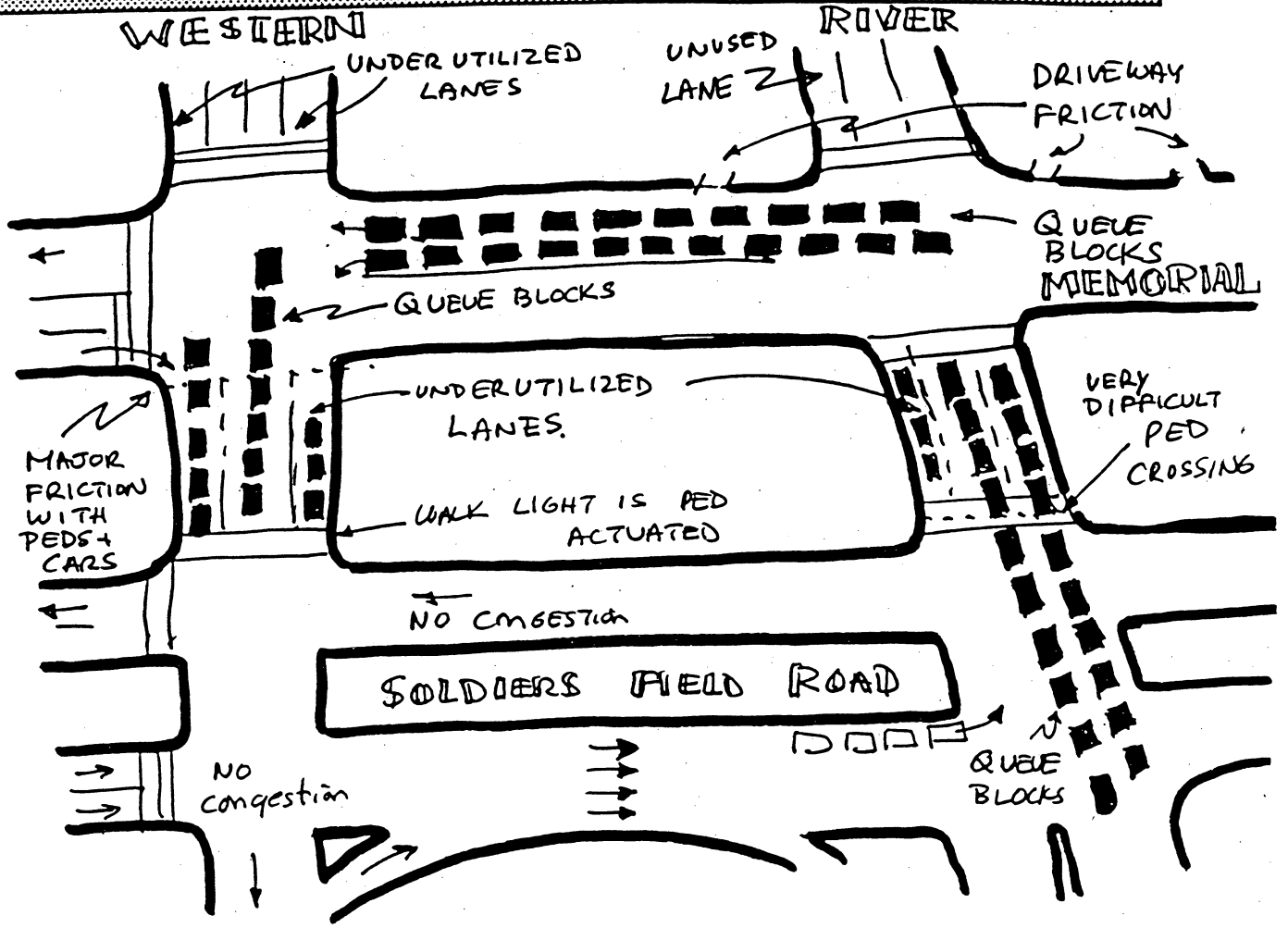



FIGURE 1 Existing Problem Areas

CNI made afternoon peak hour observations and counts in September 1997. (Congestion in the morning occurs primarily on Western Avenue -- due to inefficient signal timing – and on the Boston side of the river at the Turnpike exit.) Of the four locations under discussion, brief gridlock blockage occured at three of the four intersections. The one intersection which is below capacity is the new location #1 at Soldiers Field Road and Western Avenue. Generally, all approaching traffic flushes easily on the inbound exit ramp and the outbound service road. There are three queues which can cause intersection blockage :

* Western Avenue from Soldiers Field Road into Memorial Drive

* Memorial Drive from Western Avenue into River Street

* River Street from Memorial Drive into Soldiers Field Road.

The congestion on Western Avenue affects primarily outbound Western Avenue traffic, although the outbound Memorial Drive left turns can be held back occasionally. The Memorial Drive queue primarily affects other approaching traffic on outbound Memorial Drive, although left turns from the River Street bridge can be retarded briefly by Mem Drive queues as well.

At Soldiers Field Road and Cambridge Street, the blockage delays occur primarily for traffic coming from the Turnpike and Cambridge Street. There is some blockage that affects the beginning of the green phase for the inbound service road, but the delays are relatively brief. However, it is possible to have left turning vehicles stranded in the middle of the intersection, as they are hung up by cars ahead and a green indication to another phase, as occurs today for inbound service road traffic turning left onto a jammed River Street bridge.

## 4.0 DIFFERENT KINDS OF LOST TIME

The key to increased efficiency along the river parkways is to recognize that every time that traffic blocks an intersection there is *wasted time*. Improving the efficiency of the system means that we must use every second of time properly for productive purposes, without creating gridlock or safety problems elsewhere.

Any time which is not utilized at an ideal level of steady flow is called "lost time." There are several different elements of lost time :

1. Lost time during vehicle startup (typically 2 seconds)
   (May be increased by sneakers from other movements)

2. Lost time at the end of the phase, due to clearance or the effect of "sneakers."

3. All-Red clear with no green for any traffic or WALK for peds

4. Lost time due to general flow decline after the 15th to 20th car

5. Lost time due to inefficient lane use
   a. Premature flushing out of the lane
   b. Near-side short lanes
   c. Far-side short lanes

6. Lost time due to temporary blockage or gridlock of an intersection caused by downstream congestion

7. Poor or erratic interconnection of nearby traffic signals

All of these lost time conditions are evident in varying degrees at the four intersections. The single biggest factor is #6 above, the effect of queues blocking intersections. The second largest is item #5, lost time due to inefficient lane use. Given these priorities, the best solutions are based on traffic signal timing and pavement markings.

Any time which is recovered by the use of more efficient traffic signal operation is called "saved time." Indeed, the potential savings in lost time will be shown to be in the range of 15 to 20 % of the cycle time at the three most critical locations. Such saved time totals are about 25 seconds for a 140-second cycle and 15 to 20 seconds for a 100-second cycle, which translates into about 12-15 seconds of saved time for an 80-second cycle.

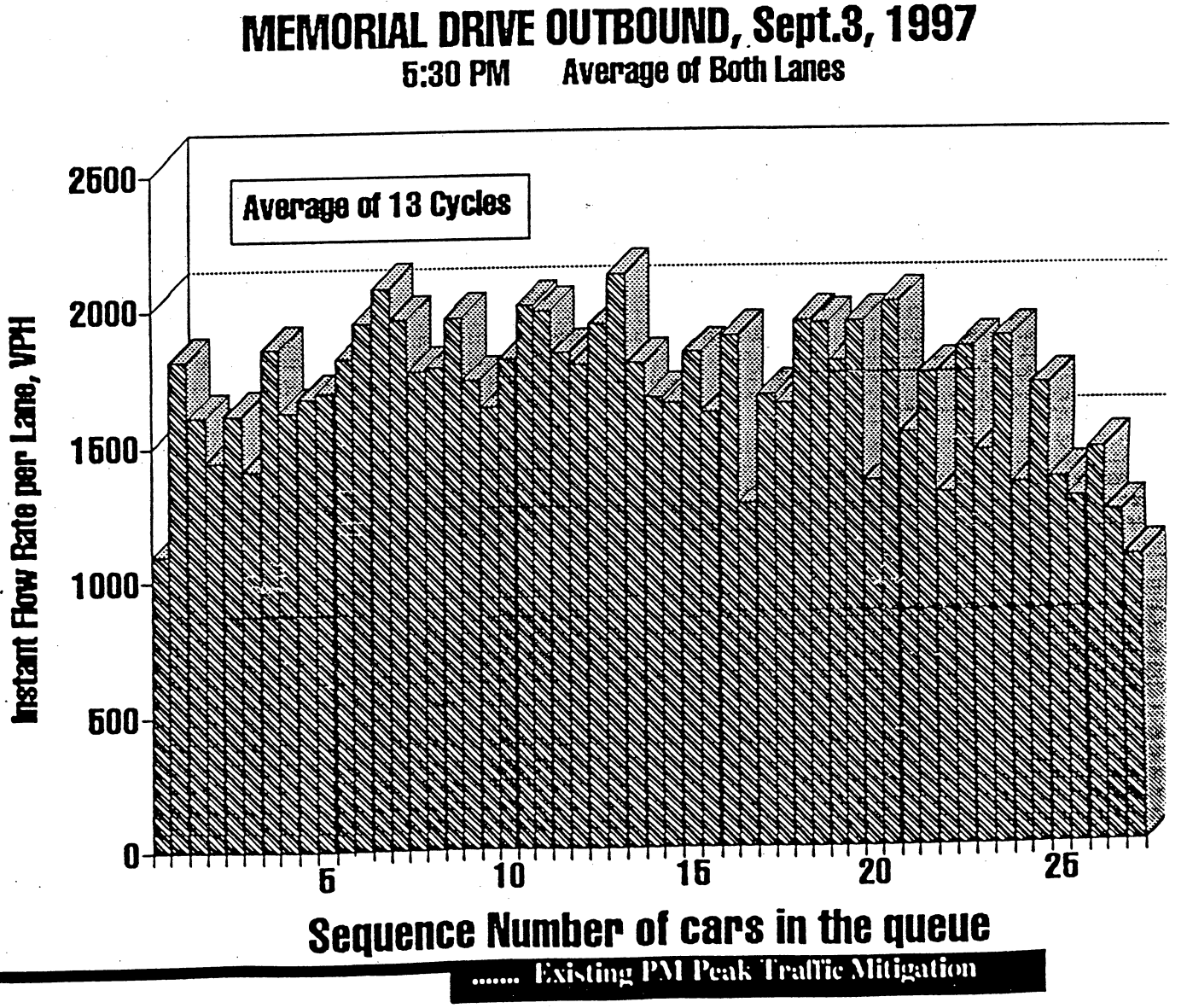
The strategy for priority reassignment of saved time is :

#1. Add pedestrian exclusive phases where possible, both for crossing River & Western Avenue and for Memorial Drive.
#2. If a pedestrian exclusive phase is not feasible, add to the vehicle clearance time (All-Red Clear) but with a lead time for pedestrians to cross on a concurrent phase.
#3. Give more green time to a move which will flush the intersection or otherwise improve safety – while not causing or increasing gridlock elsewhere.
#4. Increase green time for traffic movements which will most likely reduce traffic flows or diversions to local streets, such as Putnam Avenue.
#5. Increase green time for any traffic movement which dies not cause downstream congestion.

This listing should be considered as a #1 to #5 priority listing. Generally, the pedestrian exclusive phase should be set close to allowable minimums (about 12-15 seconds) so that saved time can be allocated to other options on the list.

The general strategy to achieve "saved time" is to retime signals at Soldiers Field Road and Western Avenue to reduce the gridlock potential on the Western Avenue Bridge and its effects on Memorial Drive. Signal cycles are reduced to improve capacity of short lanes and reduce queue lengths and delays. at all four locations.

FIGURE 2



## 5.0 MEASURING FLOWS AND LOST TIME

For all four intersections, a laptop measurement program called MOUSE-MEASURE was used to record the event occurrences and times of individual traffic movements. In this way instant and cumulative flow rates could be calculated quickly, as a vital element in estimating lost times during flow periods. Events and times are recorded on disk as ASCII and with formatting the information is imported into a spreadsheet template for calculation of time increments and flow rates. Graphing of results is also possible from the spreadsheet program.

## 6.0 SAMPLE RESULTS FOR MEMORIAL DRIVE

Figure 2 illustrates the average flow rates of each car in a queue over 13 cycles. We can see the lost time as the first car starts up, as well as the peak flow about the 15th car with a drop in flow rate for later cars in the queue, especially #25 to #28. These results are very sobering because they show the optimum phase length is 15 to 25 seconds (7 to 13 cars) in contrast to the long phase of 58 seconds now in effect. We can see clearly that capacity can be enhanced by making cycle times ***shorter***, not longer as almost all traffic engineers presume today. Such a perspective represents a dramatic reversal in the traditional traffic engineering thinking about optimizing traffic signal timing – and also applies to the City of Cambridge and other entities using long signal cycle lengths.

To repeat the key conclusion in a different way : ***increasing*** cycle lengths may actually ***reduce***, not increase capacity – especially if there are short lanes or closely spaced intersections which cause queuing problems.

## 7.0 OTHER BENEFITS OF REDUCED CYCLE TIME

Since 1985, Chapter 9 of the *Highway Capacity Manual* has been based on the definition of Level of Service as measured by average stopped delay. This source is quite explicit about the effects of long cycle lengths as contributors to delay and how optimizing signals for shorter cycle lengths can reduce delay.

For traffic movements which are not congested, the general rule is that a 10% reduction in cycle length (with a balanced 10% reduction in each phase) would result in a 10% reduction in delay. When traffic movements are congested, the cycle time will have no effect on delay, as long as capacity is retained.

Clearly, there is an optimum range of cycle lengths, so that at some point shorter cycles cause inefficiencies and increases in delay. The Memorial Drive data clearly show that the optimum phase length is about 1/3 of existing. Such a conclusion if extended to the entire intersection would imply that the 140-second existing cycle should be reduced to less than 50 seconds. Therefore, a target of an 80-second cycle appeared to be a reasonable first assumption, slightly more than half the existing 140-seconds along River Street and 20% less than the 100-seconds on Western Avenue.

It may be possible to go shorter that 80 seconds, but the primary limitation will be the 4-phase signal at the Turnpike Exit and the minimum times required for a pedestrian exclusive phase. One can always fine-tune the timing at a later time.

A consistent 80-second cycle would be applied to all locations including Putnam Avenue) and would avoid the inconsistency between the 140-second cycles at River Street and the 100-second cycles at Western Avenue.

## 8.0 PROPOSALS : SOLDIERS FIELD ROAD and WESTERN AVE.

As noted earlier in section 3.0, the distribution of green time is less than optimal and the coordination of timing between the two Western Avenue signals results in brief gridlocking on Memorial Drive. The solution is two-fold -- to transfer unneeded green time to the Western Avenue Bridge and start its green phase earlier, relative to Memorial Drive. The signal timings would be :

| | NOW | PROPOSED | TRAFFIC | CAPACITY |
|---|---|---|---|---|
| Outbound Service Road | 30 sec | 20 sec | 600 vph | 900 vph |
| Inbound exit ramp | 26 sec | 20 sec | 400 vph | 900 vph |
| Western Avenue Bridge | 40 sec | 36 sec | 2350 vph | 2450 vph |
| All-Red-Clear | 4 sec | 4 sec | | |
| | 100 sec | 80 sec | 3350 vph<br>V/C = 0.79 | 4250 vph |
| Pedestrian Crossing<br>average delay<br>actuation | 8 sec<br>manual | 8 sec<br>automatic | | |

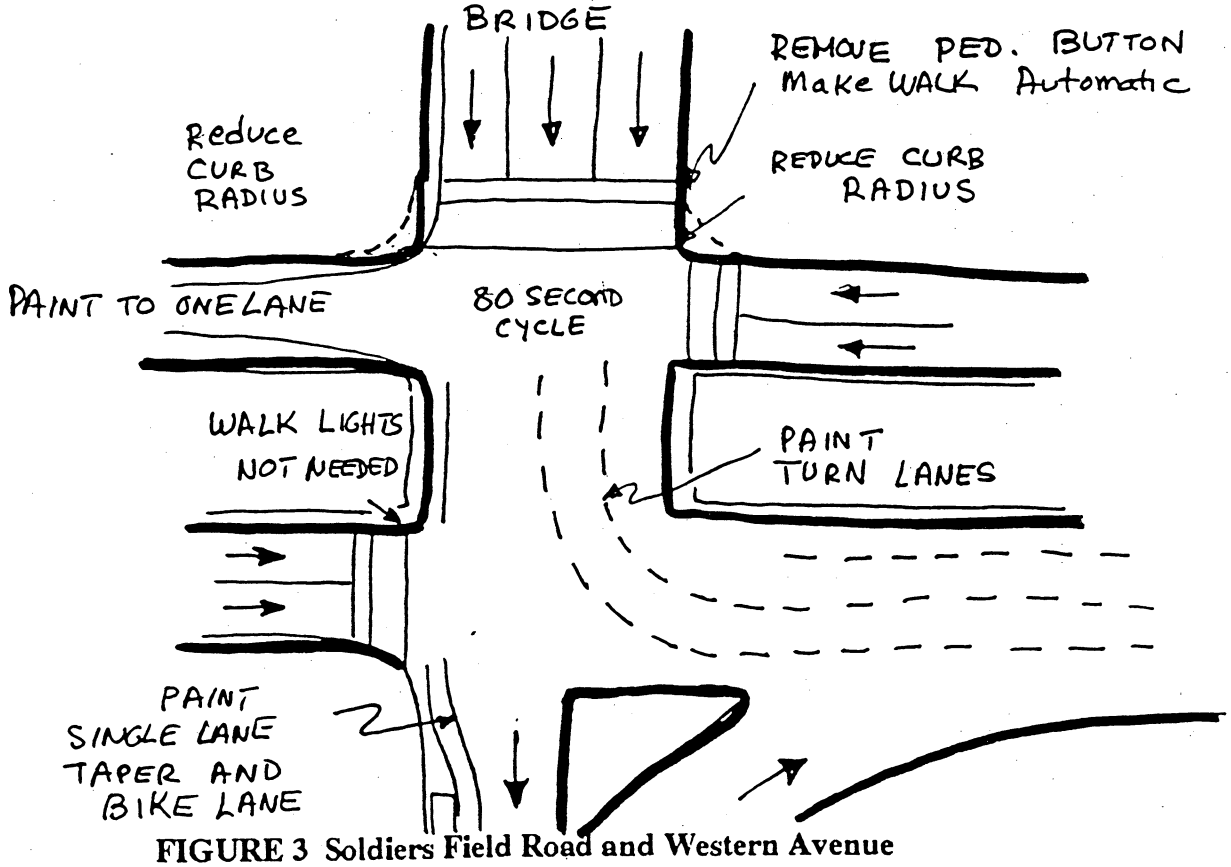



FIGURE 3 Soldiers Field Road and Western Avenue

A few years ago the Western Avenue bridge was repainted from four narrow lanes down to three wide ones. The capacity and storage provided by three lanes appear adequate, and there does appear to be sufficient room to pull the right edge line out a few feet to create a small shoulder/bike lane.

Another change would be to paint left turn guidance lines from the bridge onto the Soldiers Field inbound service road, so that vehicles on the inside would have an easier time turning with less squeezing by cars on the right in the middle lane. The intent is to increase the flow and utilization of the left-most lane on the bridge with resulting improved efficiency.

Other changes are to paint a taper and bikelane on the far-side entrance to Western Avenue at the corner with the Harvard Business School. Also paint the outbound on-ramp down to one lane and prevent passing on the ramp ... (note the severe evidence of accidents on the curve near the Weeks Bridge, with numerous demolished light poles. This curve is a high accident location).

The pedestrian WALK lights here are the only ones at the four locations, but they simply provide for concurrent movements. If the Charles River path user does not push the button, there is no WALK indication even though the Western Avenue traffic is stopped on the bridge for 60 seconds out of every 100. The need to push a button here is patently absurd : it should come on automatically and the pushbutton should be deleted. There is no sacrifice in traffic movement to allow this and everything to be gained for the upgrading of a street crossing on the MDC path for pedestrians, joggers, bicyclists, roller bladers, and wheelchairs.

There is no need for WALK lights at the remaining crossings, since the traffic flows are low enough that crossings are fairly easy and DON'T WALK lights would simply be an impediment to many reasonable crossings. Flashing DON'T WALK is very confusing to almost everyone, including some traffic engineers. A flashing DON'T WALK time of 10 seconds should be replaced by 7 seconds of a flashing countdown WALK, with the symbol alternating with the seconds remaining, followed by 3 seconds of DON'T WALK clearance time.

## 9.0 PROPOSALS : MEMORIAL DRIVE and WESTERN AVENUE

Four indications of inefficiency are observable at the Memorial and Western Avenue intersection :

1. Queues which back up from Soldiers Field Road into Memorial Drive.
2. The same queues may affect left turns from Memorial Drive
3. The Western Avenue approach includes two short lanes
4. There is a heavy pedestrian/joger/bike/skater flow on the Charles River path, causing friction with vehicles, with some yielding by inbound Memorial Drive traffic – thereby momentarily blocking the right lane.

As noted in 8.0 above, the cause of the queues is poor signal timing on the Boston side. On Western Avenue the queue occurs almost every cycle and causes an effective loss of 10 to 15 seconds to Western Avenue flow and about 3 seconds for occasional blockage to left turns from Memorial Drive.

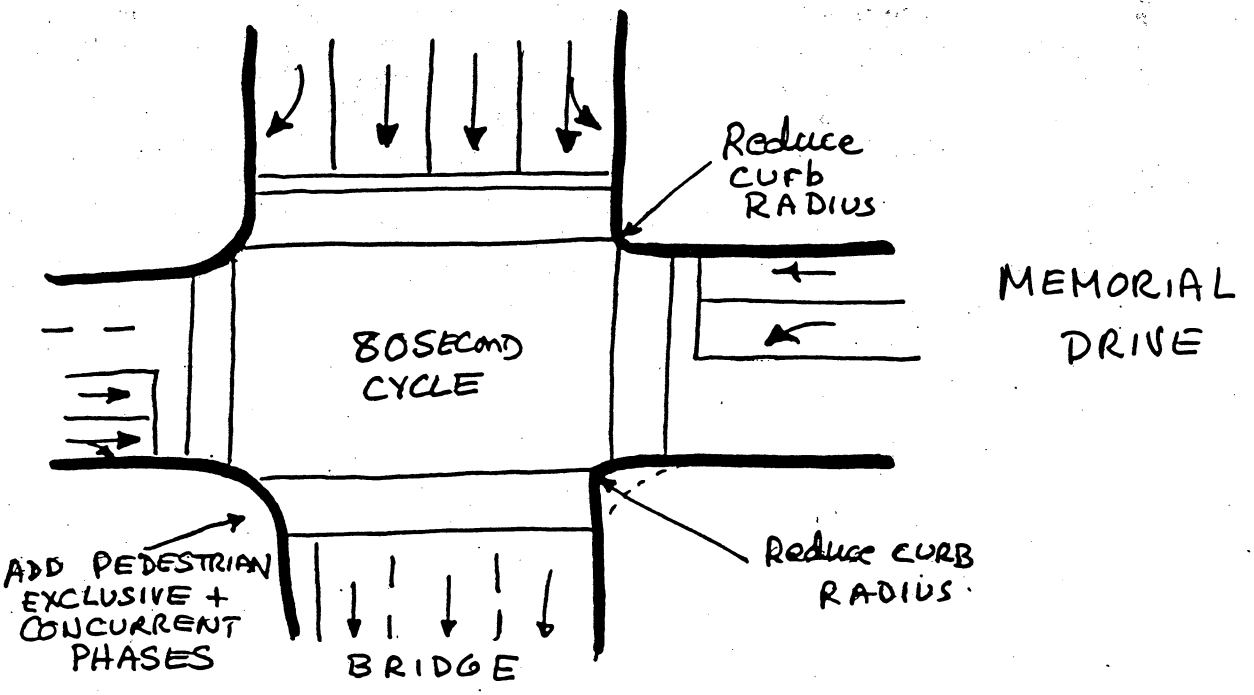



**FIGURE 4 Memorial Drive and Western Avenue**

The approach on Western Avenue appears to be four lanes, but the right lane is basically for right turns only and is lightly used by about 5 cars per cycle, while the left lane includes 6 left turns and numerous through vehicles. The left lane is a short lane that extends only to Blackstone Street and many drivers prefer to remain in the center lanes rather than change lanes. Shorter cycle times would result in better utilization of this left lane.

Lane utilization is uneven on the Western Avenue bridge, with the center lane getting the largest flows, with the right lane having slightly less and the left lane seldom being used close to its capacity. This imbalance shows itself in the queuing that blocks Memorial Drive, with the blockage beginning with the middle lane and later extending to include the right lane. I have never seen the left bridge lane backed up into Memorial Drive. Part of this problem may be due to the short left lane as Western Avenue approaches Memorial Drive. Another factor may be the difficult two-lane left turn on the other side of the bridge, as noted above.

If a pedestrian exclusive phase were introduced, there would be less friction between pedestrians and inbound Memorial Drive turns onto the bridge. This lost time is probably about 3 seconds, and could reasonably be reduced to 1 second if the bulk of pedestrians were handled by an immediately preceding pedestrian phase.

Losses due to startup time caused by shifting from a 100-second cycle to an 80-second cycle would be about 3 seconds. The net gain in "saved time" would be in the range of 12-18 seconds or about 15%, which is about 12 seconds for an 80-second cycle. Further detailed measurements need to be performed but it appears that an exclusive pedestrian phase is possible. Concurrent walk displays across Western Avenue would also be included when Western Avenue stops on the north crosswalk and when inbound Memorial Drive is flowing (south crosswalk). Across Memorial Drive, the crosswalks would encounter 3 to 4 vehicle each cycle from Western Avenue, which is low enough to permit permissive walk displays.

In the morning peak, traffic regularly queues on the Western Avenue approach to Memorial Drive and does not flush out. The tail of this queue will sometimes block the Putnam Avenue intersection, which is an important school crossing point. It may be better to have automatic pedestrian phase actuation at Putnam Ave & Western, while keeping Western Avenue from queuing back into Putnam Avenue.

## 10.0 PROPOSALS : MEMORIAL DRIVE AND RIVER STREET

Five indications of inefficiency are observable at the Memorial and River Street intersection :

1. Queues which back up from Western Avenue into River Street
2. The same queues may affect left turns from the River Street Bridge
3. There is minimal use of the left lane on the bridge and partial use of the center lane.
4. At the end of the bridge green phase, there is often vast amount of empty time when no traffic moves.
5. There is restricted flow in the right hand lane off the bridge because of friction with pedestrians
6. Some traffic interference does occur at three driveways to gas stations along the north side of Memorial Drive.

The good news is that some of this waste time is being used for pedestrian crossings, and River Street does stop completely for almost 70 seconds -- although the 140-second cycle caused long delays for pedestrians as well as motorists.

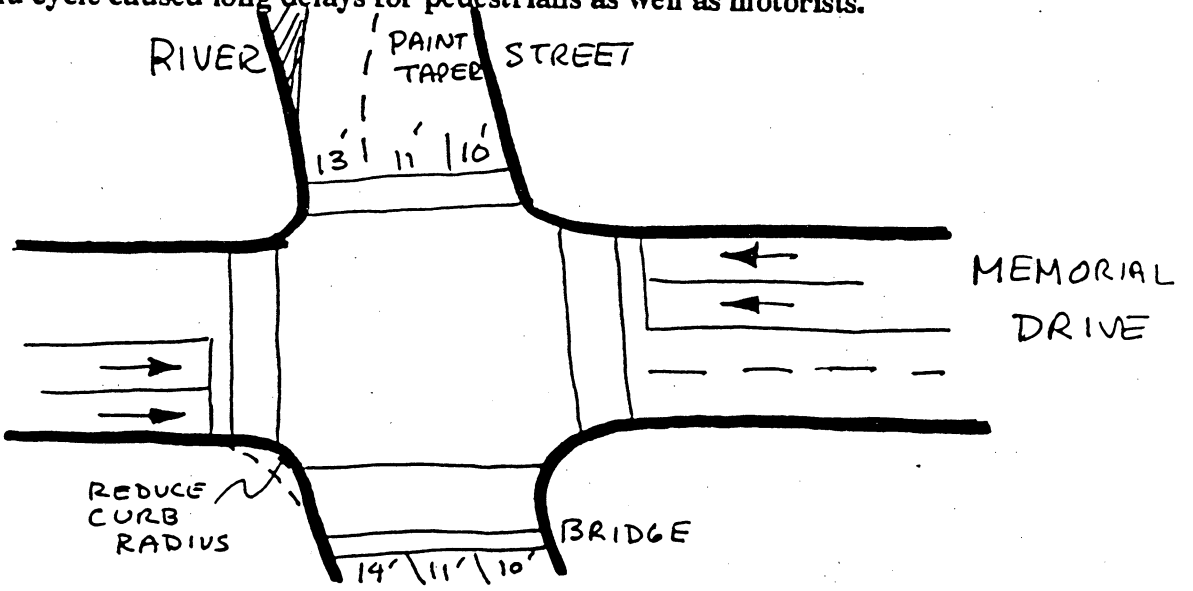



FIGURE 5 MEMORIAL DRIVE AND RIVER STREET

A detailed analysis of 13 signal cycles demonstrated that shifting from the existing 140-second cycle to an 80-second cycle would result in higher capacity, with a net time savings of 3 seconds on the outbound phase.

On the bridge, the combination of tighter signal coordination and better use of all lanes should yield a substantial time saving of about 20 seconds. Close coordination with the signal at the Turnpike exit would be required, so that vehicles from Cambridge Street would stop only briefly and then would get the green at Memorial Drive.

Other cars arriving from behind would be encouraged to use all lanes on the bridge, with the right hand lane (cars onto to Memorial Drive) being 10 feet, the middle lane 11 feet and the left lane 14-15 feet. The curbs do not line up exactly between the bridge and River Street heading towards Central Square, so that some drivers in today's left lane may find themselves headed towards the sidewalk on River street. Moreover, if they do shift right into the proper lane they must fully merge right again at Blackstone Street, because a parking lane is introduced on the left. The best solution would be to designate the right lane on the bridge as right turn only, and to encourage all through and left turning traffic to use the two left lanes. The lane marking on River Street would be shifted into an S-pattern so that the left turn on the bridge is continuous with the left lane continuing to Putnam Avenue. North of Memorial Drive the center and right lanes would taper into a single right lane, and the merging should be minimal if the right lane is almost all right-turn-only onto Memorial Drive.

The right turn onto Memorial today encounters some interference with pedestrians, who generally favor the easterly crosswalk on Memorial Drive. With a pedestrian exclusive phase, there would be less pedestrian friction, which would have a small improvement of about 1 second a cycle. Driveway interference remains the same.

Finally, the existing 12-lane advance green for inbound Memorial Drive may be excessive, and it may be more effective to allow for a 2-second advance and a 2-sec lag or clearance time in the 80-second cycle. The net effect of this lead/leg will be a time saving of 4 seconds.

On the Western Avenue bridge, startup losses would increase with the reduction in cycle length, for a loss of about 3 seconds and 4 seconds for all-red clear. To net "time saving" would be about 21 seconds or 15%. For an 80-second cycle this is about 12 seconds, or very close to enough time for a pedestrian exclusive phase. Pedestrian concurrent phases could be added where turning movements only are encountered – except for the brief lead/lag periods.

## 11.0 PROPOSALS : SOLDIERS FIELD ROAD & CAMBRIDGE ST

The lost time at the Soldiers Field Road/Turnpike Exit/Cambridge Street exit is composed of four elements :

1. Traffic backs up from the Memorial Drive signal into the Soldiers Field Road intersection. Primarily the flows which are slowed or blocked are Cambridge Street and the Turnpike ramp.

2. The same traffic backup can slow or block the left turn from the service road onto the River Street bridge

3. Occasionally, some of the left turn traffic may get hung up in the intersection and may block the outbound exit ramp from Storrow Drive.

4. The Cambridge Street approach often will have long gaps as it approaches River street.

5. The four lanes on the approach in front of the hotel are more than the three lanes on the Turnpike exit ramp and on Cambridge Street. This is a short lane situation.

Generally, the right lane of the four approach lanes is for right turn traffic only and is not a critical lane. The challenge is to utilize the other three lanes more efficiently. Shorter signal cycles would reduce the queuing effects by about half, as would better signal coordination with the Memorial Drive side.

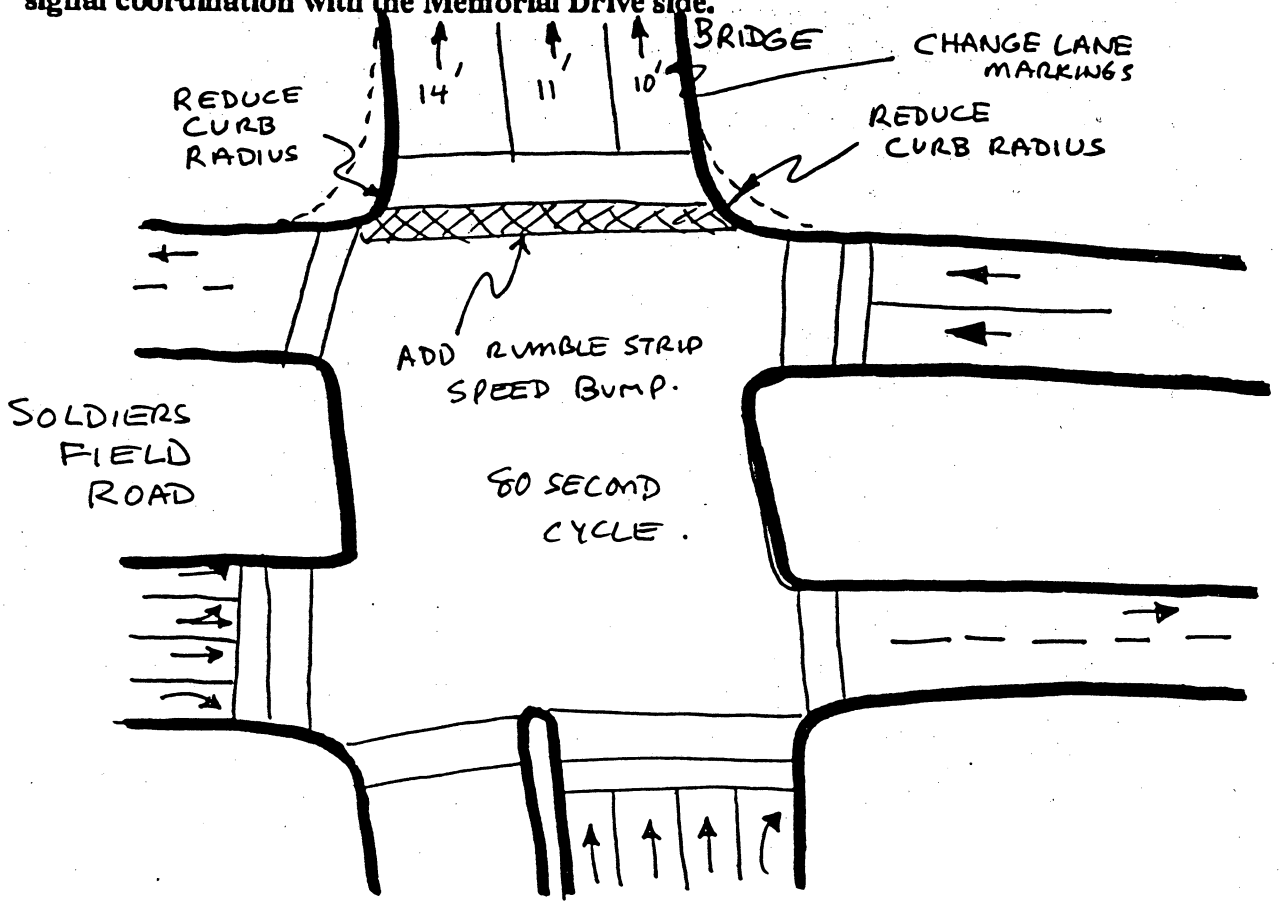



FIGURE 6 SOLDIERS FIELD ROAD AND RIVER STREET BRIDGE

Traffic counts on the Cambridge Street approach show that the latter part of the signal cycle produces only 2/3 to 3/4 of the rate as the initial part, as queue backups begin to take their toll. For the overall phase, this effect is worth 10-12 seconds in lost time. Allowing for smoother flow into the left lane on the bridge may be worth an additional second or two at least. Another 2-3 seconds can be achieved from smoother startup of the inbound left turns onto River Street, without blocking queues.

However, the added startup lost time and all-red clearance time could amount to about 12 seconds, so the net time saved would be only about 3 seconds. At the moment, this added time may be best applied proving for added clearance time and allowing pedestrians to have a jump on traffic during the only time that pedestrians using the Esplanade path can cross – during the phase for the outbound off-ramp from Storrow. It may be desirable to install a concurrent signal at this location, with WALK indications, and signs saying yield to pedestrians on turns. Vehicles today tend to yield when turning, and such a crossing would be an improvement over the incredible Dodge City nature to today's crossing location. Without a doubt, this crossing represents the worst and most dangerous crossing on the entire bikepath on the Boston side of the River (even worse than Leverett Circle!)

## 12.0 SUMMARY RECOMMENDATIONS FOR FOUR LOCATIONS

### SOLDIERS FIELD ROAD AND WESTERN

* Reallocate signal timing and change signal coordination with Memorial Drive
* Reduce cycle time from 100 to 80 seconds
* Change to automatic concurrent WALK operation
* Various changes in pavement markings
* Intersection is under capacity V/C = 0.80 PM Peak

### MEMORIAL DRIVE AND WESTERN AVE

* Minor changes produce recovered lost time of 15 %
* Reduce cycle time from 100 to 80 seconds
* Add pedestrian exclusive phase
* Various changes in pavement markings
* Small changes to pavement markings

### MEMORIAL DRIVE AND RIVER STREET

* Minor changes produce recovered lost time of 15 %
* Reduce cycle time from 140 to 80 seconds
* Add pedestrian exclusive phase
* Change lane markings on River Street and Bridge

### SOLDIERS FIELD ROAD & CAMBRIDGE STREET

* Minor changes produce recovered lost time of 2 %
* Reduce cycle time from 140 to 80 seconds
* Add clearance time and concurrent pedestrian display
* Change lane markings on bridge
* Small changes to curbing

## 13.0 CAPACITY, QUEUE LENGTHS AND DELAY CONSEQUENCES

Throughout this analysis, the goal has been to maintain existing flow capacity for existing traffic. Any signal time saved is available for mitigation. With the reduced signal cycle lengths all traffic which is not congested will have shorter queue lengths and reduced delays. If the movements are already saturated, the queue lengths and delays will remain as they are today.

Generally, about half of the traffic volumes at the four intersections would constitute flows that are not saturated and thus would gain from shorter queues and delays.

What is the delay incurred by vehicles now caught in the Memorial Drive queue? The Memorial Drive crossing of River Street has been the focus of detailed measurements. Here, an average of 52 vehicles in 2 lanes is processed in 58 seconds of GY time within a 140-second cycle. The queue length is typically 1320 feet or 60 cars, which is 120 cars in 2 lanes. The time to make it through the queue is about 4 minutes on the average. Such delays are four times the LOS F criterion and explain why many drivers will choose instead to travel on local neighborhood streets. Therefore, about 10% of the peak hour traffic outbound on Memorial Drive is sitting in the queue.

The mitigation strategy proposed by CNI does not propose to reduce these queue lengths, because the first priority is mitigation for the needs of pedestrians and others who are poorly served at these four intersections. However, if further analysis shows that signal timing and pavement markings can yield even more saved time, the added savings can be applied to moving cars and reducing queues.

## 14.0 TRIP GENERATION from Various Sites

The primary new trip generators are Polaroid, Bread & Circus, University Park and other general background growth. At the moment, afternoon peak hour generation of new traffic appears to be about 300 trips per hour for the Polaroid site, 500-700 for Break and Circus, and 1340 for University Park. University Park planners have estimated that 35% of that traffic will be going through the Memorial and Western Avenue intersection. University Park alone represents about a 10% increase in traffic flow on Memorial Drive. University Park is proposing a total of 3,000 parking spaces and no one has made any plans to receive this amount of additional traffic.

## 15.0 ACCESS ALTERNATIVES TO THE POLAROID SITE

The traffic impacts on the parkway road system will be dependent upon whatever access system is selected for the Polaroid site. Possible variations include :

1. Original 2-driveway proposal
2. The latest plan for 3 driveways
3. Relocate the driveways ... to improve safety or reduce tendency of vehicles to use local streets
4. Dead end Pleasant Street at Florence Street and require all Polaroid traffic to use Memorial Drive
5. Make Pleasant Street one-way southbound between Florence and Memorial Drive
6. Make the main Polaroid driveway right-turn only onto Pleasant Street
7. Relocate the main Polaroid driveway to west side of main building with a driveway onto Memorial Drive.

===== END ======

CITY OF CAMBRIDGE
COMMUNITY DEVELOPMENT DEPARTMENT

SUSAN B. SCHLESINGER
*Assistant City Manager for Community Development*

BETH RUBENSTEIN
*Deputy Director for Community Development*

March 11, 1998

Julia O'Brien
Director of Planning
Metropolitan District Commission
20 Somerset Street
Boston, MA 02108

Dear Ms. O'Brien:

As we discussed in our recent meeting, enclosed for your review is a memorandum which outlines proposed changes to the existing signal timing at the Memorial Drive intersections with Western Avenue and Soldiers Field Road. The City and its traffic consultant, Rizzo Associates, have been working since July 1997 with representatives from the Cambridgeport Neighborhood Initiative (CNI) and their traffic consultant, Stephen Kaiser, and Spaulding & Slye/Polaroid and their traffic consultant, R. D. Vanasse & Associates (RDV), to discuss existing traffic conditions in the neighborhood and to review impacts of the proposed development of 784 Memorial Drive by Spaulding & Slye/Polaroid.

It became apparent during our review of the traffic reports prepared by RDV and Stephen Kaiser associated with the 784 Memorial Drive project, and based upon subsequent data collection and field observations, that the signals at Western Avenue and Memorial Drive were not operating efficiently and were causing queues to back-up through the intersection during the p.m. peak hour. Additionally, it was observed that cars were diverting off of Memorial Drive and onto nearby residential streets to avoid the queue backing up from the Western Avenue Bridge onto Memorial Drive. We assembled a Memorial Drive/Western Avenue Traffic Evaluation Team, made up of representatives from the City, CNI and Spaulding & Slye/Polaroid, to review signal timing changes that could quickly be implemented with little or no physical equipment changes (Phase I Improvements).

Additional improvement phases will be looked at by the team with follow up recommendations to be forwarded to you for consideration at a later time. Additional phases will look at the potential for other signal improvements, geometric improvements, pavement markings, and possible other items.

The proposal outlined in the attached memorandum recommends the following changes:

- Reduce cycle length from 100 to 90 seconds for the Western Avenue intersections with Memorial Drive and Soldiers Field Road

City Hall Annex
57 Inman Street
Cambridge, MA 02139
Voice: 617 349-4600
Fax: 617 349-4669
TTY: 617 349-4621

- Increase green time for the Memorial Drive approach by reducing green time for the Western Avenue approach
- Increase green time for the Western Avenue Bridge approach by reducing maximum green time on the Soldiers Field Road ramps
- Increase pedestrian crossing times at Western Avenue/Soldiers Field Road

We believe that these recommendations will result in the following benefits:

- Reduced vehicular delays/queues on the Western Avenue Bridge
- Greater efficiency in the Memorial Drive vehicle flows
- Increased pedestrian crossing opportunities on Western Avenue
- Improved traffic flows on Memorial Drive, reducing cut-through trips on local residential streets
- Improved pedestrian crossings at Soldiers Field Road

We are recommending that implementation of these improvements be tested over a 30 day trial period to begin on or around April 1st. During this time a careful monitoring of the changes will be conducted to assess the effectiveness of the changes. It is critical that the trial period be undertaken during normal, or pre-summer, traffic conditions to fully understand the effectiveness of the changes.

We are ready to meet with you to discuss these recommendations. I will call you soon to set up a meeting to discuss your review.

Thank you for your consideration of this proposal.

Sincerely,

Beth Rubenstein

Beth Rubenstein
Deputy Director

Attachment
cc: Fran Faucher
Ken Kirwin

RIZZO ASSOCIATES, INC.
ENGINEERS AND ENVIRONMENTAL SCIENTISTS
AN EMPLOYEE-OWNED COMPANY
235 West Central Street, Natick, MA 01760-3755 (508) 651-3401 FAX (508) 651-1189

# Memorandum

**To:** Beth Rubenstein; Cambridge Community Development Department

**Fr:** Edward Gardiner, P.E.; Rizzo Associates, Inc. EG

**Re:** **Traffic Engineering Evaluation**
**Memorial Drive/Western Avenue and Soldiers Field Road/Western Avenue**

**Dt:** March 9, 1998

---

This memorandum summarizes the findings and recommendations of the first phase of work completed by the Memorial Drive/Western Avenue Traffic Evaluation Team. The Team consists of the following representatives:

- Catherine Daly Woodbury; Cambridge Community Development,
- Lauren Preston; Cambridge Traffic & Parking,
- Stephen Kaiser; Cambridge Neighborhood Initiative,
- David DeBaie; R. D. Vanasse & Associates, Inc.,
- Edward Gardiner; Rizzo Associates, Inc., and
- Barry Pell; Rizzo Associates, Inc.

Recommendations from this team will be developed in phases, so that signal timing changes that can be accomplished with the existing signal equipment can be implemented immediately. Recommendations from this first phase of work include signal timing adjustments at the two subject intersections, and improvements to the pedestrian crossing phases at the Soldiers Field Road/Western Avenue intersection. It is anticipated that these improvements can be implemented with the existing signal equipment. Phase 2 improvements that are currently being reviewed by the team include additional signal modifications and pavement marking improvements. Future phases may include geometric improvements, other traffic signal improvements, and coordination of the signals on Western Avenue and River Street, and will be coordinated with the Charles River Basin work being undertaken by the MDC.

## Phase I Objectives

The Memorial Drive/Western Avenue Traffic Evaluation Team has completed a traffic evaluation of the Memorial Drive/Western Avenue and Soldiers Field Road/Western Avenue intersections, and developed recommendations for improvements that are consistent with the following objectives:

- Improve traffic operations on Memorial Drive by reducing vehicle delays and queues, and making Memorial Drive a more desirable route during peak commuting hours.
- Improve pedestrian crossing opportunities and reduce pedestrian delay at Western Avenue pedestrian crossings.
- Improve traffic signal coordination between the Western Avenue traffic signals in order to reduce the likelihood of traffic backups from the bridge onto Memorial Drive.
- Reduce the likelihood of traffic diversions from Memorial Drive onto neighborhood streets.

The team will be addressing additional traffic and pedestrian needs as they are identified.

## Existing Conditions

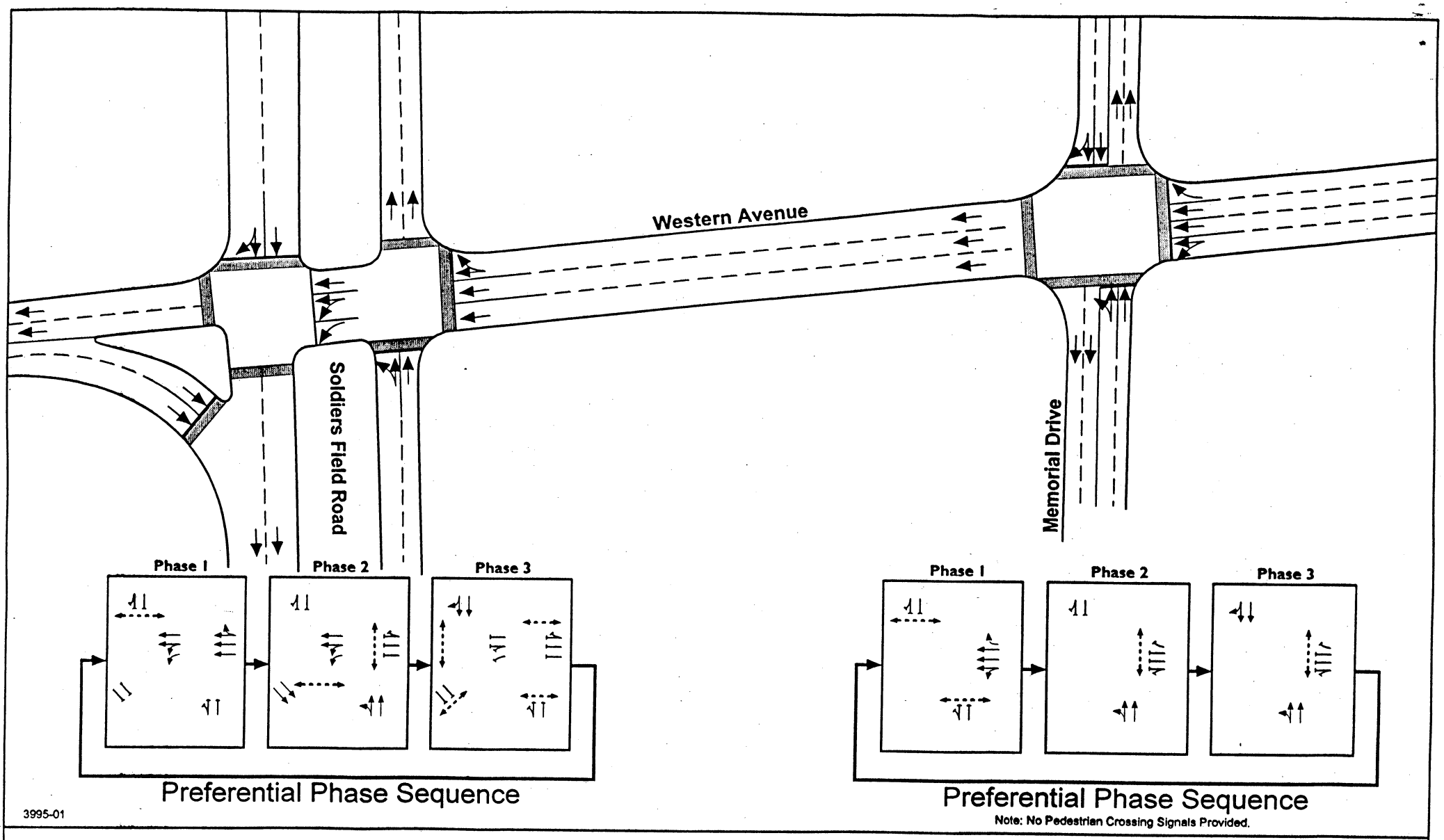
A schematic layout of the lane configurations at the subject intersections is shown on Figure 1. The traffic signal at the intersection of Memorial Drive and Western Avenue is pre-timed with three phases serving Western Avenue, Memorial Drive northbound (protected left-turn), and Memorial Drive northbound and southbound. Pedestrian crossing is concurrent with the vehicle signal phases; however, there are no pedestrian crossing signals. There is no vehicle or pedestrian detection at the intersection, and therefore, the signal does not respond to changes in traffic and pedestrian activity.

The traffic signal at the intersection of Soldiers Field Road and Western Avenue is actuated with three phases serving Western Avenue westbound, Western Avenue eastbound/Soldiers Field Road northbound, and Soldiers Field Road southbound. Protected pedestrian crossings are provided with pedestrian detection. Vehicle detection is provided on the Soldiers Field Road and Western Avenue eastbound approaches.

According to information contained on the plan titled *Western Avenue Interconnect and Coordination System*, Boston Public Works Department, March 1994, the signals are interconnected and three timing plans are programmed into the signal controllers for AM peak, PM peak, and off-peak periods.

## Analysis and Findings

Peak hour traffic volumes were obtained from the *Traffic Review and Access Study, 784 Memorial Drive*, R. D. Vanasse & Associates, Inc., November 1997, and the *Phase I Traffic Study: Genzyme Manufacturing Facility*, Vanasse Hangen Brustlin, Inc., February 1992.




3995-01

Not To Scale

Memorial Drive/Western Avenue and
Soldiers Field Road/Western Avenue
Cambridge, Massachusetts

Source: Western Avenue
Interconnect & Coordination System
Plan, City of Boston Public Works
Department; March 1994

RIZZO ASSOCIATES, INC.

Figure 1

Traffic Movement Pattern

Analysis of the existing traffic conditions, and observations of existing operations indicate the following:

Memorial Drive/Western Avenue

- Green time on the Western Avenue approach to the Memorial Drive intersection is typically greater than required.
- Backups from Western Avenue at Soldiers Field Road periodically block Memorial Drive.
- Green time on the Memorial Drive northbound approach is not always adequate to clear the left turn demand onto Western Avenue.
- The Memorial Drive southbound approach is operating at or near capacity.

Memorial Drive/Soldiers Field Road

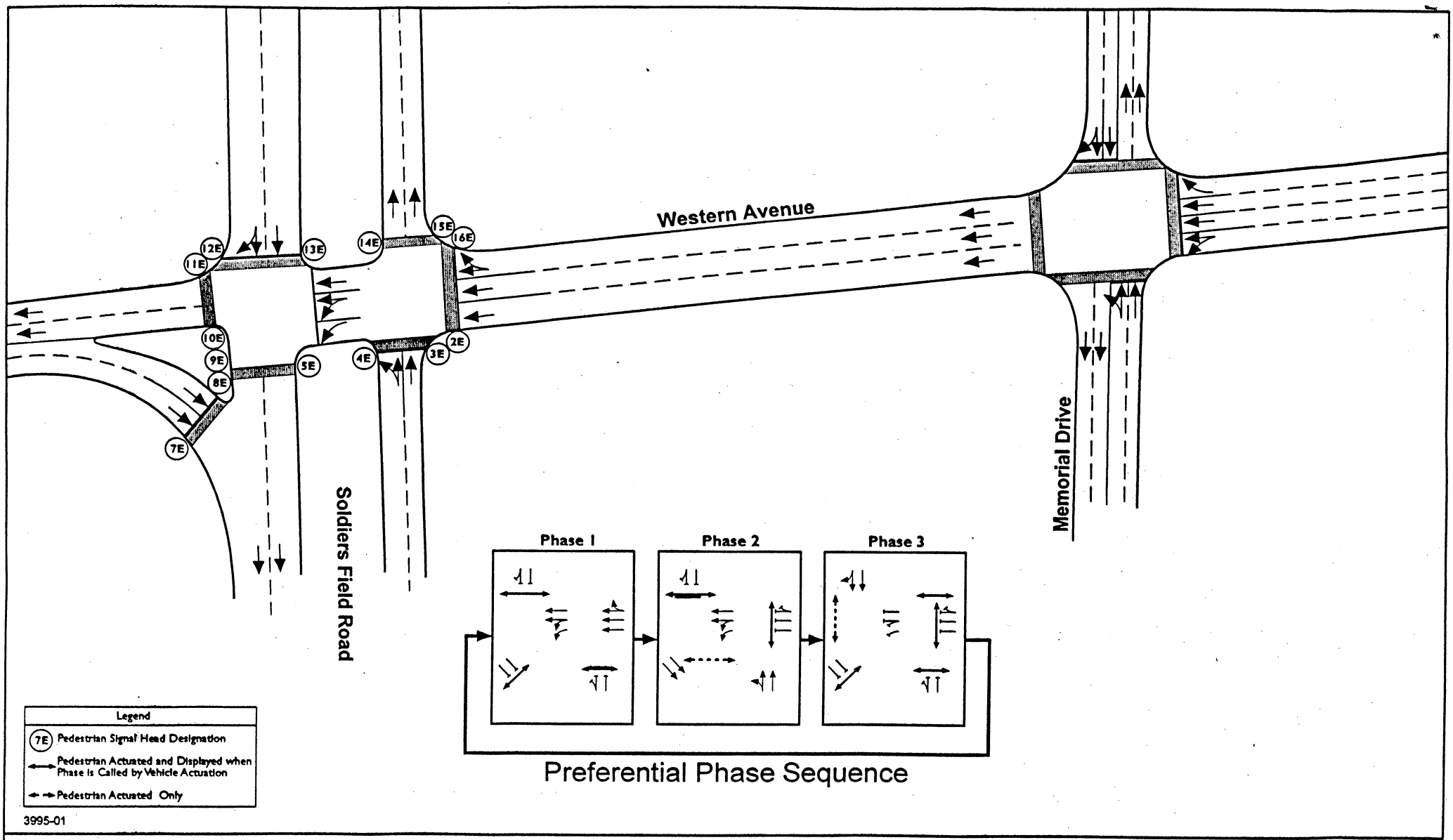
- Backups on the Western Avenue westbound approach periodically extend across the bridge and onto Memorial Drive, and block the flow of traffic on Memorial Drive. This typically occurs when traffic is highest on the Soldiers Field Road Ramps.
- Soldiers Field Road ramps appear to operate with minimal delay.

## Recommendations

Signal timing adjustments were developed based on capacity analyses and observations of existing conditions. The first consideration was to reduce the peak hour cycle lengths in order to reduce red time and the consequent queues. Reductions from the existing 100-second cycle length to 90 or 80 seconds were considered. High volume to capacity (v/c) ratios prompted the use of a 90-second cycle; however, it was identified that testing of lower cycle lengths might be considered based on observations of future traffic conditions.

Specific recommendations from the evaluation are as follows:

1. Signal timing adjustments for coordinated data summarized in Appendix A and described below.
2. Pedestrian crossing signal modifications at Soldiers Field Road/Western Avenue as follows (see Figure 2):
   - Display pedestrian heads 3E and 4E (Soldiers Field Road northbound), 7E and 8E (Western Avenue eastbound) and, 12E and 13E (Soldiers Field Road southbound) during phase 1.
   - Increase the phase 2 minimum green time to 12 seconds. Display pedestrian heads 2E and 16E (Western Avenue westbound), and 12E and 13E (Soldiers Field Road southbound) during phase 2.
   - Increase the phase 3 minimum green time to 13 seconds. Increase the phase 3 pedestrian clearance interval to 12 seconds. Display pedestrian heads 2E and 16E (Western Avenue westbound), 3E and 4E (Soldiers Field Road northbound), 7E and




Not To Scale

Source: Western Avenue Traffic Signal Plan, City of Boston Public Works Department; April 1994

RIZZO ASSOCIATES, INC.

Memorial Drive/Western Avenue and
Soldiers Field Road/Western Avenue
Cambridge, Massachusetts

# Soldiers Field Road/Western Avenue Recommended Pedestrian Crossings Modifications

Figure 2

8E (Western Avenue eastbound), and 14E and 15E (Soldiers Field Road northbound) during phase 3.

The signal offset, or the time difference between the Western Avenue green light display, at the two intersections is currently 15 seconds. A detailed analysis of the effect of the offset on vehicle queuing, and selection of the desired offset was discussed by the team. It is recommended that the offset remain at 15 seconds so as to provide delayed progression for the Western Avenue westbound movement, and develop a dense traffic platoon on the bridge before releasing it to Soldiers Field Road.

At Memorial Drive/Western Avenue the green time was reduced from the Western Avenue approach and allocated to Memorial Drive. In order to improve left turning from Memorial Drive onto the bridge (phase 2), and increase pedestrian crossing opportunities at Western Avenue (phase 3), additional time was allocated to both of these signal phases. Vehicle capacity on Memorial Drive will be increased by over five percent. The number of pedestrian crossing opportunities on Western Avenue at Memorial Drive will increase by 11 percent (from 36 to 40 per hour).

At Soldiers Field Road/Western Avenue maximum green times on the ramps have been reduced, and the time has been allocated to the Western Avenue westbound approach. The proposed timing changes are expected to reduce vehicle delay on the bridge, and will provide time necessary to reduce queuing on the bridge, and thereby prevent backups from blocking Memorial Drive. Minimum green times are increased slightly to accommodate more frequent pedestrian crossings.

A comparison of the traffic signal operations under the existing timing plans and proposed timing plans is included in Appendix B. The analysis includes intersection capacity analysis, queuing analysis, and time-space diagrams to graphically compare signal coordination and vehicle queuing for two alternative timing plans.

## Monitoring and Fine Tuning

Monitoring of traffic characteristics is the most accurate method to determine the effectiveness of the signal timing changes. Monitoring will include intersection turning movement counts by lane, and queue length measurements on critical approaches during the PM peak period (4:00 PM - 6:00 PM) on a typical weekday before and after the implementation of timing changes.

Phase 1 recommendations are intended for a 30-day trial period. Preferably, this trial will be completed in April 1998 in order to monitor traffic changes while local schools and universities are in session. Fine tuning and adjustment of the timing changes may be required during the 30-day trial period based on field observations.

C: Catherine Daly Woodbury; Cambridge Community Development
Lauren Preston; Cambridge Traffic & Parking
Stephen Kaiser; Cambridge Neighborhood Initiative
David Debaie; Vanasse & Associates, Inc.
Barry Pell; Rizzo Associates, Inc.

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# Appendix A

## Recommended Signal Timing Changes

### Memorial Drive/Western Avenue — Existing

| COORDINATION DATA (SEC) | | | | | | |
|---|---|---|---|---|---|---|
| | | PH 1 | PH 3 | PH 4 | CYCLE | OFFSET |
| CYCLE 2 | 2PM-8PM | 35 | 31 | 34 | 100 | 85 |

### Memorial Drive/Western Avenue — Proposed

| COORDINATION DATA (SEC) | | | | | | |
|---|---|---|---|---|---|---|
| | | PH 1 | PH 3 | PH 4 | CYCLE | OFFSET |
| CYCLE 2 | 2PM-8PM | 27 | 31 | 32 | 90 | 75 |

### Soldiers Field Road/Western Avenue — Existing

| COORDINATION DATA (SEC) | | | | | | |
|---|---|---|---|---|---|---|
| | | PH 1 | PH 2 | PH 3 | CYCLE | OFFSET |
| CYCLE 2 | 2PM-8PM | 42 | 33 | 25 | 100 | 0 |

### Soldiers Field Road/Western Avenue — Proposed

| COORDINATION DATA (SEC) | | | | | | |
|---|---|---|---|---|---|---|
| | | PH 1 | PH 2 | PH 3 | CYCLE | OFFSET |
| CYCLE 2 | 2PM-8PM | 46 | 23 | 21 | 90 | 0 |

**Notes:**

1. Existing timing and phasing from *Western Avenue Interconnect and Coordination System*, Boston Public Works Department, March 1994; and *Western Avenue Traffic Signal Plan*, Boston Public Works Department, April 1994.
2. No change to existing clearance intervals.
3. There is no Phase 2 designation for Memorial Drive/Western Avenue.

**Table 1**
**OPERATIONAL ANALYSIS RESULTS -**
**MEMORIAL DRIVE AT WESTERN AVENUE**
**1997 BASELINE WEEKDAY EVENING PEAK HOUR**

| Case | Cycle Splits | | | Approach/Lane | V/C[b] | AD[c] | LOS[d] | 95% Queue[e] |
|---|---|---|---|---|---|---|---|---|
| | Phase 1[a] | Phase 2 | Phase 3 | | | | | |
| Existing timing at 100 seconds. | 35 | 31 | 34 | Western Avenue WB LT/TH/RT[f] | 0.86 | 27.1 | D | 382 |
| | 35% | 31% | 34% | Memorial Drive NB LT | 1.13 | NC[g] | NC | 1,190 |
| | | | | Memorial Drive NB TH | 0.92 | 22.2 | C | 1,012 |
| | | | | Memorial Drive SB TH/RT | 1.05 | 60.1 | F | 651 |
| Existing timing splits adjusted to 90 seconds (VAI). | 32 | 27 | 31 | Western Avenue WB LT/TH/RT[f] | 0.85 | 24.3 | C | 346 |
| | 35% | 31% | 34% | Memorial Drive NB LT | 1.15 | NC | NC | 1,162 |
| | | | | Memorial Drive NB TH | 0.94 | 23.0 | C | 957 |
| | | | | Memorial Drive SB TH/RT | 1.04 | 56.1 | E | 596 |
| Cycle at 90 seconds with adjusted splits (VAI). | 27 | 31 | 32 | Western Avenue WB LT/TH/RT[f] | 1.03 | 48.7 | E | 378 |
| | 30% | 36% | 34% | Memorial Drive NB LT | 1.02 | NC | NC | 895 |
| | -5 | +4 | +1 | Memorial Drive NB TH | 0.86 | 13.6 | B | 817 |
| | | | | Memorial Drive SB TH/RT | 1.01 | 45.4 | E | 559 |

[a]Western Avenue.
[b]Volume-to-capacity ratio.
[c]Average delay per vehicle (in seconds).
[d]Level of service.
[e]95th percentile vehicle queue per lane in feet.
[f]Three and a half lanes on westbound approach.
[g]Not calculated. Delay and LOS are not meaningful when any v/c is greater than 1.2 or 1/peak-hour factor.
NB = northbound; SB = southbound; EB = eastbound; WB = westbound; LT = left-turn movement; RT = right-turn movement; TH = through movement.

**Table 2**
**OPERATIONAL ANALYSIS RESULTS - SOLDIER'S FIELD ROAD AT WESTERN AVENUE**
**1997 BASELINE WEEKDAY EVENING PEAK HOUR**

| Case | Cycle Splits | | | Approach/Lane | V/C[b] | AD[c] | LOS[d] | 95% Queue[e] |
|---|---|---|---|---|---|---|---|---|
| | Phase 1[a] | Phase 2 | Phase 3 | | | | | |
| Existing timing at 100 seconds. | 42 | 33 | 25 | Western Avenue EB RT | 0.48 | 20.5 | C | 230 |
| | 42% | 33% | 25% | Western Avenue WB LT | 0.94 | 32.4 | D | 772[f] |
| | | | | Western Avenue WB LT/TH | 0.99 | 34.4 | D | 704[f] |
| | | | | Soldiers Field Road NB LT/TH | 0.47 | 22.0 | C | 251 |
| | | | | Soldiers Field Road SB TH/RT | 0.59 | 27.5 | D | 254 |
| Existing timing splits adjusted to 90 seconds (VAI). | 37 | 30 | 23 | Western Avenue EB RT | 0.47 | 18.3 | C | 210 |
| | 42% | 33% | 25% | Western Avenue WB LT | 0.97 | 36.1 | D | 753[f] |
| | | | | Western Avenue WB LT/TH | 1.02 | 40.5 | E | 673[f] |
| | | | | Soldiers Field Road NB LT/TH | 0.47 | 19.8 | C | 230 |
| | | | | Soldiers Field Road SB TH/RT | 0.59 | 24.6 | C | 232 |
| Cycle at 90 seconds with moderate adjustment to splits. | 46 | 23 | 21 | Western Avenue EB RT | 0.62 | 23.5 | C | 230 |
| | 53% | 27% | 20% | Western Avenue WB LT | 0.77 | 14.0 | B | 588[f] |
| | +9 | -7 | -2 | Western Avenue WB LT/TH | 0.81 | 13.7 | B | 546[f] |
| | | | | Soldiers Field Road NB LT/TH | 0.64 | 25.3 | D | 251 |
| | | | | Soldiers Field Road SB TH/RT | 0.65 | 26.7 | D | 238 |

[a]Western Avenue.
[b]Volume-to-capacity ratio.
[c]Average delay per vehicle (in seconds).
[d]Level of service.
[e]95th percentile vehicle queue per lane in feet.
[f]Queue model does not accurately reflect queues on this approach given three different arrival rates.
NB = northbound; SB = southbound; EB = eastbound; WB = westbound; LT = left-turn movement; RT = right-turn movement; TH = through movement.

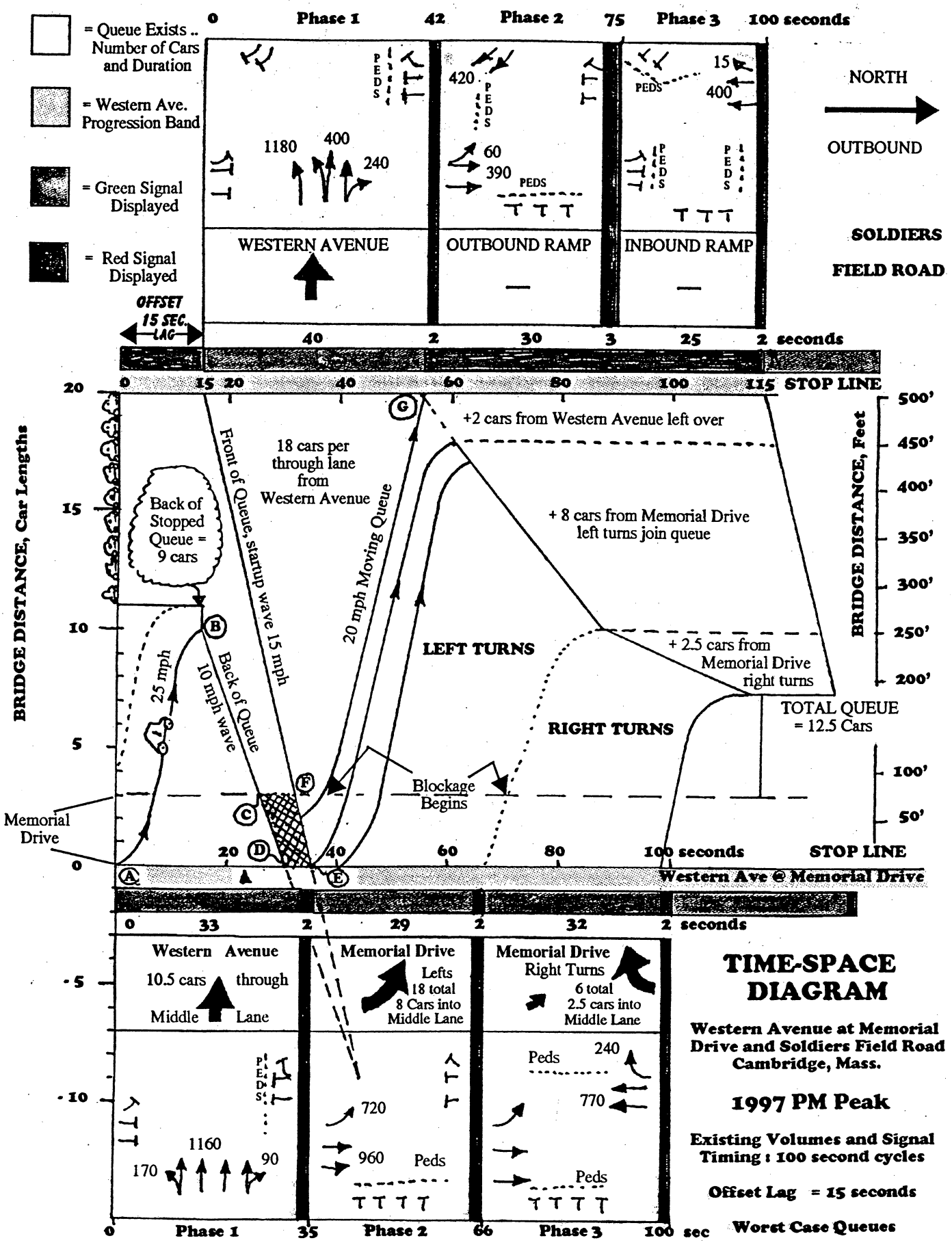


Figure 8 Signal Phasing, Flows and Queues ..... by S. Kaiser, CNI March 10, 1998

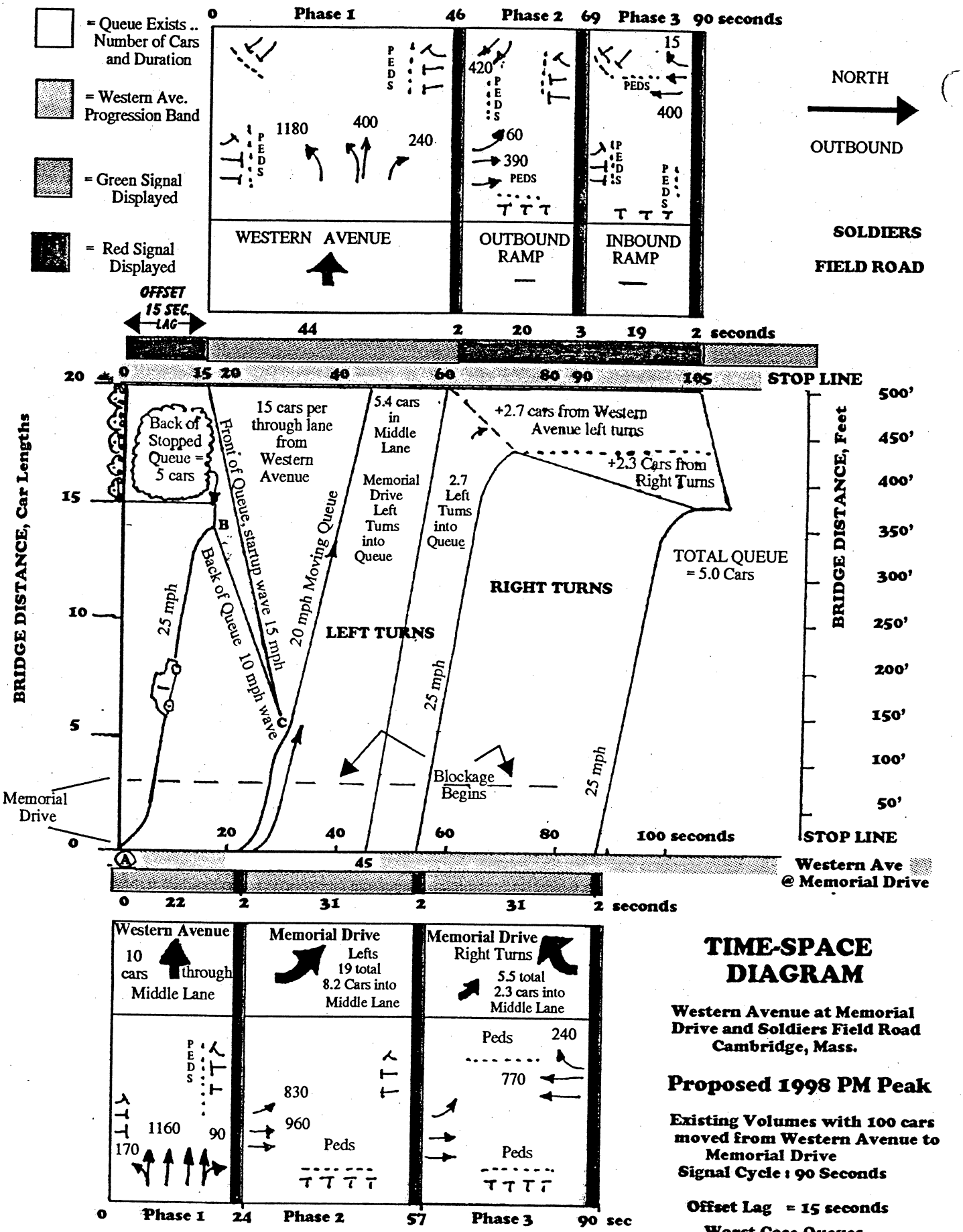


Figure 9 Signal Phasing, Flows and Queues ..... by S. Kaiser, CNI March 17, 1998

Vanasse & Associates, Inc.
Transportation Engineers & Planners

# MEMORANDUM

**TO:** Mr. Robert Dickey
Spaulding & Slye
125 Cambridgepark Drive
Cambridge, MA 02140

**FROM:** Mr. David DeBaic
Vanasse & Associates, Inc.
10 New England Business Center Drive
Suite 314
Andover, MA 01810
(508) 474-8800

**DATE:** April 8, 1998

**REF:** 1636

**SUBJECT:** 784 Memorial Drive Cambridge
Traffic Signal Warrants Analysis
(Amended per Traffic Engineering group comments)

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Traffic signal warrant analyses have been prepared for the proposed project on 784 Memorial Drive, Cambridge in the standard form cited in the *Manual on Uniform Control Devices* (MUTCD). Table 1 summarizes the review of each of the Warrants and Table 2 provides a sensitivity analysis with respect to trip distribution from the proposed garage. A series of site trip distributions to Pleasant Street were reviewed including existing, a 30 percent distribution, a 40 percent distribution, and a 60 percent distribution of exiting traffic to Pleasant Street as quantified in the November 1997 Traffic Review and Access Study (TRAS); five warrants were considered in the sensitivity analysis.

The analysis indicates that the rigorous eight-hour warrants would not be satisfied under any of the site trip distributions; however, four-hour and peak-hour warrants would be satisfied under specific conditions. Calculations are provided on attached detailed analysis.

## ASSUMPTIONS

1. The series of site trip distribution conditions are variations of that contained in the November 1997 TRAS for 784 Memorial Drive.

2. A temporal distribution includes the assumption that 90 percent of development generated trips occur between 7:00 AM and 8:00 PM.

3. Peak-hour volumes are as presented in TRAS. Non-peak hours between 7:00 AM and 8:00 PM were assumed to experience a percentage of the daily volume consistent with October 1995 empirical data collected by the city of Cambridge at a corporate center in Cambridge.

4. A single lane approach on Pleasant Street and four lane roadway on Memorial Drive was assumed.

**Table 1**
**MEMORIAL DRIVE AND PLEASANT STREET, CAMBRIDGE**
**TRAFFIC SIGNAL WARRANTS ANALYSIS SUMMARY**

| Warrant | Met | Comment |
|---|---|---|
| 1: Minimum Vehicular Volume | No | See Table 2 |
| 2: Interruption of Continuous Traffic | No | See Table 2 |
| 3: Minimum Pedestrian Volume | No | See Note 1 |
| 4: School Crossings | No | See Note 2 |
| 5: Progressive Movement | No | See Note 3 |
| 6: Accident Experience | No | See Note 4 |
| 7: Systems | No | See Note 5 |
| 8: Combination of warrants | No | See Note 6 |
| 9: Four-Hour Volumes | Yes at 40% | See Table 2 |
| 10: Peak-Hour Delay | Yes at 30% | See Note 7 |
| 11: Peak-Hour Volume | Yes at 30% | See Table 2 |

1. Warrant 3 is met when 100 or more pedestrians cross during each of any four hours; or, 190 or more during any one hour. Pedestrian crossings of this magnitude have not been observed.
2. This intersection is not a school crossing
3. The nearest signal is less than the minimum spacing requirement of 1,000 feet.
4. Trials of less restrictive remedies have not been attempted; Cambridge Police records indicate no recent (1995 to 1997) accident occurrence; the 80 percent requirement of Warrant 2 is met at 40 percent distribution; progression opportunity has not been reviewed in detail.
5. Two or more major routes do not exist.
6. Eighty percent of Warrants 1 and 2 are required during each of eight hours; under 60 percent distribution only two hours would meet the required level of Warrant 1.
7. Warrant 10 is satisfied when four vehicle hours of delay (or 14,400 vehicle seconds) is incurred during one hour. At 30 percent distribution, an average delay greater than 107 seconds/vehicle would meet the warrant condition; at 40 percent: 87 seconds; at 60 percent: 64 seconds/vehicle. Analysis included in the TRAS supports the likelihood that the 107 seconds/vehicle average delay will be exceeded at the 30 percent distribution of site trips to Memorial Drive via Pleasant Street.

**Table 2**
**TRAFFIC SIGNAL WARRANTS SENSITIVITY ANALYSIS**

| Site Trip Distribution[a] | Warrants Satisfied | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 9 | 10 | 11 |
| Existing[b] | No | No | No | No | No |
| 30%[c] | No | No | No | Yes | Yes |
| 40%[d] | No | No | Yes | Yes | Yes |
| 60%[e] | No | No | Yes | Yes | Yes |

[a] To Memorial Drive via Pleasant Street.
[b] Existing as presented in TRAS (October 1997).
[c] 784 Memorial Drive distribution to Memorial Drive as presented in TRAS.
[d] 784 Memorial Drive distribution to Memorial Drive with 10 percent reassigned from Florence Street.
[e] 784 Memorial Drive distribution to Memorial Drive with 20 percent reassigned from eastbound Putnam Avenue (after exiting the garage via Putnam Avenue driveway).

S-152

Consent Communication #23

Step-3 Report on 784 Memorial Drive.

In City Council March 1, 1999

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