Traffic and Parking Management in the City of Cambridge

Worcester Polytechnic Institute

Interdisciplinary Qualifying Project

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April 29, 2002

Acknowledgements

We would like to thank the following people for contributing to the development and completion of this project:

From the City of Cambridge, we would like to thank:

Jason Schrieber
Susan Clippinger
Wayne Amaral
Jeff Parenti
Catherine Preston
Jeff Amero
Eric Josephson

From Worcester Polytechnic Institute, we would like to thank our professors:

Ted Crusberg
Michelle Ephraim
Fabio Carrera

We would also like to thank the entire staff of the Traffic, Parking, and Transportation Department and Community Development Department for providing use with office space and allowing us to do this project.

Also, we would like to thank the members of the GIS department for providing us with technical assistance relating to the GIS program in Cambridge.

Authorship Page

Statement from the team: *All team members shared equally in the creation of this report.*

Abstract

We developed a system to monitor and manage parking resources in the City of Cambridge, Massachusetts. This system includes a database, Geographical Information System map layers, and a set of standard operating procedures to collect and organize data on the city's on-street and off-street parking resources. We also performed a trial integration of our system to optimize performance of the system and demonstrate its analytical capabilities to the City of Cambridge.

Executive Summary

For years, the City of Cambridge has pursued a cleaner environment and a higher quality of life for city residents through city ordinances, regulations, and other measures aimed at decreasing traffic and increasing the use of environment-friendly modes of transportation. These measures have ranged from the parking freeze in 1984 which set a limit on the total number of commercial parking spaces in Cambridge (partially in order to conform with the federally-implemented Clean Air Act), to the recent Parking and Transportation Demand Management Ordinance which requires organizations to implement numerous measures aimed at decreasing employee reliance on single-occupant vehicles for commuting to work. The Traffic, Parking and Transportation Department (TPTD), one of several city departments that work together with the objective of improving the transit options available to city residents and reducing the impact of these means of transportation on the environment, currently monitors the use of parking resources in the city and their role in dealing with traffic issues.

While the City has conducted inventories of parking facilities in previous years, there is no method for systematically confirming or updating this information. The TPTD's effort to manage and monitor parking resources in the city is hindered by this lack of a comprehensive and current source of information. The prior inventories of off-street and on-street parking resources did not take advantage of the City's advanced capabilities in graphically depicting and analyzing this information.

The main goal of this project was to develop a new system that facilitated access to a current inventory of parking resources and allowed this information to be depicted graphically. The team designed a new Microsoft Access database for storing, accessing, and analyzing information for on-street and off-street resources that incorporates both the data from the department's old inventories and the new data gathered from the project's study area. We developed and demonstrated a systematic method for cataloging all parking resources in a geographic region of the city and delivered this in the form of a standard operating procedure that can be utilized by the city when implementing similar inventories in other neighborhoods. The collected data was represented graphically in the form of map layers which were linked to the database in order to illustrate the advantages of using the Geographic Information System resources already available at the TPTD to display and manipulate this data and to study geographical relationships between the parking resources.

In order to demonstrate the analytical capabilities of our system we developed thematic maps and other similar spatial analyses, examples of which included maps representing the relation between residential populations to available parking resources using Census data for individual neighborhoods. Such a study would allow the TPD to better identify imbalances between the parking needs of particular neighborhoods and the availability of parking resources in those areas. This in turn would enable them to proactively deal with parking issues in problem areas through early identification. Other analyses included identification of discrepancies between actual field data and the

Figure 1: GIS Map Layers

information possessed by the Traffic and Parking Department through the use of color-coded maps depicting locations of those particular facilities and the types of discrepancies that exist. Some of the map layers created by the team are shown in below.

The maps created by the project team illustrating locations of off-street parking lots combined with a description of the usage of each of these lots, such as commercial, public etc. will allow for a study of the balance in types of parking available. Availability of data on off-street lots linked to map layers with outlines of lots and their configurations will make it easier for a new user to access data about a lot by reducing ambiguities in identification of lots, such as those with multiple addresses listed. This would also eliminate the reliance on experienced department members with an extensive knowledge of these resources as it would make a clear picture available to all users. Multiple layers illustrating the various types and numbers of parking spaces in a region along with traffic and population information will aid the department in making permit granting decisions. Such a visual representation will also enable planning of future surveys, something that the current mechanism does not allow. Above and beyond the actual uses of the data collected, the standard operating procedures developed for gathering data on parking resources in other neighborhoods will prove useful in ensuring compatibility of data gathered by different individuals over the course of time.

In the larger context, having access to a comprehensive and current database of parking resources will help the City in fulfilling an important departmental goal which is to balance the economic needs of businesses with the concerns of the members of the community. Parking plays a very important role in of the lives of local residents, so much so that they are willing to put in a significant amount of time and effort to ensure that the City is aware of any perceived parking problems. This was amply demonstrated by the residents of the Riverside neighborhood who presented the TPTD with results of a residential parking supply inventory performed by them as part of a lobbying effort against expansion in the neighborhood by Harvard University. Figure 2 illustrates the sentiments of some Riverside residents towards large-scale parking development. In the future, instead of having to conduct case-by-case studies to verify claims made by residents, the City will be able to negotiate such issues based on the comprehensive data available through the new parking management tool.

Figure 2: Community Sentiments - Riverside vs Harvard

At the completion of this project, the group concluded that the City needed to begin streamlining its data-gathering mechanisms in order to avoid the unnecessary expenditure caused by various departments maintaining separate databases on parking resources. We recommend that the TPTD use this new system to create a centralized database that multiple departments can access. This will not only keep the available information current, but will also help avoid discrepancies in data used by different departments. The project should further be extended to cover the entire city using the standard operating procedures developed by the team so as to provide current and accurate data that will allow efficient management and monitoring of all parking resources in Cambridge.

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1 Introduction

Automobiles have come a long way since Karl Benz first invented the three-wheeled "Motorwagen", the world's first practical vehicle to be powered by an internal combustion engine, in Mannheim, Germany back in 1885. Henry Ford and his Model T then went on to alter the face of American society over the first half of the twentieth century by bringing an affordable means of private transportation to the masses. Today's multitude of makes and models has made cars an indispensable part of our daily lives. Of course, cars have also brought with them their share of problems, the most persistent being the traffic issues associated with this increasingly growing means of transport. All of us have probably had to deal with the effects of traffic at some point in our life. Possibly, it was an hour's worth of sitting idle in the middle of a city street while missing an important meeting two blocks away. It could have been the taste of car exhaust in the air as you walk down the sidewalk. Maybe it even involved avoiding the reckless actions of a fellow driver under the influence of "road rage." Automobile traffic has a noticeable effect on the quality of life.

Cities around the world have devoted substantial resources to managing traffic related issues, but few have met with complete success in controlling traffic. One such city is Cambridge, Massachusetts, which was the focus of our project. The ultimate goal of this project was to assist the Traffic, Parking and Transportation Department (TPTD) of the City of Cambridge in improving the quality of life for the local community by regulating traffic through efficient management and monitoring of parking resources within the city. This involved designing database systems and using spatial modeling software to produce reports that can be used as a decision-making support tool to formulate policies and ordinances in order to control parking.

The following chapters describe the background information needed to gain a more complete understanding of our project, the methodology employed to achieve the project's goals, and results and analysis.

- **Chapter 2** discusses the necessary background literature. It first provides geographic and demographic information on the City of Cambridge and offers details on the transportation infrastructure within the city. Next, it goes on to describe the various government organizations and agencies that influence the traffic laws and regulations in the city. The chapter concludes with studies of techniques used by other cities to solve similar problems.
- **Chapter 3** explains the methodology applied in order to attain our goals. It identifies the main objectives of the project and lists the methods we will use to fulfill each of these objectives.
- **Chapter 4** summarizes the results of the study. It details the currently available tools the various data gathering processes utilized and finally describes the salient features of the system that we developed.
- **Chapter 5** contains a description of how the data gathered was analyzed and interpreted.

- **Chapter 6** includes the conclusions the project team reached and recommendations we made upon the completion of the project.
- **Chapter 7** includes a complete bibliography of sources used in the compilation of this proposal.
- **Appendix A** has the annotated bibliography.
- **Appendix B** offers information on the agency sponsoring the project, the Traffic, Parking and Transportation Department of the City of Cambridge.
- **Appendix C** provides details on other organizations connected to the project, such as the Community Development Department.
- **Appendix D** is the full text of the Vehicle Trip Reduction Ordinance and the Parking and Transportation Demand Management Ordinance, contained in Chapter 17 and 18, respectively, of Title 10 of the City of Cambridge Municipal Code.
- **Appendix E** is a full-page map of East Cambridge, the study area of the project.
- **Appendix F** contains screenshots of the data-entry forms and map layers developed as part of the parking management system. It also lists the structure of the fields in the database tables.
- **Appendix G** provides copies of the data-collection forms that were used to gather data in the field.
- **Appendix H** contains the standard operating procedures developed by the team for the data-collection, data-entry and mapping tasks.
- **Appendix I** illustrates the calculations that were used to perform the time-study analysis.

2 Background and Literature Review

This chapter describes the background of the City of Cambridge in which the project is to take place and details the need for implementing such a study.

- **Section 2.1** introduces the City of Cambridge and discusses its geographic location and historical background. It then offers a statistical abstract of Cambridge's demographics, including population, housing, and economic trends.
- **Section 2.2** explains the traffic and transportation infrastructure in Cambridge. It details the various public and private transportation means available within the city and provides details on the problems these modes off transportation pose to the city.
- **Section 2.3** lists the various government agencies at the federal, state and city levels that influence the traffic situation in the city. The section then goes on to provide details on the various laws and regulations enacted by government agencies to deal with traffic problems and describes the agencies that are responsible for implementing these rules.

2.1 City of Cambridge

The City of Cambridge, in the Commonwealth of Massachusetts, is located on the northern border of Boston. It was incorporated as a town in the year 1636 and as a city in 1846.[1] The City Government is headed by the City Manager whose Office is the Executive Department for the City of Cambridge. The city also has a mayor and a City Council, which consists of nine councilors.[2] This geographically small city of 101,355 people lies on the Charles River, and is home to one of the most ethnically diverse populations in the country. About 20% of its residents are foreign-born and students at its public schools come from sixty-four different nations and from families that speak 46 different languages. Four colleges, including two of the world's most renowned universities –

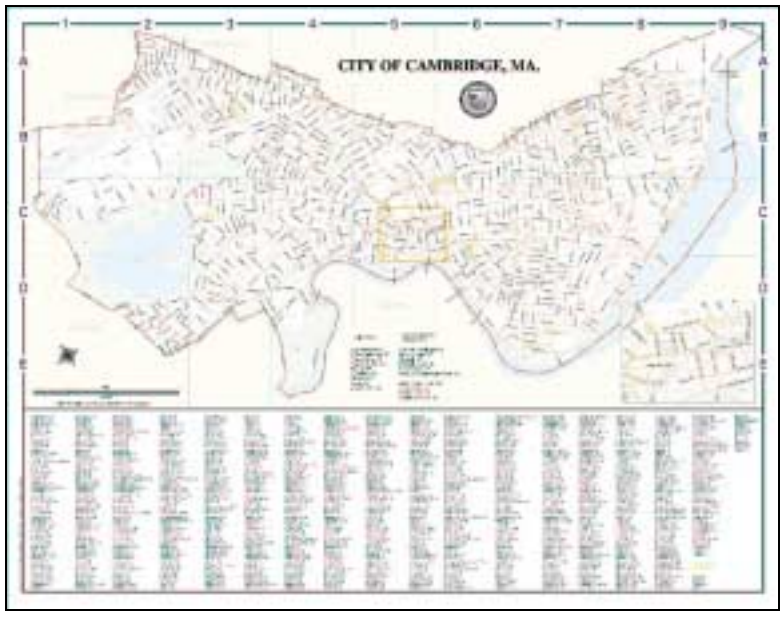

Figure 3: Map of the City of Cambridge

[1] "Boston.com" Your Town – Cambridge.
n.d. <http://yourtown.boston.com/town/cambridge/> (24 January 2002).
[2] City of Cambridge, Massachusetts. City of Cambridge.
n.d. <http://www.ci.cambridge.ma.us/> (20 January 2002).

Harvard and the Massachusetts Institute of Technology – are located here. More than one-fourth of its residents are college students and one-sixth of all the jobs in the city are in higher education.[3]

Covering an area of only about six and a half square miles, it contains 120 miles of public roads and 44,725 housing units (see Figure 3 for a map of the city).[4] The population density is quite high, approximately 15,942 persons per square mile, as can be expected of a city located in New England's largest metropolitan area. This average density is almost twenty times as great as the 810 persons per square mile in the rest of Massachusetts, making Cambridge the third most densely populated city in the state. Cambridge ranks fifth in Massachusetts in terms of population but only 329th in terms of area, further demonstrating how saturated the city really is. The population has grown by 5.8% since 1990 but is only 0.99% larger than the population in 1970.[5] Cambridge's population is expected to grow 3.6 % further by the year 2005 to 104,984.[6] The city is therefore facing steadily mounting pressure on its limited resources.

The number of housing units per square mile is a high 6,957, which is quite characteristic of a crowded city. The number of households in the city was 42,615 in the year 2000, up from 39,405 in 1990 – an increase of 8.1 percent over the past ten years. The number of families in Cambridge however, only increased by 0.1 percent, pointing to a steep increase in the number of non-family households.[7] The average annual wage earned by people employed in Cambridge in 2000 was $58,781, well over the state average of $43,869.[8] The number of businesses in Cambridge is over 4000 (excluding the self-employed), a large number for such a small city. The business sector in Cambridge primarily consists of service industries with some wholesale and retail trade businesses and a few manufacturing industries.[9] The number of jobs in Cambridge reached a new peak of 115,614 in 2000, a result of the vast number of high-tech industries emerging in and around the metropolitan area. The fact that the number of jobs in the city is larger than the available resident workforce points to a net inflow of commuters headed for work. The data available from the 1990 census also indicate that the number of workers in Cambridge commuting to work in cars is 35% more than those using public transportation to get to work. The statistics discussed in this section are summarized below in Table 1.

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[3] Massachusetts Department of Housing and Community Development. Cambridge, Middlesex County. n.d. <http://www.state.ma.us/dhcd/iprofile/049.pdf> (31 January 2002).

[4] U.S. Census Bureau. Profiles of General Demographic Characteristics, 2000 Census of Population and Housing, 354. n.d. <http://www.census.gov/prod/cen2000/dp1/2kh25.pdf> (24 January 2002), and "Boston.com" Your Town - Cambridge (24 January 2002)

[5] Citizen Information Service, Commonwealth of Massachusetts. Massachusetts Facts. n.d. < http://www.state.ma.us/sec/cis/cismaf/mf1c.htm> (31 January 2002) and Boston.com Your Town – Cambridge.

[6] Massachusetts Division of Employment and Training. Mass Stats. n.d. < http://www.detma.org/MassStats/websaras/index.asp> (31 January 2002).

[7] U.S. Census Bureau, 354.

[8] City of Cambridge. Frequently Asked Questions About Cambridge Demographics. December 28, 2001 <http://www.ci.cambridge.ma.us/~CDD/data/datafaq.html> (January 23, 2002) and U.S. Department of Commerce, Bureau of Economic Analysis. Regional Accounts Data, Annual State Personal Income. 10 December 2001. < http://www.bea.doc.gov/bea/regional/spi/> (31 January 2002).

[9] City of Cambridge, FAQ About Cambridge Demographics.

	Cambridge[10]	Massachusetts[11]
Year Incorporated	1846	-
Population *(2000)*	101,355	6,349,097
Population *(1990)*	95,802	6,016,425
Growth Rate	5.8%	5.5%
Projected Population *(2005)*	104,984	6,505,160
Projected Pop. Growth Rate	3.6%	2.5%
Foreign-born percentage	> 20%	12%
Students Percentage	> 25%	25%
Workers 16 years and over *(1990)*	52,595	2,979,594
Drove alone	19,719 (*37.5 %*)	2,148,065 (*72 %*)
In carpools	3,937 (*7.5 %*)	318,026 (*11 %*)
Using public transportation	12,376 (*23.5 %*)	247,381 (*8 %*)
Using other means	1,869 (*3.5 %*)	29,447 (*1 %*)
Walked or worked at home	14,694 (*28 %*)	236,675 (*8 %*)
No. of households *(2000)*	42,615	2,443,580
No. of households *(1990)*	39,405	2,247,110
Household Growth Rate	8.1%	8.7%
Area	6.5 square miles	7,838 square miles
Population Density	15,942 persons/sq. mile	810 persons/sq. mile
Miles of public roads	120.61 miles	-
No. of housing units	44,725	2,621,989
Housing unit density	6,957 per sq. mile	334.5 per sq. mile
Avg. Annual Wage *(2000)*	$58,781	$43,869

Table 1: Cambridge Demographics

2.2 Transportation in and around Cambridge

The City of Cambridge provides a wide array of public transit options and provides infrastructure for private transportation. Buses and trains can be a less expensive, quicker, and easier way to get into and around the city. Although this is a very appealing form of transportation to the residents, it can be just as appealing to non-residents who also need to find parking, avoid traffic, and get into Boston or other neighboring cities. In Cambridge alone there are approximately 115,000 jobs and only about 100,000 residents. Since the resident population of Cambridge includes children, college students, retirees, residents working outside of Cambridge, and other non-working citizens, it is clear that a sizeable number of people need to commute into Cambridge for work.[12] Many different factors contribute to the significant traffic and pollution problem in Cambridge. This traffic adversely affects the quality of life by creating air and noise pollution and making it difficult to drive in the city. The City of Cambridge does not appear to need more public transportation as much as it needs to encourage commuters and residents to regularly use public forms

[10] U.S. Census Bureau. Profiles of General Demographic Characteristics, 2000 Census of Population and Housing, 354. n.d. <http://www.census.gov/prod/cen2000/dp1/2kh25.pdf> (24 January 2002), and "Boston.com" Your Town - Cambridge (24 January 2002)
[11] U.S. Census Bureau. American FactFinder. n.d. <http://factfinder.census.gov/servlet/BasicFactsServlet> (6 February 2002)
[12] U.S. Census Bureau. Profiles of General Demographic Characteristics, 2000 Census of Population and Housing. May 2001. <http://www.census.gov/prod/cen2000/dp1/2kh25.pdf> (24 January 2002).

of transportation alternatives to single-occupant automobiles. The city needs to manage its transportation and parking options without causing parking and congestion problems on the Cambridge roadways.[13]

2.2.1 Private Transportation in Cambridge

Within Cambridge there are five state and U.S. routes. The highways traveling through and around Cambridge add to the traffic trouble in the city by requiring Cambridge to accommodate for the daily through trips that the city cannot easily regulate. State Routes 2, 2A, 16, 38, and US Route 3 all pass through Cambridge. (Figure 4) The Mass Turnpike travels right along the Boston side of the Charles River, which is the southern border of Cambridge. Also, Interstate 93 passes along the Somerville side of the border to the east. All of these roads make the traffic a greater problem by making it easier for non-residents to drive to Cambridge and further deteriorate traffic conditions.

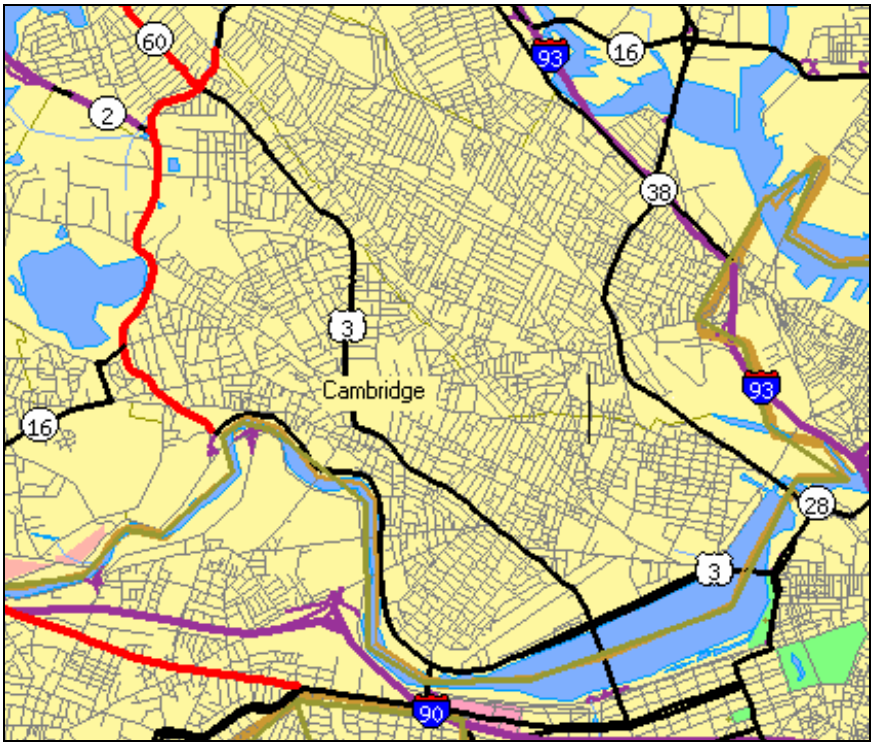

Figure 4: Cambridge Highways Map[14]

Cambridge is already trying to implement traffic-calming measures to slow down the use of private cars as transportation and to encourage an increase in the amount of bikes, walkers, and other non-polluting types of transportation for commuting to work or school. The city is trying to promote businesses to encourage employees to ride their bikes or walk by making changing facilities available and to purchase T passes for some of their employees. Also, there may be some problems around the two parking structures provided at the Massachusetts Bay Transit Authority (commonly called MBTA or T) stations. The total number of commuters and businesses that need to use the MBTA services provided might exceed the limit of the

[13] "Boston.com" Your Town – Cambridge.
n.d. <http://yourtown.boston.com/town/cambridge/> (24 January 2002).

[14] U.S. Census Bureau. Tiger Map Server Browser. n.d. < http://tiger.census.gov/cgi-bin/mapsurfer?infact=2&outfact=2&act=move&on=CITIES&on=majroads&on=places&on=streets&on=interstate&on=statehwy&on=ushwy&tlevel=-&tvar=-&tmeth=i&mlat=42.33602&mlon=-71.01789&msym=redpin&mlabel=Boston%2C+MA&murl=&lat=42.36325&lon=-71> (14 February 2002)

parking structures. Only Lechmere and Alewife Stations offer public parking, approximately 320 and 2200 spaces respectively. [15]

2.2.2 Public Transportation in Cambridge

The MBTA controls most of the public transportation in the greater Boston area and in eastern Massachusetts. It operates four subway lines: the Red line running north-south through Boston and Cambridge, the Green line which also has one stop in Cambridge, the Orange line, and the Blue line. The MBTA also operates five commuter boat routes, thirteen commuter rails, and approximately one hundred seventy bus routes throughout the area. Several of these bus routes and commuter rails run through Cambridge. The MBTA stations inside Cambridge include Kendall Square, Harvard Square, Central Square, Porter Square, Alewife, and Lechmere. (Figure 5) Each of these stations is connected to multiple bus routes that run almost all day long (5:00am – 1:30am). All of the stations except for Lechmere are on the Red line. Lechmere Station is on the Green line, which runs east-west into downtown Boston. At the Porter Square Station, the Red line makes a connection with the Commuter rail, which runs from Boston's North Station to Fitchburg.

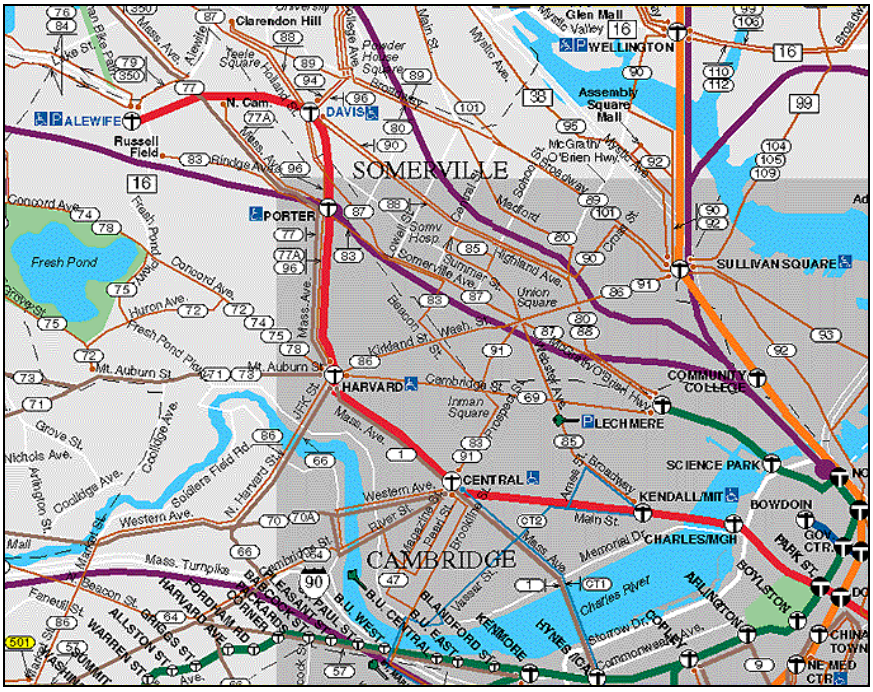

Figure 5: MBTA map of all routes through Cambridge

Cambridge has numerous T bus routes and trains running through its borders too. This results in some advantages and some drawbacks for the City of Cambridge. While the T is beneficial for the residents who live in Cambridge and do not have to go far to find a quick and affordable way into Boston, the MBTA could also affect and inadvertently contribute to unwanted traffic. The buses, which run all day long and more frequently during rush hour, could be contributing to the traffic problem because they have to pull over at almost all of the bus stops along their respective routes, resulting in a slow down in the flow of traffic. Much of the Boston work force comes from the outside of Boston and some of them go through Cambridge. The schools, businesses, and transit stops in Cambridge have the potential to draw a large volume of people

[15] Massachusetts Bay Transportation Authority n.d. <http://www.mbta.com/> (24 January 2002).

into the city. This consequently creates the risk of filling the city with more traffic than the roads can support and more cars than can fit into the legal parking spaces available.

2.2.3 Successful Traffic Management Projects in Other Cities

Other cities across the world have successfully managed parking and incorporated public transportation into the daily lives of most of their respective inhabitants. Zurich, Switzerland and Copenhagen, Denmark are two of these cities. Both cities have large public transportation systems based around punctuality, alternative modes of transit, and traffic deterrents. These two cities are good example because they have many of the same problems and some of the same characteristics as Cambridge. Zurich, Copenhagen, and Cambridge all lie on the water and all have very similar climates. All three were designed before the invention of cars so most of the roads are narrow. An examination of the techniques used in Copenhagen and Zurich sheds light on some of the tools potentially available to Cambridge in its response to traffic problems.

Copenhagen used many different techniques to deter traffic. The city restricted all types of parking and increased the prices of parking tremendously in areas that were accessible by public transit. There were also numerous road-obstructing tactics used that made the roads less drivable. Because of these measures, city residents developed a strong dislike for city driving and subsequently these measures caused an increased number of people turned to the use of public transit. Another strategy employed by Copenhagen was to raise taxes and fees on the purchase of cars. Vehicle weight and engine size were made primary factors in determining the tax to be paid. This was to discourage the large fuel inefficient vehicles that roam freely in the U.S. An interesting point about Denmark is that the number of non-motorized vehicles is exceptionally high. Lots of people in the area ride bikes or walk to where they need to go. In Section 2.3.3, we will explore how Cambridge plans to develop similar bicycle and pedestrian alternatives through city legislation. Copenhagen has only about 190 cars per 1000 residents (1994), an astonishingly low number for a first world city. In comparison, Cambridge has approximately a 2-1 ratio of residents to cars.

Zurich is also an extraordinary city in terms of mass transit. Switzerland is known for the punctuality of its trains, but it also used other techniques to encourage use of public transportation. On average, Zurich residents make about 560 trips annually using transit. To calm traffic, the City decreased the right of way of cars, in place of trams, pedestrians, and buses. Trams (above ground railway cars) were given various new privileges, and both buses and trams were given lanes designated specifically for their use only. Cars were outright banned from some areas. Zurich also developed a fairly complicated system for controlling traffic signals based on the number of cars on the road. The city uses sophisticated computers and monitoring equipment to anticipate traffic problems and direct them to other parts of the city and clear up major traffic congestion even before it occurs. One of the more popular strategies is the use of cost-rewards programs to award frequent users of the mass transit systems. Some of the techniques employed by these programs

include offering large price discounts on monthly transit passes, allowing users to switch between transit lines or modes of transit for a single fare, and integrating transit passes into tickets for special events or hotel accommodations within the city. These programs appear to be a success because they offer a financial incentive for the people of Zurich to use public transportation instead of automobiles whenever possible. The ideals behind most of these programs parallels to efforts in Cambridge to increase mass transit ridership by encouraging or requiring some employers to provide discounted MBTA passes for their employees. Many of Copenhagen's and Zurich's strategies could be employed by Cambridge to solve its own traffic problems and improve mass transit usage. [16]

2.3 Transportation Laws and Regulations

Concerns for the protection of the environment on the federal, state, and local levels provide significant motivation to manage traffic in the City of Cambridge. In 1990, Congress made major amendments to the Clean Air Act, which, among other issues, addresses traffic concerns based on the premise that "urbanization, industrial development, and the increased use of motor vehicles" is the cause of enough air pollution to endanger public health. The act specifies that States and local governments are responsible to control the air pollution caused in their area.[17] At the federal level, the Environmental Protection Agency (EPA) ensures that each of the states develop a State Implementation Plan (SIP). These SIPs, which must be approved by the EPA, are sets of regulations or laws developed by the States in conjunction with their local communities to meet the requirements of the Clean

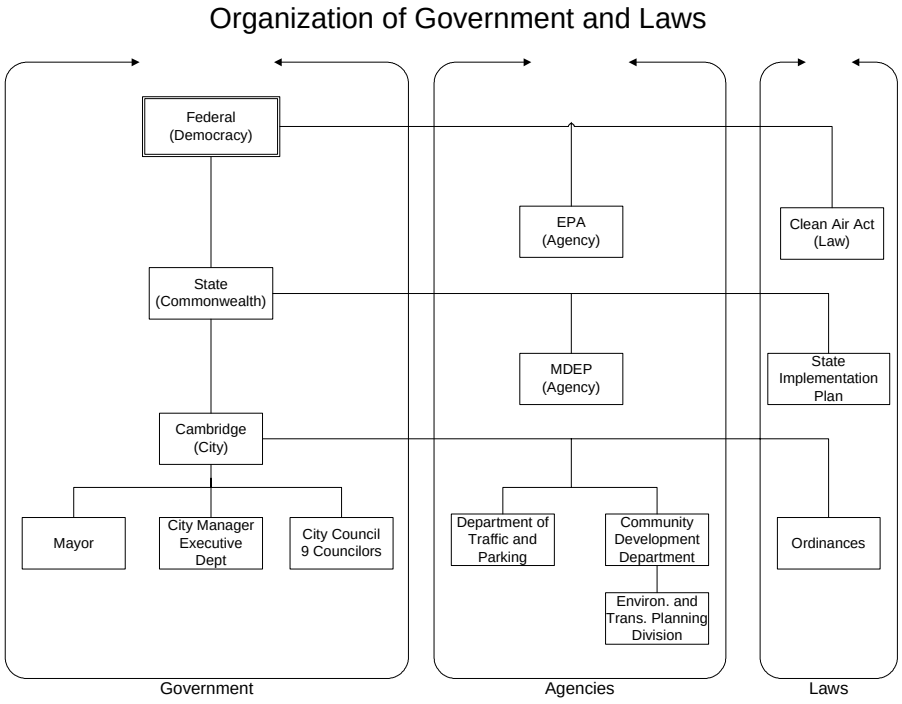

Figure 6: Organization of Government and Laws

[16] Cervero, Robert. The Transit Metropolis: A Global Inquiry. Washington, D.C.: Island Press, 1998. p. 132-154, 299-318.
[17] U.S. Congress. Senate. "Clean Air Act of 1990." 101st Congress, 2nd Session, S.1630. Congressional Record, Volume 136. n.d. <http://thomas.loc.gov/cgi-bin/query/z?c101:S.1630.ENR:> (24 Jan 2002).

Air Act.[18] The Massachusetts Department of Environmental Protection enforces the SIP within the Commonwealth.[19] The tree in Figure 6 shows organization of these agencies and laws.

2.3.1 The Cambridge Traffic, Parking, and Transportation Department

Within Cambridge, there are additional agencies that work to increase quality of life through the understanding of traffic and parking. The Transportation Policy Goals of the City of Cambridge as stated by the Traffic, Parking, and Transportation Department attempt to provide the widest possible range of transportation systems to fill the needs of the residents, businesses, and institutions of Cambridge. This goal statement places priority on developing travel options in such a way as to encourage commuters and visitors to use methods other than single occupant vehicles, thus reducing air pollution, congestion, and other negative attributes of automobile transportation. The Traffic and Parking Department monitors and maintains the parking resources in Cambridge. Such activity supports transportation needs in the community of Cambridge and limits traffic and pollution.[20]

2.3.2 The Cambridge Community Development Department

Another agency that is charged with carrying out the goals of the City's transportation policy is the Environmental and Transportation Planning Division of the Community Development Department. This division states that it is "responsible for improving the city's quality of life, by working to protect and improve the city's environment and natural resources and by planning improvements to the city's transportation system." Its methods for achieving these objectives include promoting methods of transportation other than motorized single occupant vehicles, encouraging energy efficiency, and executing the Vehicle Trip Reduction (VTR) Ordinance and the Parking and Transportation Demand Management (PTDM) Ordinance.[21]

2.3.3 Vehicle Trip Reduction Ordinance

The Vehicle Trip Reduction Ordinance and the Parking and Transportation Demand Management Ordinance detail plans of action to control air pollution in Cambridge. These ordinances compose two chapters of Title 10 of the City of Cambridge Municipal Code. The Vehicle Trip Reduction Ordinance initiates a number of programs with the aim to achieve the requirements of the National Ambient Air Quality Standard included in the 1990 amendments to the Clean Air Act. A few sections of the ordinance propose changes to be made to the State Implementation Plan in order to reduce pollution from automobiles in

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[18] Office of Air Quality Planning and Standards of the Environmental Protection Agency. "The Plain English Guide to the Clean Air Act." EPA-400-K-93-001: April 1993. 5 September 2001.
<http://www.epa.gov/oar/oaqps/peg_caa/pegcaain.html> (28 Jan 2002).

[19] For a status report on MDEP's efforts to implement the SIP see: Massachusetts Department of Environmental Protection: Bureau of Waste Management. Implementation of the 1990 Federal Clean Air Act Amendments: A Massachusetts Status Report, April 2000. Air Program Planning Unit Publications. 25 April 2000
<http://www.state.ma.us/dep/bwp/daqc/files/1990caaa.htm> (1 Feb 2002).

[20] Paraphrased from City of Cambridge. "About the Traffic, Parking and Transportation Department." 18 April 2000.
<http://www.ci.cambridge.ma.us/~Traffic/about.html> (19 Jan 2002).

[21] City of Cambridge. "Community Development Department: Environmental and Transportation Planning Division." 8 January 2002.
<http://www.ci.cambridge.ma.us/~CDD/envirotrans/index.html> (19 Jan 2002).

Cambridge and the rest of the region. On the local level, this ordinance ordered an investigation of increasing parking restrictions and adjusting zoning requirements to decrease parking availability for commuters in areas with other forms of public transportation or sufficient infrastructure for non-polluting form of private transportation. The VTR Ordinance created and provided funding for a program to increase bicycle and pedestrian travel in the city and initiated discourse between the MBTA with the objective to increase the public transit availability in the city. In parallel with the efforts to increase the number of transit routes, the ordinance assigned some city departments with the task of surveying members of the Cambridge community to determine the most common motivations for avoiding public transportation systems and how make those systems more appealing to commuters. Of particular interest to this project are the Automobile Efficiency Rate (AER) calculations, which aimed to produce a quantitative measure of how efficiently commuters of a company, area, or city use automobile resources and to produce a benchmark for the effectiveness of VTR programs. Various programs in the VTR Ordinance, such as the AER calculations, depend on the owners of the commuter and commercial parking facilities to gauge or influence the environmental efficiency of commuters' use of their transportation options.[22]

2.3.4 Parking and Transportation Demand Management Ordinance

The PTDM Ordinance extends the goals of the Vehicle Trip Reduction Ordinance by regulating parking spaces to reduce automobile trips and air pollution. From the viewpoint of the PTDM Ordinance, the creation of any new parking space in the city has the potential to generate more vehicle trips within the city or en route to the city. All parking spaces must therefore be registered with the city. Based on the nature and size of the new parking spaces, the PTDM officer can require the owner of the property to implement incentives for its patrons to use non-motorized or non-single-occupant methods of travel. Such incentives include subsidized transit passes, shuttle services, bicycle and pedestrian facilities, flexible working hours, and preferential parking for employees who share rides. The requirements of the PTDM apply to all parking facilities (constructed or altered after the effective date of the ordinance) that contain more than four non-residential parking spaces. The ordinance pays particular attention to parking facilities with commercial (rented for daily use by the public) parking spaces and facilities with at least 20 spaces, while allowing more freedom to parking facilities for city residents. Motivation for these ordinances derives from a previous determination by the city that automobile traffic is a major cause of the city's air pollution.[23] This determination is supported by the treatment of automobile emission in the Clean Air Act.[24] Regulation of parking spaces in Cambridge is a major step in its pollution reduction campaign.

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[22] Cambridge City Council. "Vehicle Trip Reduction Ordinance." Cambridge Municipal Code: Title 10, Chapter 17. January 2001. <http://bpc.iserver.net/codes/cbridge/index.htm> (24 Jan 2002). See Appendix D: Cambridge Municipal Ordinances" for full text of this ordinance. Detail on the AER calculation program are given in Section 10.17.130.

[23] Cambridge City Council. "Parking and Transportation Demand Management (PTDM) Ordinance." Cambridge Municipal Code: Title 10, Chapter 18. January 2001. <http://bpc.iserver.net/codes/cbridge/index.htm> (19 Jan 2002). The full text of this ordinance is available in Appendix D: Cambridge Municipal Ordinances".

[24] "Clean Air Act of 1990." Title II – Provisions Relating to Automobile Sources.

2.4 The Demand for Data Tracking Tools in Cambridge

The City of Cambridge has limited data on the parking resources within the city. In 1990 and 1996, there were inventories done of Cambridge's off-street resources. Currently, some of these records have become obsolete or could be incomplete due to the rapid urban development within Cambridge. Property owners can re-stripe their parking lots or change the usage of parking spaces without informing the city of the change. Most of the city's information is spread out through a couple of different data sets. Specifically, the department has one spread sheet with off-street data from the 1990 and 1996 inventories with additional entries for the changes that the department has noticed or been informed of since the inventories. The paper map associated with the spread sheet allows the department to locate the parking facilities, but does not allow an easy analysis of the characteristics of the facilities in an area. The Traffic and Parking Department's inventory of metered parking spaces is written on paper and does not track all of the meters that have been added in recent years. The city does not have records of the locations of the on-street curbside parking regulations. New tools for organizing the on-street, off-street, and metered parking in the city will increase the efficiency of parking regulation and provide easier access to information for analysis.[25]

The City of Cambridge also needs to be able to keep track of parking resource information as time progresses. Often, the most effective tool for tracking or analyzing parking resources is simply the person who made previous decisions relating to the management of that resource. However, keeping records and procedures only in such an informal manner can cause problems when promotion or retirement passes resource management responsibilities onto another person. Data-tracking tools should allow the current members of the Parking and Transportation Department to inform future members of the parking resources available and the reasoning behind decisions that will affect resources in the future.[26]

[25] Statements based on examinations of the current datasets available in the Traffic and Parking Department and conversations with members of the department.
[26] Based on conversation with Wayne Amaral, Traffic Operations Manager for the City of Cambridge.

3 Methodology

This project aims to assist the Community Development Department of the City of Cambridge to more efficiently manage traffic and improve the quality of life for the local community by developing tools that will help regulate on and off-street parking and facilitate coordination between City departments.

In order to accomplish this mission, we identified three principal objectives:

1) Develop a system to inventory parking resources
2) Perform a field inventory to catalog these resources
3) Demonstrate the effectiveness of the new system

The rest of the chapter describes the various methods employed in fulfilling the above objectives and is divided into the following sections:

- **Section 3.1** specifies the domain of the study and provides definitions of key terms such as "off-street parking" that are of key significance to the project.
- **Section 3.2** describes the geographic extent of the study's coverage area and illustrates the various neighborhoods encompassed in the same.
- **Section 3.3** lists the temporal intervals covered by the project and details the dates and times during which data was collected.
- **Section 3.4** explains the design process involved in developing the new tools for monitoring and managing the city's parking resources.
- **Section 3.5** details the steps involved in the actual inventory of the three different components of the parking infrastructure in the city, on-street, off-street and metered parking resources.
- **Section 3.6** contains a description of the various analyses used to demonstrate the capabilities of the new tool developed by the team.

3.1 Domain of Inquiry and Definitions

The domain of this project is the on-street, metered, and off-street parking resources of Cambridge. Off-Street parking facilities are parking lots or parking garages. Garages are any structured parking lots that are not open-air facilities. On-street regulation zones are the zones between regulations signs. Metered parking is parking with timed coin operated meters. Commercial parking space refers to parking space available to the general public at a fee. This does not include spaces that are used for the employees, costumers, patrons, students, residents or guests that are not available for the general public use. A residential parking space is a space designated for the use by residents.

3.2 Study Area

The study area for this project overlaps with the East Cambridge neighborhood as shown in Figure 7 and marked by the red border. The dotted line marks East Cambridge. This area is bounded on the east by First Street. The southern border is Charles St. from First to Fulkerson St. The railroad tracks on the edge of East Cambridge will be the western border. The northern border of the City of Cambridge and the Monsignor O'Brien Highway mark the northern border of the study area. Even though the region north of the O'Brien Highway is part of East Cambridge, we will not be studying this area because the city does not control most of those roads and a planned redevelopment project will soon render obsolete any data that we might collect from there. We will collect data from all of the streets within the study area and the streets that make up the borders of the study area. A small section of Cambridge was selected by the sponsor in order to allow us to study the area in enough detail to produce data that will be useful to the city. This area was also chosen due to the fact that it has gone through extensive development in the past 10 to 20 years and any parking data that is not current within a few years is very likely to be inaccurate. Any new data and a new system to track changes will be very beneficial to the department.

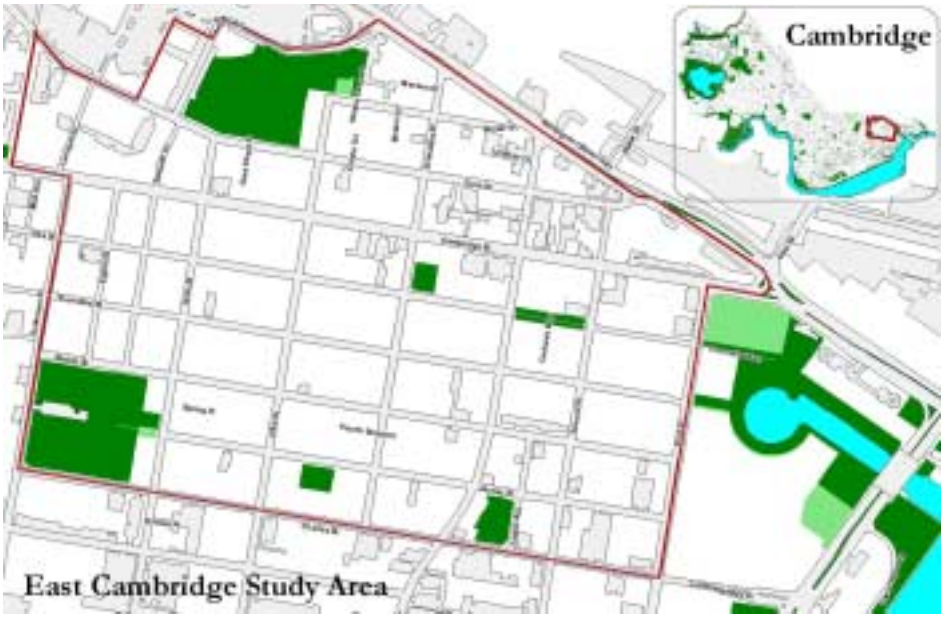

Figure 7: Study Area

Data sets could only be collected for a subset of the total study area we had originally designated. Our reasoning behind this decision was that we had to have time to write up the report and complete the analysis. This cut off was also chosen to allow for the easiest continuation of the study.

3.3 Temporal Coverage

We implemented the methodology of this project between March 12th and April 30th 2002, collecting all of our data during normal business hours from 8:00 A.M. to 5:00 P.M. on weekdays. The hours of the study have no affect on the data because the information is based on inanimate stationary objects so there is no variation in the results. We have defined a number of different tasks in our methodology. While the entire project will extend over the period from March 12th to April 30th, the tasks involved will cover shorter intervals as indicated on the Gantt chart in Figure 8.

ID	Task Name	Start	Finish	Duration
1	Finalize Background	3/12/02	4/12/2002	24d
2	Determine department needs	3/12/02	4/4/2002	18d
3	Examine the maps available	3/12/02	3/18/2002	5d
4	Examine the current files	3/12/02	4/25/2002	33d
5	Field Work testing	3/13/2002	3/20/2002	6d
6	Finalize Methodology	3/14/2002	3/22/2002	7d
7	Field Work	3/20/2002	4/2/2002	10d
8	Compile database	3/25/2002	4/29/2002	26d
9	Develop GIS tools	3/25/2002	4/29/2002	26d
10	Develop scenarios	4/9/2002	4/29/2002	15d
11	Analyze tool	4/9/2002	4/29/2002	15d
12	Refine Methodology	4/19/2002	4/26/2002	6d
13	Analyze results	4/9/2002	4/29/2002	15d
14	Conclusions/Recommendations	4/22/2002	4/29/2002	6d
15	Executive Summary	4/19/2002	4/26/2002	6d

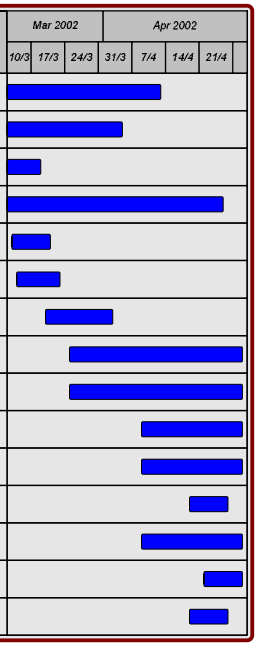

Figure 8: Project Schedule

3.4 Design Parking Resource Management Tools

3.4.1 Import Departmental Records

The Traffic, Parking, and Transportation Department had records of parking resources in paper and digital format. We needed to determine which of these data resources contained information that could be useful in future departmental activities and bring that information into the new system that we developed. The department's record on parking meters consisted of lists of meters on sheets of paper in a three ring binder. This metered parking inventory was not imported because if the information was not current and would not contain any information unique to what we collected in the field. It was not until we had finished a significant portion of the project that we became aware that the city had Word Perfect documents containing a previous inventory of on-street parking resources. For this reason, we did not have the opportunity to consider incorporating the old data into our system. Before we began this project, the Traffic and Parking Department kept all of its information concerning off-street parking resources in an Excel spreadsheet. It was important that we bring this information into the new management tool because contains the department's current knowledge of the parking facilities and allows for the tracking of the histories of

those facilities. We imported the Excel spreadsheet into Access and set up a series of queries to format the data for the storage in an Access table with the new records that we collected. During a series of conversations with Jason Schrieber, the Transportation Planner, we identified the type of information in and relevance of different fields from the previous records. Based on these discussions, we removed irrelevant information and we merged fields that contain the same information.

3.4.2 Parking Resource Database

We used Microsoft Access to design a parking resource database. In this database, we created three main tables and forms to provide easy entry, storage, and viewing of data on metered parking, curbside parking regulations, and off-street parking facilities. Along with the main tables and forms, we created a number of smaller tables, forms, queries, and macros to support the functions of the database. We designed the forms and database functions with the objective of creating an interface to the data that is easy to understand and that automates data entry.

3.4.3 GIS Map Layers

We planned out the organization of GIS map layers to geographically represent the collected data. Using MapInfo, we drew the parking resource objects. Then, we converted the maps to ArcView format for use by the City of Cambridge. Due to expectations that the city will make future changes to the both the objects on the map layers and the data associated with these objects in the Access database, we searched for methods to connect the map layers and the database that would allow data to be viewed or altered in either the ArcView or the Access interface. To accomplish this, we aimed to keep all of the data in the Access tables and write ArcView queries to look up data on mapped parking resources from the database and write changes back to the databases whenever the data is altered in ArcView. We did not have time to learn how to write these queries using ArcView in the timeframe of the project. However, we did succeed in coding the map layer objects to establish this type of link between Access and MapInfo. By doing this we demonstrated that the connection could be established and provided map layers that already contain object with identification codes to allow a similar query to be set up by the Cambridge GIS department using ArcView.

3.4.4 Standard Operating Procedures

The Traffic and Parking Department will use the system that we developed to continue to catalog and manage the parking resources in Cambridge. In order to achieve consistent data as different people contribute to the collected data, the system needs a set of standard procedures for data collection and data entry. These procedures give step-by-step directions for updating the parking resource data. They also include sets of heuristics for making decisions in a number of possible situations where the data may seem ambiguous.

3.4.5 Trial Integration of the Parking Management Tools

The main components in the system that we developed include the database; the GIS map layers, the operating procedures, and the parking data. In order to gauge the performance of the entire system as a whole, we integrated the tools and performed the full data collection process for a section of Cambridge. This allowed us to identify the attributes of the system that could use improvement and to test the result of making changes to the tools. Section 3.5 gives more details on how we collected data for the system integration trials.

During some of our data entry and mapping sessions, we recorded the time we spent entering each type of data in order to estimate the cost in person-hours of using the tools we developed to track various types of data. We attempted not to record periods of time during which we performed other tasks in addition to the type of data entry that we were tracking in that session. The data entry sessions were tracked in units of hours per parking facility, hours per parking meter post, and hours per field map or per regulation zone for off-street facilities, metered parking, and curbside parking zones, respectively. Using a log that we kept of our daily project-related activities, we also performed a study of the amount of time spent collecting data in the field and preparing forms for that data collection. During the calculations, we removed any time periods spent eating lunch or walking from the department office to the study area.

3.5 Inventory Parking Resources

3.5.1 Observation Routes

After we had identified the pertinent pieces of parking resource data to measure and constructed the database to hold this data, we began field observations. We moved through the study area in an organized manner planned with the intention of covering all the streets of the study area without wasting too much time by moving repeatedly over streets that have already been measured. The starting point for our measurements was the northwest corner of the study area. We focused on one block at a time and for each block we moved in a clockwise circuit as viewed from above. This means that on-street data was collected moving in the direction of traffic for all two-way streets. We chose an arbitrary numbering scheme for the blocks to help organize the data collection. We examined on-street and metered parking resources together. This allowed for the quickest data collection because two members could easily handle the two data sets working together. The off-street data was collected separately due to the complicated nature of the tasks involved in accurately recording the characteristics of a parking facility. There was not enough time in the duration of this project to complete all of the planned measurements over the original study area, so we decided to perform all of the measurements and focus on a smaller geographic region within the original study area. We chose to do this so that we would be able to explore the process of and the results of all of the types of data collection we believed could be helpful to the sponsor.

3.5.2 Off-Street Parking

The first dataset we collected was information concerning off-street parking facilities. Before beginning our research in the field, we searched the parking resource database (see Section 3.4.1) to find all current records for the lots in the area we intended to study. Printing out these records allowed us to check the information on file with the actual state of the parking facilities at the time of this study. We counted the number of spaces dedicated to following uses: employee, commercial, customer/visitor, residential, institutional, and vacant. We took pictures of the entrances to the facilities and of signs listing prices or restrictions. While in the field, we also drew the shape and parking space configuration of open-air parking facilities (parking lots). For underground, multi-level, or closed garages we indicated the position of the garage on the map with a symbol instead of tracing the outline. We did not enter these garages to count the spaces within the facilities. We entered the collected data into the database as new records. The previous records were left in the database to track the changes in parking resources over time. From our data collection maps, we created GIS map layers associated with the database records. For more details on the methods used in this off-street parking survey see Appendix F:

This study does not focus on private residential lots with fewer than five parking spaces. The parking ordinances that supply the motivation for this study do not indicate a necessity to regulate residential lots for less than five cars. At the beginning of the data collection process we considered keeping a tally of these residential spaces as we proceeded through the study area, but elected to drop the tally in order to make a more efficient use of time spent in the field.

3.5.3 On-Street Parking

Next we gathered data on the number of parking spaces available as metered parking provided by the city. At the same time, we tracked all curbside parking regulations for East Cambridge. We completed this by recording the types and locations of parking-related zones on the streets of the study area. The data-collection forms used are attached in Appendix F:. To measure the locations of meters or signs along a street, our team used a measuring wheel that uses units of feet and inches. Two members of the WPI team worked together to gather on-street data. One person used the wheel to measure distances while the other person recorded the values. After trying a few different form layouts, we found that using a single data collection form to collect both meter parking and curbside regulations is the most efficient method. The form we used, shown in Appendix F:, records location of each meter and the start and end of each regulation zone. The measurement started at one corner and traveled in the natural direction of traffic on the right side of a street, unless we were on a one-way street. For each stretch of curb, we used the corner of the first building on the street as a reference point and measured all distances from that point because we expect that it is the most stable reference point that can be identified in the field for streets where sidewalks may be extended in the future. Due to concerns that recording the locations of all curb cuts would significantly

lengthen the time necessary to track on-street resources, we ignored curb cuts for driveways unless city signs marked the driveway openings. We collected the data by blocks using a series of maps of the study area that we numbered in an arbitrary manner. The group looked at each of the sides of the block before continuing on to the next block. This method allowed for the easiest path of data collection.

Once the data collection was finished for all of the on-street resources, we entered the data into the new database structure and mapped the data using MapInfo. We drew the 14 types of curbside regulation resources on individual map layers and put the metered parking on a different layer. When this was finished, we converted the MapInfo layers were converted and combined into two on-street map layers in the ArcView format. The curbside regulation zones make up one layer and the meter locations reside on the other layer. This combination of the curbside regulations was done to facilitate the queries linking the map layers with Access tables, which was mentioned in Section 3.4.3.

3.6 Demonstrate Capabilities of the new GIS Tools

As a final objective we demonstrate the utility of the tools that we have developed from the datasets gathered and completed in the first two objectives. The primary issues that this section demonstrated are the need for a newer method of monitoring the parking resources and the usability of the one that we have developed. To address this we show how it improves upon the older system. To compare the usefulness of our system with the features of other tools at the disposal of the Traffic and Parking Department we developed scenarios of tasks which the system could help the department resolve. We based these scenarios on what we determined to be the common tasks performed by the department. As we developed the map layers, members of the Traffic and Parking Department gave us their input on the use of the layers and we responded to their feedback on the characteristics the maps. During this time we also considered how the characteristics of the GIS tools could help other city departments to use this parking resource data.

4 Results

As a result of this project, we delivered a system for tracking parking resources and data on the actual parking resources in our study area.

- **Section 4.1** describes the characteristics of tools that we were able to create and details how the attributes of these system components may have varied from our expectations while developing the methodology.
- **Section 4.2** demonstrates the new system in action reporting the results of our data collection trials.

4.1 Design Parking Resource Management Tools

4.1.1 Import Departmental Records

Using a series of queries, we imported the previous off-street parking records from the Traffic and Parking Department's Excel spreadsheet into the Access database as 2324 records. Most of the data values from the original spreadsheet are in fields with similar names in the new database. The multiple fields used for general notes in the previous records fit into two types of notes fields in the new database table. We took care with importing the assessor block and assessor lot information into the new table because of its usefulness for locating parking facilities on city maps. In the previous records, some of the addresses were recorded as text instead of numbers causing missing values on a small percentage of the imported records. We ran various queries on the imported records and removed most of the discrepancies by automatic or manual means. However, due to time restraints, we were not able to correct every record with a missing value. The Excel spreadsheet had extra fields containing information of parking studies that had been performed on a few of the parking facilities. Based on discussions on the relevance of various fields with our project liaison from the Traffic and Parking department, these fields were not imported into the new database. While we do not expect any of these differences between the previous records and the current records to present a problem, the previous Excel spreadsheet could be examined in the case that an imported record is found to be ambiguous.

4.1.2 Parking Resource Database

The central database that we designed contains individual tables for each of the three types of parking resources. Forms were developed that allow easier access to the records contained within the database. These also simplify the data-entry tasks associated with keeping the database current. The new system incorporates drop-down lists which automatically complete the value and allowing the user to select a value rather than have to type it in. The database thus provides many improvements over the current system used by the Traffic Department to track parking resources. For screenshots of the data entry forms and for details on the individual fields in the structure of the database tables see Appendix E:.

Figure 9: Example of Collected Off-Street Data

4.1.3 GIS Map Layers

Each one of the tables from the database was incorporated into a map layer. Off-street parking data was represented on three different layers. The first layer illustrates the layout of the parking spots within lots, and the second outlines the boundaries of those parking lots. The third layer contains all parking garages and underground lots which cannot be demarcated by boundaries, and are represented by a parking symbol. The on-street parking data was

Figure 10: Example of Off-Street GIS Map Layer

represented on two different map layers one for meters and one for the on-street regulations. The on-street regulation zones were color-coded so as to enable the user to distinguish and analyze individual types. The final layer was the metered parking layer, which contains all the parking meters within the study area. Figure 11 shows a subset of the objects on the meters layer.

Figure 11: Parking Meters Layer

4.1.4 Standard Operating Procedures

A major result of this project, apart from the actual data gathered, was the parking resource tracking procedure we developed. The data collection techniques, coding schemes, database and map layers created by the team shall form the basis of a tool used by the department to monitor and track parking resources within Cambridge. The traffic department will in the future use this model to implement similar studies throughout the city of Cambridge, and thus develop a comprehensive database containing parking information for all of Cambridge. The standard operating procedures are attached as Appendix G:.

4.1.5 Time Study

Our records of time periods spent on individual data entry tasks, allowed us to estimate average time that we spent on each type of data entry tasks. The results of this study are shown in Table 2. For each data set, we listed the rate at which we performed the major tasks for entering that data set. We also combined the tasks to find a rate for the entire process for entering each data set. Each of these tasks can be completed by a single person so the figures in the table should have the same values in terms of "items entered per person-hour" as they do in terms of "items entered per hour."

Data Entry Task	Rate of Completion
Metered Parking	
Database Entry	52 parking meters per hour
Mapping Meters	78 parking meters per hour
Coding Map Layer	52 parking meters per hour
Entire Process	**19.5 parking meters per hour**
Curbside Regulation Zones	
Database Entry	41.9 curbside regulation zones per hour OR 2.60 blocks per hour
Mapping Zones	32.9 curbside regulation zones per hour OR 2.04 blocks per hour
Coding Map Layer	73.6 curbside regulation zones per hour OR 4.57 blocks per hour
Entire Process	**14.7 curbside reg. zones per hour OR 0.91 blocks per hour**
Off-Street Parking Facilities	
Database Entry	1.85 facilities per hour
Mapping Facility Outlines	41.3 facilities per hour
Mapping Lot Layouts	9.23 facilities per hour
Entire Process	**1.48 facilities per hour**

Table 2: Estimated Rates for Data Entry Tasks

We also tracked the hours spent collecting data in the field to calculate the cost of collecting the data for this study. Table 3 lists the six major tasks that we needed to perform to inventory the parking resources of our study area. Next to each task is the average time cost of performing the task. These estimated time costs could be used to project the staff resources necessary to continue the parking inventory over a larger section of Cambridge. For more details on the calculations used to produce the numbers in this study see Appendix F:.

Task	Cost
Preparing Maps and Forms	0.35 person-hours per block
On-Street Data Collection	0.69 person-hours per block
Off-Street Data Collection	0.42 person-hours per facility
Entering Curbside Parking	1.09 person-hours per block
Entering Meters	0.05 person-hours per meter
Entering Off-Street Facilities	0.67 person-hours per facility

Table 3: Estimated Costs of Study in Staff-Power

4.2 Inventory Parking Resources

4.2.1 Off-Street Parking

We completed field data collection of off-street parking facilities for the entire study area. The process of entering the collected information into the database took considerably longer than expected. As a result of this, we were not able to enter all of the facilities into the database. Figure 12 shows the off-street facilities within our study area. We canvassed the area enclosed by the orange boundary and mapped all of the facilities that we could find. The blue boundary encloses the area that we were able to into the database. The black outlines and blue parking symbols represent the individual facilities that we have recorded in the database. The red outlines and parking symbols are the facilities that we observed in the field and did not have to enter into the database. During the course of our data collection, we observed about 63 parking lots and garages and created new database records for 46 of those facilities. The entire inventory is displayed in Figure 24.

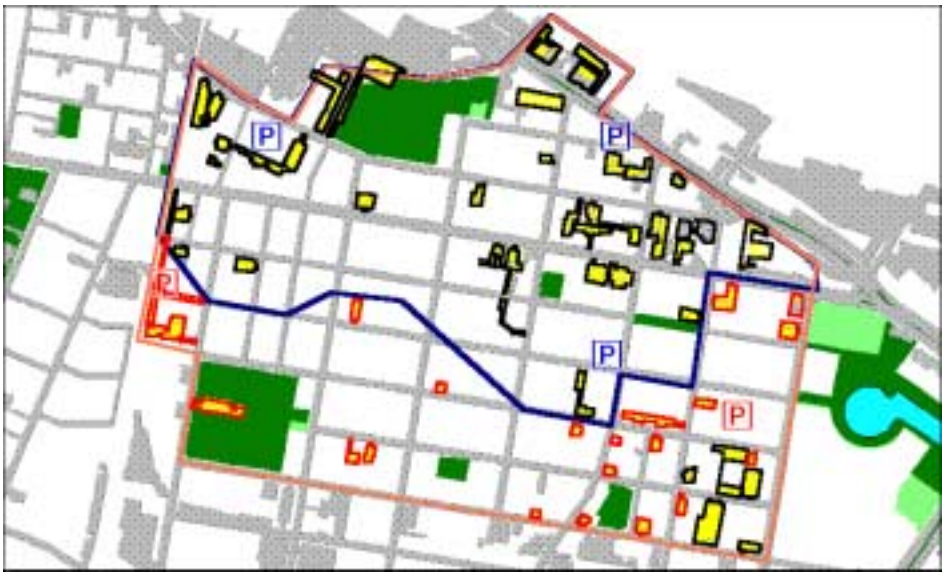

Figure 12: Off-Street Parking Facilities Visited and Entered into Database

4.2.2 On-Street Parking

The on parking facilities were inventoried for the entire study area and data gathered was entered into the newly designed database. The regulation zones were mapped using MapInfo but were then imported into ArcView for easier use by the City, whose GIS department uses the ArcView package. The on-street zones were represented using poly-line objects and the parking meters were represented with point objects. The on street regulation zones are represented in fourteen different colors decided upon in consultation with department members.

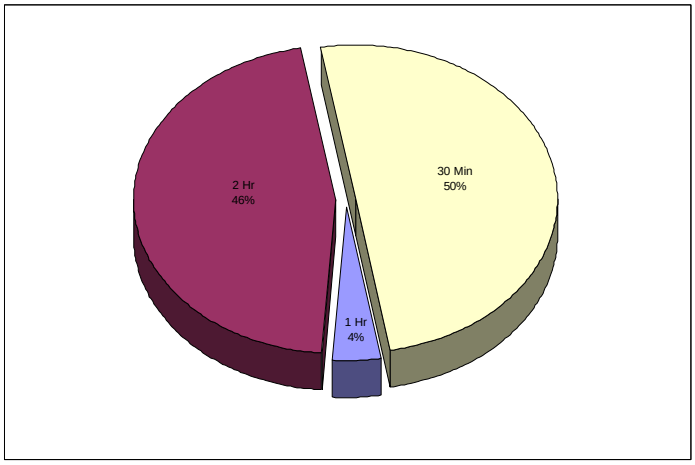

Figure 13: Parking Meters by Time Limit

Time Limit	First Head	Second Head	Total
1 Hr	11	5	16
2 Hr	126	59	185
30 Min	19	12	201
Total Meters	156	76	**232**

Table 4: Total Number of Parking Meters in Study Area

Only twelve of the regulations were actually recorded in the study area and they are shown in the legend in Figure 27 on page 79. The metered parking resources were analyzed by time limit as shown in Figure 13 and Figure 14, which also displays the breakdown in terms of primary and secondary meter heads. Table 4 details

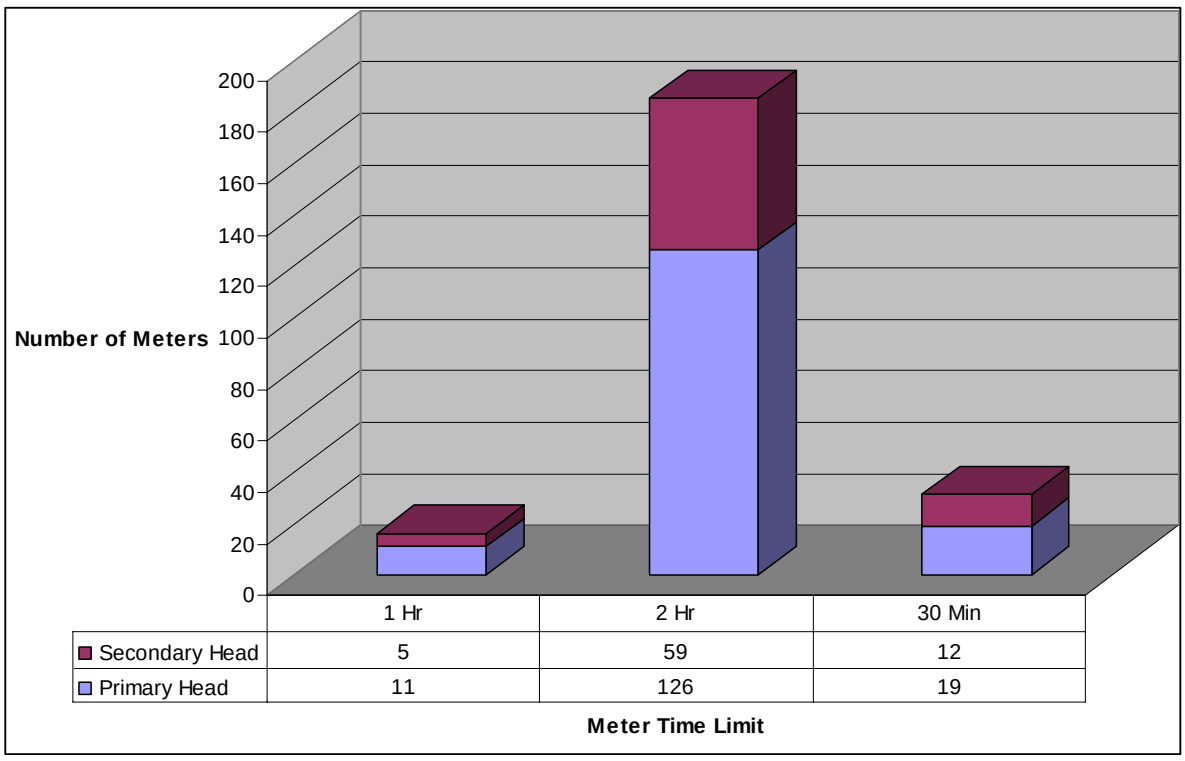

Figure 14: Total Number of Parking Meters by Type

the total number of parking meters that were cataloged in the project study area. The on-street regulation zones, which were recorded in linear feet, were studied to determine the footage of each type of zone, as shown in Figure 15 and Table 5.

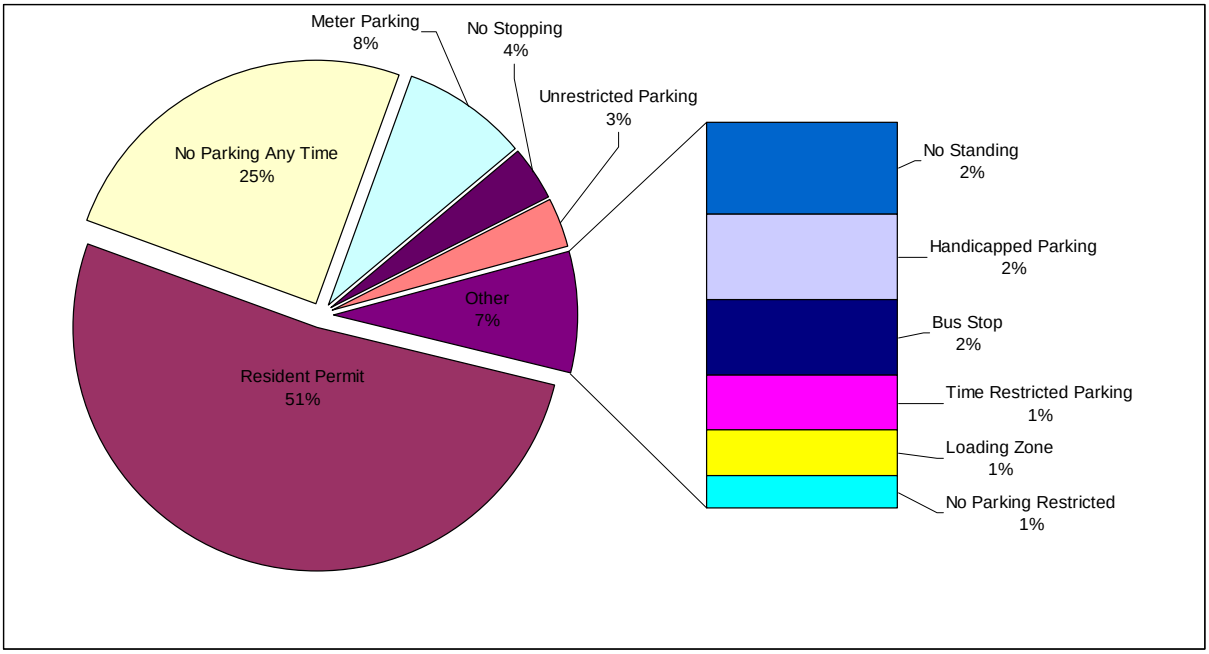

Figure 15: On-Street Regulation Zone by Type

Regulation	Cumulative Length
Bus Stop	874
Handicapped Parking	974
Loading Zone	535
Meter Parking	4626
No Parking Any Time	13939
No Parking Restricted	369
No Standing	1080
No Stopping	2037
Resident Permit	28676
Taxi Stand	82
Time Restricted Parking	635
Unrestricted Parking	1853
Total Length	55680

Table 5: Cumulative Regulation Zone Lengths

The GIS allow the parking resources to be viewed from the largest possible perspective and can the department to view the many different characteristics of the city's parking structure. With the help of this GIS system, the department can help improve the quality of life for many of its residents by helping identify neighborhoods that either have inadequate parking facilities or have an excess of the same, placing them in need of relief from either problem. Having current layers will also make future maintenance of the database easier since they will now have knowledge of what the parking situation is on the field.

5 Analysis

In addition to the technical tasks involved in designing parking inventory and management tool for the City of Cambridge, the social implications of the tools' capabilities warrants extensive analyses. Most important is an examination of how the tool would allow the city to balance the parking needs of residents and those of local commercial establishments. Our analysis of the results both examines the nature of parking and traffic in Cambridge and identifies operational changes that the tools can provide for the department.

- **Section 5.1** describes a scenario in which the new parking management tools could assist in parking enforcement.
- **Section 5.2** highlights the limitations of previous parking inventories. It also describes the effects of the assumptions or approximations that we needed to make in the execution of this project.
- **Section 5.3** demonstrates one use of the collected data by attempting to map parking resource data and the data on the residential and employee population to look for any differences between the parking available in areas of East Cambridge and the parking needs of the people who live and work there.
- **Section 5.4** weighs the cost in person-hours of collecting each dataset in the inventory against the potential usefulness of the data to the department.
- **Section 5.5** compares the new system with a similar study of parking resources in the Riverside neighborhood completed by local residents.
- **Section 5.6** examines how we sought to balance the time constraints of this project against the need to deliver an effective system.

5.1 Enforcement Scenario

The maps and database will provide the Traffic and Parking department with new methods for tracking how a parking facility has changed over time. An example of the utility of the maps is when a land developer repaints the stripes in a parking lot to increase parking capacity without informing the city. If such a change comes to the attention of the Traffic and Parking Department after a number of years, it can be difficult to verify exactly what parking spaces were originally in the lot or how the lot increased. Our map layers include layouts of individual spaces for open-air parking lots. The database that we constructed tracks the history of the characteristics of the lot such as the number and the purpose of parking spaces. The combination of the previous layouts of the parking spaces and a history of the total number of parking spaces should make it easier to assess what actually happened in a lot.

The parking facilities around 271 Cambridge Street highlight some of the advantages of this type of tracking capability. A record from the 1996 inventory indicates that the parking lot behind 271 Cambridge Street had 13 spaces. In 2002, we counted 26 spaces in this lot. Based on our field observation of this facility, and information from the previous files we mapped the parking lot as shown in Figure 16. In this figure, the facility under consideration is outlined in red with yellow tracing on the individual parking spaces. The black and gray lines are other parking facilities on the same city block. From the set of lots that we observed in the field, it is unusual case to find a parking lot where the owners would be able to double the number of spaces available by repainting the stripes. Another possible history for this lot becomes apparent when taking into consideration the boundaries between assessor lots (shown in light blue in Figure 16). These lines divide the city blocks into parcels of land that may have different owners. One line (indicated by a green arrow) running through the lot under consideration might divide the lot into two separate parking facilities with different owners. If this is the case, then the previous record may have only counted the spaces of the portion of the red outline area that is controlled by 271 Cambridge Street and we should only record 14 of the current spaces to be in the parking facility for 271 Cambridge Street. Also, in this case, the other 12 parking spaces should be recorded as a separate parking facility. However, there is not a previous record for the other spaces in this lot, and we are not able to tell for certain whether we detected an increase in parking spaces due to a re-striping of the lot or due to the combination or two lots when we counted.

Figure 16: 271 Cambridge Street Observation

Our new system will be able to avoid this type of confusion from arising in the future. For each parking lot observed using our system, the individual spaces and the outline of the lot are drawn uniquely identifying how the observer considers the spaces to be grouped in the facilities. If the previous record for 271 Cambridge Street had been created with our tools, then the map would either show that the lot covered the full area available and the spaces were arranged differently or show that only half of the area had been considered to be part of the parking facility. Under the current system, completing an updated record for this lot would depend on the memory of the person who conducted the previous inventory of this facility. And,

if that person were no longer available, then completion of the record would depend on an assumption by the current recorder. In addition to making the recorded parking facility information easier to understand, our new tools help to free the Traffic and Parking Department from the risk of losing valuable information as members of the department advance to other positions or responsibilities.

5.2 Limitations of Models

The 1990 survey cataloged lots containing ten or more parking spaces. To meet the tracking requirements of the current city ordinances, we aimed to count all non-residential parking facilities and residential lots of five or more spaces. The former off-street inventory system was on paper where as the tool developed by the team is digitally stored and simplifies access. The on-street inventory was in a WordPerfect document and the off-street was in an Excel spreadsheet. These two formats were very difficult to use to find information. Finding the exact location of a lot in the previous system required searching for a pair of numbers drawn on the location of the lot on a map. Now finding a particular lot on a map involves either searching for the lot in the Access database or searching the area on the GIS map layers. Each record will be associated with both a location on the map and the database information. This allows the opening of the data on a lot by clicking on the outline of the lot instead of having to search for reference numbers in the record. With both the visual and database references the searching and tracking of a lot can be made easier.

Just as the previous parking inventory was not perfect due to the fact that lots under 10 spaces were not included, our system for tracking parking contains limitations due to the approximations that we needed to make in our model. For instance, we did not count individual driveways that could contain less than five cars as off-street parking facilities and the on-street regulation zones do not record breaks in curbstone for entrances to parking facilities because the collection of this data would have prevented us from completing our study area in a reasonable amount of time.

The off-street resources were not completely inventoried for one because of time constraints and also because the projects main focus was the off-street lots that contained non private residential. The parking lots containing only five residential spaces or less were not recorded because of the lack of time and the lack of usefulness to the department. This makes any estimate of total residential parking inaccurate. Another of the problems that were encountered in the off-street inventory that raised problems was the address of the parking facility. The off-street parking facilities were coded by the address associated with them but this method is very troublesome due to the fact that the addresses can be more easily changed or confused. The best way to code the lots would have been the Assessor's block and lot numbers but this problem was not found in time to allow for the correction,

The on-street inventory also has its drawbacks. For calculating a total number of parking spaces on the curbside the linear distance must be divided by an average parking space size. The breaks in curb for driveway entrances were not measured and this makes any estimate of on-street parking inaccurate.

5.3 Residential Parking Demand and Supply

Above and beyond the passive task of monitoring and managing parking resources in the city, the TPTD plays an active role in the parking-related planning actions of the City. It aims to provide sufficient resources to fulfill the transportation needs of residents, workers and visitors to the city. An inventory of parking resources can deliver a better idea of the relation between the number of people in the city and the parking spaces available for them to use. To analyze the potential use of such a capability, the project team used the inventory data gathered by it to compare the availability of parking spaces available to residents in the study area to the approximate number of cars in the same area. For the demand component of this calculation, data from the 2000 U.S. Census on the number of housing units in each block was used.

The total number of housing units was thus calculated by summing up the number of units within each of the various census blocks in the study area. Data on the total number of households and housing units in the city was used to calculate an average number of households per housing unit. The number was assumed to be an accurate estimate since there were no major non-household group quarters such as dormitories, group homes or hospitals in the study area which would adversely affect the average. This average was in turn applied to the study area to calculate the approximate number of households. Using this number and data on the number of cars owned per household in Cambridge, we were able to make an approximation on the number of cars in the study area.

	Households	Housing Units	Ratio
Cambridge	42,615	44,725	0.953
Study Area	2,546	2,672	0.953

Table 6: Housing Units and Households

		Cambridge		Study Area	
	Percentage	Households	No. of Cars	Households	No. of Cars
None	28.20%	11,137	0	718	0
One	51.60%	20,339	20,339	1,314	1,314
Two	16.90%	6,676	13,352	430	860
Three or More*	3.30%	1,283	3,849	84	252
Total		39,435	37,540	2,546	2,426

*Estimated total assumes three cars for all households reporting three or more cars.

Table 7: Vehicles per Household

Due to the fact that 2000 Census data on the number of vehicles owned per household was still unavailable at the time of this project, data from the 1990 Census was utilized instead. Supply of parking spaces was calculated using data from the inventory performed by the team. All residential off-street and on-street parking was included in calculating available parking for local residents.

Regulation	Number of Spaces
Handicapped Parking	49
Loading Zone	25
Meter Parking	232
No Parking Restricted	18
Resident Permit	1444
Time Restricted Parking	33
Unrestricted Parking	94
Total Spaces	1895

Table 8: Residential Parking Available

The results of this analysis show a deficit in the number of parking spaces in the study area. The total number of parking spaces was found to be 2,185 whereas the number of cars that needed to be parked was 2,426.

Type	Spaces
Off-Street	290
On-Street*	1,895
Total	2,185

*On-Street includes all parking available to residents at night.

Table 9: Total Residential Parking Available

Cars	2,426
Spaces	2,185
Space Deficit	241

Table 10: Demand versus Supply

Performing such analyses will help the TPTD plan future parking development to ensure that a balance is maintained between the parking demand and supply. The parking resource data collected might also be useful for similar analysis of the number of customers in Cambridge to the customer/visitor parking resources, which will help the City in ensuring that the both the needs of residents and those of businesses are met.

5.4 Projecting Time Costs for Expanding the Study Area

We have implemented a new parking management system and demonstrated its functionality based on data from a small portion of Cambridge. To achieve the full potential of this system, the city will need to extend the study area to cover more of Cambridge. This means that the ability to manage Cambridge's parking resources with the new system comes with the price of an initial investment of time and staff. Using the information in Table 3 (page 23), the Traffic, Parking, and Transportation Department should be able to make a rough estimate of the staff resources needed to cover a wider study area. The department can then weigh the advantages of having an inventory of its parking resources available through the new tools against the costs of performing an inventory and entering it into the system. If the department wants to consider dropping certain components of the inventory, Table 2 on page 23 provides a breakdown of the time we needed to spend on entering individual components into the system. One limitation to our time estimations is that these time-costs were based on the rate that we were able to move through the East Cambridge neighborhood. Different field agents working in different neighborhoods of Cambridge may move at different rates. So, the Traffic and Parking should allow for a margin of error in any projections of the cost of continuing the study.

During the course of this project, we discovered that the time needed for various parking inventory related tasks were not divided as we expected. We expected field data collection to be the most time consuming task in our study. However, after we finished collecting the data and began entering the data, we realized that it takes longer to enter the information into the tracking system than to collect the data in the field. One of the most time intensive tasks in this process was drawing the on-street regulations zones onto the GIS map layers due to the number of regulation zones that need to be drawn. The other task that took

much longer than expected was the process of entering the off-street facility data into the database. This task takes a long time due to the time needed to match what was observed in the field with the previous record for the facility and to determine possible causes of discrepancies found in the field. We recorded all of our observations on paper in the field. The use of a handheld digital device for recording data in the field would not be helpful for on-street data collection, since we expect that it would complicate the process of recording the data. Such a device might increase the efficiency of the off-street inventory process if the device were able to hold database records for the study area and would allow the recorder to enter observations directly into the database forms while in the field instead of transcribing them from paper to the database in the office.

5.5 Riverside Neighborhood Parking Study

The Riverside neighborhood in Cambridge that surrounds part of the Harvard campus is lobbying to stop the university from expanding with new building developments. The residents are of the opinion that further development in their neighborhood will deplete already limited parking resources. To prove their point, the residents completed a similar parking inventory to the one that we have completed. We used this inventory to compare and contrast our methods with those that others might use and to show how our inventory and procedure can have and effect on the residents of Cambridge. To do this, we inventoried four sample blocks in the Riverside neighborhood using our data collection methods. We then compared the data thus gathered to that collected by the Riverside community in their inventory for those blocks.

The original Riverside study was done by the residents to estimate the total capacity of resident parking and the total number of resident dwellings. This collection of data is somewhat different from our study because our group recorded all parking resources except for private residential lots of fewer than five parking spaces. The Riverside study only became a problem when looking at parking lots because the Riverside residents do not describe the lots they count that have resident and other types of parking. Also, when recording the lots, the residents just seemed to put them into the address of the closest building. This would not be an efficient way to do it over time but it is not a problem for their study. The residents of Riverside counted on-street parking in a different manner than our procedure. Although their study provides similar numbers to the ones that we produced. The method that we use is different because we use linear distance divided by an average spot size. This is opposed to their method, which most likely involved the counting of parked cars and estimation of empty space along the curbside. Our procedure also utilizes mapping techniques to more clearly represent resources over any size area where as the resident's study only shows numbers on a standard data collection form without representing the actual geography or layout of the area.

The standard procedure we have developed is a more efficient display of all types of parking in an area as opposed to one that only looks at resident parking. The city-wide use of this standard procedure that

we have developed would help to solve different types of problems throughout the city. One of the scenarios that this type of standardized procedure can solve is where other neighborhoods in Cambridge have larger parking problems. These neighborhoods that may have more parking can use their parking study to discourage new development but unfairly towards these other neighborhoods that may have already been developed and therefore must just live with those parking shortages. If there is already an entire inventory of the city completed they could use that data to show whether there is sufficient or insufficient parking in any area of the city. When that data becomes out of date the city can employ the procedure provided in this report, focus on a small area and update the data already collected. This will keep the city's parking resources at least more comparable if not keep the resources more fairly distributed throughout the city. If this is achieved it will keep the quality of life at a higher level over the entire city and as even as possible in terms of parking resources.

5.6 Scope and Scalability of the Project

As the project developed, we made a number of decisions between different activities based on the time constraints of the project. On the broadest level our original objectives for this project equated to a redesign or reorganization of the system used by the Traffic and Parking Department to track information on the entire city's parking resources. The major components that we aimed to deliver included: 1) a database to structure and process the parking resource information; 2) map layers to allow visual analysis of the data; 3) standard procedures to allow the collection of data with a uniform format; 4) sample data for the neighborhood of East Cambridge; 5) demonstrations of the usefulness of the data. We desired to accomplish this for off-street parking, curbside parking, and metered parking resources. However, when we began the project, we became aware that the development of each of these products was a more time-intensive task than we had originally expected. Presented with the need to reduce the size of the project in order to be able to deliver results within the available timeframe, we decided to reduce the size of each component of the project instead of removing components and losing the desired scope of the project. We prioritized the components. We reduced the geographic range of the study area to regions in which we could thoroughly collect datasets rather than sacrificing the quality of a dataset. On the map layers, we were not able to establish links between the map objects and Access in ArcView, so we demonstrated in MapInfo that the features were possible and produced ArcView layers with the objects coded to allow the same type of query to be established if the city chooses to do so at a later point. Compromises such as these allowed us to produce the essential elements of the original system that we set out to develop. We were able to scale the project tasks to the available timeframe without reducing the scope of the project's application to the community of Cambridge.

6 Recommendations and Conclusions

During the course of this project the team encountered some problems that raised a few concerns. This led us to draw some conclusions and come up with a list of recommendations which we believe will make the future extension of this project and the greater task of managing parking in Cambridge much easier.

We strongly recommend that the TPTD immediately begin using the new system designed by the team in place of the current Excel spreadsheet, since it is clearly more user-friendly and incorporates far more advanced features. The overall goal of this project was to develop a parking monitoring and management tool for the City. What has been accomplished is the design of the tool and a sample inventory to demonstrate the viability of the tool as a solution to the City's parking management problem. This tool will not however be truly complete until the city finishes this inventory for all the neighborhoods in the city. The narrow timeframe available to the project team meant that the database was only populated with data from a very small study area. As and when the city does continue the cataloging of parking resources initiated by this project, the use of the standard operating procedures developed by us for the data collection, data entry and mapping aspects of the inventory will ensure that all future data gathered will be compatible with both the system and the data already in it.

Another task that had to be left incomplete due to time constraints was the linking of the Access database to the map layers in ArcView to allow for editing of information in the database from ArcView and real-time reflection of these changes in the database and vice-versa. The team performed a demonstration of the linking within MapInfo, which was the GIS application used by the team for creation of the map layers. We recommend that the TPTD seek the assistance of the City's GIS department to complete this linkage in ArcView, since it will vastly enhance the usefulness of the system and make it easier to maintain by simplifying data-entry tasks.

Another observation made by the team while implementing this project was the existence of multiple datasets on parking resources within the City. Three departments – the TPTD, the Licensing Commission and Inspectional Services maintain separate but similar databases on parking facilities in the City. Such duplication not only increases expenditure on maintenance and updating of these databases but also leads to discrepancies between data possessed by different departments. Changes in information on a facility noted by one department from an inspection or permit application are not visible to other departments which continue to keep the old data in their databases without being aware of this change that may in fact require them to take some action. This problem could ideally be solved by integrating these three different department-specific datasets into a central database that is accessible to all three departments. Doing so would allow any changes in information on a parking facility recorded by one department to be immediately seen by the other departments and be acted upon if necessary. Such a central database would create a single source for accurate

and comprehensive data on all parking resources within the city, and eliminate the possibility of individual departments possessing obsolete data. This solution may not however be easily implemented due to the sovereignty issues involved in dealing with departmental data since every department desires maximum control over their data. Until such a central database becomes feasible, the City should at least ensure that there is sufficient inter-departmental cooperation to compare and fix any gaps in the databases within each department. The City may need to develop a mechanism which ensures that every department making a change to the current information on a parking facility informs other departments that possess records on the given facility.

To prevent accidental erasure of the database, the Department should make sure backup copies of the database are made periodically. This should ideally be done every time a change is made to the data. In the future, if a new off-street parking management system is designed, we recommend that Assessor's Block and Lot numbers be used to code facilities in the database in place of street addresses to enhance the system's ability to manage changing addresses.

In conclusion, the project team notes, the parties most affected by this new procedure will be the residents and businesses in Cambridge. Both will benefit from the city's enhanced ability to balance the needs of both these vital components of Cambridge society. The new system will help by allowing for easier communication, enforcement and permit issuance. This standard procedure and inventory will allow the city to make more parking and resident friendly decisions with the use of the new GIS approach to monitoring and management of parking problems.

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Appendix A: Annotated Bibliography

This appendix contains a listing of the various sources that were studied through the duration of the project. Both sources that were useful and those that were not very helpful for the purposes of this project are listed. Each source is accompanied by a brief description explaining what types of information the source contained and whether this information was useful or not. The sources have been grouped into five categories depending upon topic.

Demographics – Cambridge and Massachusetts contains all the sources that were referred to for demographic data on the City of Cambridge and the Commonwealth of Massachusetts.

Sources of other information on Cambridge, such as city government, historical information etc. are listed under Cambridge – General Information.

The Geographic Information Systems category contains sources that we studied for information on what GIS tools are and what different kinds are available. Numerous sources are also listed for information on how GIS has been, or can be used for various day to day applications.

Details on transportation in general and for transit data for Cambridge in particular were researched from the sources listed in the Traffic and Parking section. Sources of general information on traffic issues affecting Cambridge and case studies of traffic management projects implemented elsewhere are also included.

The Parking category contains sources of information related to parking in general and in Cambridge specifically. Some sources listed offer information on the effects of parking on quality of life in the cities.

The last group of sources listed under Laws and Regulations lists the various sources studied for information on legislation that affects the parking and traffic scenario in Cambridge. Sources for federal and state regulations regarding pollution control and traffic management are also listed here.

Demographics – Cambridge and Massachusetts

U.S. Census Bureau. Profiles of General Demographic Characteristics, 2000 Census of Population and Housing.
May 2001. <http://www.census.gov/prod/cen2000/dp1/2kh25.pdf> (24 January 2002).

The definitive and thorough source for information on demographic data on American towns and cities. Most current data available, accurate as of May, 2001.

U.S. Census Bureau. American FactFinder. n.d. <http://factfinder.census.gov/servlet/BasicFactsServlet> (6 February 2002)

An excellent resource for quick access to Census 2000 and Census 1990 data organized into useful tables and maps for various states, counties, cities and towns.

City of Cambridge. Frequently Asked Questions About Cambridge Demographics. December 28, 2001.
<http://www.ci.cambridge.ma.us/~CDD/data/datafaq.html> (January 23, 2002).

A quick guide with answers to questions about Cambridge demographics basics. Contains information from both U.S. Census and the Commonwealth of Massachusetts.

"Boston.com" Your Town – Cambridge.
n.d. <http://yourtown.boston.com/town/cambridge/> (24 January 2002).

This website contains many facts, tables, charts, and statistics for various cities in the Commonwealth of Massachusetts. An excellent resource for information on the city of Cambridge.

Massachusetts Department of Housing and Community Development. Cambridge, Middlesex County. n.d.
<http://www.state.ma.us/dhcd/iprofile/049.pdf> (31 January 2002).

A good place to find demographic data relevant to the City of Cambridge gathered in one place. Contains the latest data from the 2000 U.S. Census.

Cambridge Demographic, Socioeconomic & Real Estate Market Information.
8 January 2002. <http://www.ci.cambridge.ma.us/~CDD/data/> (23 January 2002).

A wide assortment of demographic, socioeconomic and real estate market data is available via the Cambridge Community Development Department web site. This page acts as index to the various data pages available.

Citizen Information Service, Commonwealth of Massachusetts. Massachusetts Facts. n.d. <
http://www.state.ma.us/sec/cis/cismaf/mf1c.htm> (31 January 2002).

Yet another reliable source for complete and current data on the Commonwealth of Massachusetts. An official Government website, it can be relied upon for accurate information on all aspects of the state.

U.S. Census Bureau. Tiger Map Server Browser. n.d. < http://tiger.census.gov/cgi-bin/mapsurfer?infact=2&outfact=2&act=move&on=CITIES&on=majroads&on=places&on=streets&on=interstate&on=statehwy&on=ushwy&tlevel=-&tvar=-&tmeth=i&mlat=42.33602&mlon=-71.01789&msym=redpin&mlabel=Boston%2C+MA&murl=&lat=42.36325&lon=-71> (14 February 2002)

An excellent source for maps of census areas. Allows selection of particular focus regions, and is overall a great site for census map data.

U.S. Department of Commerce, Bureau of Economic Analysis. Regional Accounts Data, Annual State Personal Income. 10 December 2001. < http://www.bea.doc.gov/bea/regional/spi/> (31 January 2002).

The authoritative source for information on economics related areas for the United States. The BEA collects this data annually and offers information from the past 10 years.

"Mass.gov" Commonwealth Communities, City of Cambridge, Middlesex County.
n.d. <http://www.state.ma.us/cc/cambridge.html> (23 January 2002).

A good source for Cambridge-specific or region-specific information from various government agencies at the state and city level.

Massachusetts Division of Employment and Training. Mass Stats. n.d. < http://www.detma.org/MassStats/websaras/index.asp> (31 January 2002).

Useful source for data on income and employment for the state of Massachusetts. Probably the most current data available on income since it is updated monthly based upon surveys of employers in the state.

Commonwealth of Massachusetts, Department of Revenue. At a Glance Report for Cambridge.
6 February 2001. <http://www.state.ma.us/dlsaag/aag049.htm> (23 January 2002).

As the title suggests, this is a brief report providing the basic information about the city of Cambridge. However most of it is finance and budget related and hence quite useless for our research purposes.

Cambridge – General Information

City of Cambridge, Massachusetts. City of Cambridge.
n.d. <http://www.ci.cambridge.ma.us/> (20 January 2002).

The official web site of the City of Cambridge, and an excellent source for information on the city government and the officials responsible for running the city. Contains a vast amount of information on the various departments of the city government, its public schools and city-managed transportation options.

Cambridge Office for Tourism. "Visitor Information"
n.d. <http://www.cambridge-usa.org/visitor/visitorset.htm> (20 January 2002).

An extremely useful source for current information on the City of Cambridge, its people and its landmarks.

Goldfrank, Edward, Janice Goldfrank, Alexander Humez and Nicholas Humez. Boston Basic Bicycle Book. Boston, Massachusetts: David R. Godine, Publisher, 1975.

Very useful reference for a cycling/walking tour of Boston, includes tours of the best sights in Boston and its surrounding cities. Again of little use for our research as it lacked information on the people and the local community.

Knowles, Katharine and Walter Muir Whitehill. Boston and Cambridge: Portrait of Two Cities. Barre, Massachusetts: Barre Publishers, 1972.

An excellent source for information on the two cities' historical landmarks and for an illustrated description of their histories. However, being a mostly pictorial work, it is of little use in our research.

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Again an excellent source for a pictorial description of Cambridge, but yet again of little use to our research since it offers information that is not current anymore. Much has changed in Cambridge since the writing of this book.

Rand, Christopher. Cambridge, U.S.A. New York: Oxford University Press, 1964.

This book was very informative about the Cambridge's often overlooked contributions to not only Massachusetts or the United States, but to the whole world at large. It gave us a very good picture of life in the city and the socio-economic affairs of the city. This data however is again dated, and lacks the demographic statistics that we are primarily interested in.

Vexler, Robert, ed. Chronology and Documentary Handbook of the State of Massachusetts. Dobbs Ferry, New York: Oceana Publications, Inc., 1978.

Mostly a history book, stating facts and describing important events and the dates they took place on. It too did not contain the demographic data we sought.

Geographic Information Systems

MassGIS, Commonwealth of Massachusetts Executive Office of Environmental Affairs. Massachusetts Geographic Information Systems. 25 January 2002. <http://www.state.ma.us/mgis/> (4 February 2002).

This is a state site with a number of GIS maps and layers available for download. Some of these maps could be useful in our project.

Huxhold, William E. An Introduction to Urban Geographic Information Systems. New York: Oxford University Press, 1991.

A great book for information on how towns and cities use Geographic Information Systems to process large amounts of data. Contains examples of how GIS can be used for various municipal needs. Even has chapters on the design and implementation process.

Peuquet, Donna J. and Duane F. Marble. Introductory Readings in Geographic Information Systems. London: Taylor & Francis Ltd., 1990.

This book provides a useful introduction to GIS and offers practical examples of its application. It then goes on to describe the operations and problems of building a database, data representation and analysis techniques and finally walks us through the process of GIS design and evaluation. A useful source for implementation details.

Longley, Paul A., ed., et al. Geographical Information Systems: Volume 1, Principles and Technical Issues. New York: John Wiley & Sons, 1999.

This book contains a lot of detail on various concentrations within GIS. This book tries to look at GIS from the viewpoint of multiple professions. Going into detail on any one subtopic of GIS in this source will be time consuming, but it should be worth it if any of the steps of methodology closely parallel any topics. Includes a wide range of topics and viewpoints.

Korte, George B. The GIS Book, 3rd Edition. Santa Fe, New Mexico: OnWord Press, 1994.

The book is a "manager's guide to purchasing, implementing, and running a geographic information system" and hence of more use to the City of Cambridge than for the purposes of this project. Provides details on currently available GIS systems and offers reviews of each.

Li, Ki-Joune, ed., et al. Proceedings of the Eighth ACM Symposium on Advances in Geographic Information Systems. Washington, D.C., 10-11 November 2000.

This source is a collection of journal articles on GIS advances. It is recent enough to be useful. However, I think it is too technical and too specialize on topics that do not apply to our project to be useful to us. If we want to use something this technical, we should search through journals for an article that is related to a task we need to perform.

Langran, Gail. Time in Geographic Information Systems. London: Taylor & Francis Ltd., 1993.

More of a technical resource, this book describes how the concept of cartographic time can be implemented in a Geographic Information System. Dwells far too much on technical details to be of any use in our research.

Star, Jeffrey and John Estes. Geographic Information Systems: An Introduction. Englewood Cliffs, New Jersey: Prentice Hall, 1990.

This book gives an understandable and concise introduction to the basic concepts and issues in GIS. It splits the process of GIS design into a number of steps. They later go into each step in detail to describe why it is important to the process and what you need to consider in the step. Unfortunately, the book is from 1990 so it anything it says dependant on computational power should be out of date and it may not be able to mention applications that computers have recently made possible in GIS.

Traffic and Transportation

Massachusetts Bay Transportation Authority
n.d. <http://www.mbta.com/> (24 January 2002).

Contains lots of maps of different routes, lists of fares, times, routes, resources, and lots of other important and useful information.

Cervero, Robert. The Transit Metropolis: A Global Inquiry. Washington, D.C.: Island Press, 1998.

This book is mostly composed of case studies of cities that were able to successfully implement a public transit system as a reasonable alternative to automobile travel for its citizens. Written with a theme of sustainability. Topics: Why driving is bad for sustainability – basic numbers and environmental issues (p. 31 and on); Auto reduction: Copenhagen: limiting roads and parking (150-151); Singapore: high taxes on everything car related and limits on national car imports (168); Zurich: traffic calming in neighborhoods, government limiting of parking, easier parking near transit stops, lessening parking requirements for housing developers near transit stops (312)

U.S. Department of Transportation, Federal Highway Administration. Part IV Standard and Guides for Traffic Controls for Street and Highway Construction Maintenance, Utility, and Incident Management Operations (MUTCD). U.S. Department of Transportation, Federal Highway Administration, 1993.

This manual is based on construction detours and traffic problems caused by construction and maintenance.

Newman, Peter and Jeffrey Kenworthy. Sustainability and Cities: Overcoming Automobile Dependence. Washington, D.C.: Island Press, 1999.

This book talks about cars being a problem, but its plans for responding to the problem do not focus on controlling traffic through limiting the amount of parking available. There does not appear to be much useful information here.

Witheford, David K. Zoning, Parking, and Traffic. Connecticut: ENO Foundation for Transportation, 1979.

This source could be a little bit old but seems to have a lot of useful information about parking and traffic. It includes many different ideas on how to help solve problems, how to avoid them and the zoning laws and regulations that are enforced.

Second International Conference (15-18 April 1986). Road Traffic Control. New York: Institution of Electrical Engineers, 1986.

The source has many different formulae and information about traffic. Will be useful if any calculations for traffic are needed.

Barfield, Woodrow and Thomas A. Dingus, ed. Human Factors in Intelligent Transportation Systems. Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers, 1998.

This source is not useful. The systems it describes refer to improving efficiency and safety in the use of a transportation system by incorporating technology that utilizes information about the transportation environment. Its examples are not useful for our project.

Parking

Highway Research Board. Parking Principles (Special Report 125). Washington, D.C.: The National Academy of Sciences, 1971.

Chapter 4 talks in general about parking authorities such as the Department. However, being written in the early 1970s this book does appear to address the same parking related traffic issue. It sees on-street parking as cause rather than sheer number of cars. Its solution is the establishment of extra off-street parking, which differs from the efforts in Cambridge. One useful idea in the Introduction is the concept that any transit system has three pieces (vehicle, right-of-way, terminal). Hence, by limiting terminals, government can limit amount of travel in the vicinity of those terminal.

Parking Consultants Council, National Parking Association. The Dimensions of Parking. Washington: Urban Land Institute and National Parking Association, 1979.

This book is put together to help people understand the problems of traffic and parking and should be very helpful. It contains lots of good thoughts on how to reduce problems and what causes them.

Chrest, Anthony P., Mary S. Smith, Sam Bhuyan. Parking Structures (2nd). Boston.: International Thompson Publishing, 1996.

This book does not seem to have much relevance to the project. It is basically a manual based on building and maintaining parking garages or parking lots.

Laws and Regulations (relating to traffic management)

Cambridge City Council. "Parking and Transportation Demand Management (PTDM) Ordinance." Cambridge Municipal Code: Title 10, Chapter 18. January 2001. <http://bpc.iserver.net/codes/cbridge/index.htm> (19 Jan 2002).

This was put in to place in November 1998. It requires the developers of new (not previously licensed) commercial parking spots to register them with the city. Depending on the number of new and total parking spots in the facility, the developer will need to agree to a PTDM plan to encourage the users of the parking spots to encourage the users not to make single occupant trips. This document is valid to our topic since it appears to be one of the reasons that we will perform our project.

City of Cambridge. "About the Traffic, Parking and Transportation Department." 18 April 2000. <http://www.ci.cambridge.ma.us/~Traffic/about.html> (19 Jan 2002).

This documents states the goals of the Traffic, Parking and Transportation Department. We will want to give a basic description of what they do and their goals so we can later describe how actions are going to fill some of the goals of this department. (It might be more useful if we can find a written document stating the mission of the Department.)

City of Cambridge. "Community Development Department: Environmental and Transportation Planning Division." 8 January 2002. <http://www.ci.cambridge.ma.us/~CDD/envirotrans/index.html> (19 Jan 2002).

This is the website for the sponsoring department. This department is our sponsor and is responsible for implementing the PDTM Ordinance. We can use this site to describe the goals and objectives of the agency.

Cambridge City Council. "Commercial Parking Space Permits." Cambridge Municipal Code: Title 10, Chapter 16.
January 2001. <http://bpc.iserver.net/codes/cbridge/index.htm/> (19 Jan 2002).

Section 030 connects the committee to carry out this ordinance with the activities of various environmental and traffic agencies on the city, state, and federal level. Section 040 (c) (9) recommends the creation of the PTDM Ordinance (Tile 10, Chapter 18) asking for "A plan, approved in writing by the City Manager's Designee for regulation and control of air pollution from motor vehicles." This demonstrates that the PTDM Ordinance came from efforts to control air pollution.

Cambridge City Council. "Vehicle Trip Reduction Ordinance." Cambridge Municipal Code: Title 10, Chapter 17. January 2001. <http://bpc.iserver.net/codes/cbridge/index.htm> (24 Jan 2002).

This chapter gives a wider view of the city's efforts to control traffic than does the PTDM ordinance. It references air pollution and inconvenience of travel as two reasons the traffic should be discouraged. It states reduction of single occupant vehicles and parking as a goal. It also references the Clean Air Act of 1990 and the Massachusetts State Implementation Plan.

Office of Air Quality Planning and Standards of the Environmental Protection Agency. "The Plain English Guide to the Clean Air Act." EPA-400-K-93-001: April 1993. 5 September 2001.
<http://www.epa.gov/oar/oaqps/peg_caa/pegcaain.html> (28 Jan 2002).

This source explains some of the details of the Clean Air Act. We use it to show the chain of what organizations are responsible for meeting the requirements of the Clean Air Act and who enforces them.

U.S. Congress. Senate. "Clean Air Act of 1990." 101st Congress, 2nd Session, S.1630. Congressional Record, Volume 136. n.d. <http://thomas.loc.gov/cgi-bin/query/z?c101:S.1630.ENR:> (24 Jan 2002).

Full text of the Clean Air Act. This document is useful because it contains the federal government's statements that pollution is bad for its citizens and sets guidelines that the state and city governments need to follow.

U.S. Department of Transportation, Federal Highway Administration. Highway Statistics 1997. U.S. Department of Transportation, Federal Highway Administration.: 1998.

This Source includes many charts, graphs and statistics about highways, highway use, gas use, vehicle registration and many other transportation related categories. It is probably not useful for this background.

City of Cambridge, Massachusetts. The Zoning Guide: A User Guide to the City of Cambridge Zoning Ordinance. 2nd edition. Cambridge, MA: September 1999. 21 April 2001.
<http://www.ci.cambridge.ma.us/~CDD/commplan/zoning/zoningguide/index.html> (28 Jan 2002).

This source gives information about the basics of Zoning in Cambridge. Its intended audience is citizens and businesses in Cambridge. This document may allow us to more closely examine the themes that drive community development efforts in Cambridge if we need to explore this issue further in our background chapter.

Massachusetts Department of Environmental Protection: Bureau of Waste Management. Implementation of the 1990 Federal Clean Air Act Amendments: A Massachusetts Status Report, April 2000. Air Program Planning Unit Publications. 25 April 2000 <http://www.state.ma.us/dep/bwp/daqc/files/1990caaa.htm> (1 Feb 2002).

This document details the progress of the efforts of the MDEP to create and enforce the SIP as required by the 1990 Clean Air Act.

Appendix B: Sponsor Information

CITY OF CAMBRIDGE
Traffic, Parking, and Transportation Department
238 Broadway
Cambridge, MA 02139
Hours: 8:30 AM to 5:00 PM, Monday - Friday
Phone: 617-349-4700
Fax: 617-349-4747
< http://www.ci.cambridge.ma.us/~Traffic/>

Jason Schrieber
Transportation Planner
CITY OF CAMBRIDGE
Traffic, Parking and Transportation Department
617-349-4745

City of Cambridge Transportation Policy Goal

The City's transportation systems must meet the mobility needs of the residents, businesses and institutions within the City. These transportation systems should provide the broadest possible array of options for moving people and goods with particular emphasis on enhancing modes other than single occupant vehicles.

The City's transportation facilities and its education and enforcement programs must promote safety.

The City's transportation programs must reduce the negative impacts of transportation such as air pollution, noise and congestion. These programs should support a safe and vibrant City protected from excessive vehicle trips and inappropriate speeds.

Departmental Goals

1. Increase the public safety of our transportation facilities.
2. Support the transportation needs of residents, businesses, institutions and other City departments.
3. Enhance the Department's customer service orientation.
4. Increase the efficiency of the operations and procedures of the Department.

Organization and Responsibilities

- Administration
- Traffic Engineering
    - Signals - 122 Locations
    - Curb regulations
    - Permits to close or occupy a street
        - 200 Street closures per year
        - 4,500 Street obstructions per year
    - Signs
    - Pavement markings
        - 1,700 Crosswalks
        - 900 Stoplines
    - Development reviews
        - Traffic studies
        - Curb cuts
        - Access/egress
        - Safety

- Parking
    - Meters
    - Resident permit parking
    - Ticketing and vehicle impoundment
    - Parking ticket processing and adjudication
    - Facilities
        - Central Square and East Cambridge garages
        - Metered lots

Appendix C: Related Organizations

CITY OF CAMBRIDGE
Community Development Department
238 Broadway
Cambridge, MA 02139
Hours: 8:30 AM to 5:00 PM, Monday - Friday
Phone: 617-249-4600
TTY: 617-349-4621
Fax: 617-349-4669
< http://www.ci.cambridge.ma.us/~CDD/>

The Community Development Department is the City's chief planning and development agency. Responsibilities include economic development, environmental and transportation planning, housing, community planning and urban development. The Department strives to enhance the physical environment, improve the quality of life found in Cambridge and support the diversity of the City's population.

The Department administers the City's federal Community Development Block Grant, which funds programs of benefit to people with low and moderate incomes, primarily in the areas of housing and human services.

Environmental and Transportation Planning Division

Division Overview

Susanne Rasmussen srasmussen@ci.cambridge.ma.us <mailto:srasmussen@ci.cambridge.ma.us>
Director of Environmental & Transportation Planning

The Environmental and Transportation Planning Division of the Community Development Department is responsible for improving the city's quality of life, by working to protect and improve the city's environment and natural resources and by planning improvements to the city's transportation system. The division works to achieve these objectives in the following ways:

- Managing the design of the transportation system to improve travel for all transportation modes, particularly high occupancy and non-motorized modes;
- Promoting walking, bicycling, ridesharing, and public transit;
- Implementing the city's Vehicle Trip Reduction Ordinance <http://ordlink.com/codes/cbridge/_DATA/Title_10/17/index.html> and Parking and Transportation Demand Management Ordinance <ptdm/index.html> to reduce congestion and improve air quality;
- Planning transportation infrastructure projects;
- Reviewing development proposals to mitigate the impacts;
- Promoting energy efficiency, reduced use of toxic products, and other environmentally sound practices;
- Preventing childhood lead poisoning; and
- Answering general questions about environmental issues

Overview of Programs and Services

Lead-Safe Cambridge <http://www.ci.cambridge.ma.us/~LeadSafe/>

Lead-Safe Cambridge works to remove lead contamination from residential buildings throughout Cambridge. Services include technical advice, medical treatment, temporary relocation, and community-based outreach and education, as well as up to $10,000 per unit in financial assistance to private property owners in Cambridge. Lead-Safe Cambridge can be reached by phone at 617-349-LEAD (617-349-5323).

Infrastructure Projects <infraproj/index.html>

The division is involved in a number of transportation infrastructure planning and design projects. The goals for these projects vary and include improving pedestrian and bicycle access, reducing traffic on residential streets, upgrading the aesthetics of a corridor, and improving travel safety. These projects aim to accommodate all travelers, including pedestrians, cyclists, transit users, and drivers.

Traffic Calming <trafcalm/index.html>

The goal of traffic calming projects is to improve the quality of life in neighborhoods and allow cars to peacefully coexist with other modes. This involves the creation of physical and visual cues, such as speed tables, sidewalk neck downs, and roadway markings which slow the speed of traffic and increase safety.

Pedestrian Programs <walking/index.html>

Walking is as a healthy, environmentally friendly way to get around Cambridge and the Boston area. Walking allows you to combine transportation and exercise, and is the form of exercise that people are most likely to stick with over time. Examples of the City's pedestrian projects include making intersections safer for pedestrians, repairing and improving sidewalks, and reviewing proposed developments to make sure they are as pedestrian-friendly as possible.

Bicycle Programs <bicycle/index.html>

The Division works to promote bicycling as healthy, environmentally friendly ways of getting around Cambridge and the Boston area. Cambridge is well suited to bicycling and more people are using their bikes every day for commuting, shopping, and general transportation. Bicycle programs include installing bicycle lanes and other bicycle improvements as streets are repaved, bicycle safety campaigns in schools and elsewhere to teach safe cycling to both children and adults, and the installation of bicycle parking throughout the city.

Transportation Demand Management <tdm/index.html>

The goal of the City's Transportation Demand Management (TDM) programs is to improve mobility and access, reduce congestion and air pollution, and increase safety. These programs work to reduce the level of drive alone travel by promoting walking, bicycling, carpooling, vanpooling, public transportation, and other alternative modes. The City works cooperatively with citizens, businesses, and institutions in Cambridge and the Boston area to implement TDM measures. The division is also responsible for implementing the Parking and Transportation Demand Management (PTDM) Ordinance.

Environmental Planning <enviroplan/index.html>

The division works to protect and improve environmental quality in Cambridge through programs and projects that prevent pollution, encourage environmentally friendly alternatives, and promote energy conservation. Current projects include the introduction of alternative fuel vehicles (i.e., natural gas and electric) to the City's fleet and the implementation of an integrated pest management policy to reduce pesticide use.

Regional Planning Projects and Organizations <regional.html>

In addition to the programs described above, the division participates in the planning and design of a number of projects taking place regionally and in adjacent cities and towns. The division also participates in a number of regional planning organizations.

Appendix D: Cambridge Municipal Ordinances

Chapter 10.17 of the Cambridge Municipal Code: VEHICLE TRIP REDUCTION ORDINANCE

Section 10.17.010 Time period of chapter.

Sections 10.17.040 through 10.17.180 of this chapter shall take effect sixty days after final approval by the City Council. The remaining provisions shall not take effect until, and shall at that time supersede and replace Chapter 10.16, sixty days after final approval by the U.S. Environmental Protection Agency ("U.S. EPA") of a SIP amendment for Massachusetts which (i) contains a program of transportation control measures that are imposed equally on all communities in the Commonwealth such as an employer-based vehicle trip reduction program; and (ii) revokes any provisions of 40 C.F.R. Section 52.1135 that are applicable to Cambridge. (Ord. 1139 (part), 1992)

Section 10.17.020 Findings.

The City of Cambridge finds and determines that:

A. High levels of vehicle traffic and congestion add to air pollution, noise, and inconvenience and erode the quality of the living and working environment.

B. An increasing number of automobile registrations and jobs in the City has resulted in growth of traffic in and around Cambridge.

C. While the City has pursued programs to mitigate these conditions, new measures must be implemented by the City and the Commonwealth involving the participation of all sectors of the community on a local and regional bases to make more efficient use of mass transit, bicycling, walking, and other alternatives to trips by single-occupancy vehicles.

D. The Clean Air Act amendments of 1990 call for the attainment of compliance with the National Ambient Air Quality Standard for Ozone within the Commonwealth by 1999.

E. Attainment of the Ozone Standard will require increased control of vehicle-related air pollution ("transportation control measures") throughout the Commonwealth, as well as the Nation.

F. Throughtrips and other traffic over which Cambridge has no control contribute significantly to the degradation of air quality in the region. The degradation of air quality, particularly ozone, is a regional problem which requires global and regional solutions.

G. A large portion of vehicle traffic on Cambridge streets is attributable to trips that neither originate nor end in Cambridge ("throughtrips"). The City of Cambridge has virtually no control over these throughtrips. Accordingly, it is imperative that DEP amend the SIP to include transportation control measures applicable equally to all communities in the Commonwealth, including an employer-based vehicle trip reduction program, to achieve reductions in the number of vehicle trips and vehicle miles travelled throughout the region.

H. Increasing the use of commuting alternatives and reducing the number of trips by single-occupancy vehicles is beneficial for the City and the Commonwealth in reducing vehicle miles travelled, traffic and associated air pollution, fuel use, noise, and congestion.

I. Programs offered through City Departments, employers, institutions, owners of multiple-tenant buildings and complexes and other organizations to encourage the use of mass transit, bicycling walking, and other alternatives to commuting by single-occupancy vehicles are effective and should be expanded on a citywide and regional basis.

J. The approach which includes, where consistent with employers' needs, adoption and enforcement of driving disincentives, particularly those applicable to the regular work-day commuter, and best suited to accommodate the diverse needs and capabilities of the governmental, business and institutional communities in the City, and recommended for adoption by DEP for state-wide application is a flexible approach which establishes performance coals and

permits government and private employers, institutions, and automobile owners to select from among a variety of measures designed to contribute toward reaching the goals.

K. The vehicle trip reduction program recommended for adoption by DEP on a state-wide basis should give credit to those employers which have already made substantial progress in encouraging the use of mass transit, bicycling, walking, and alternative means of commuting and in providing such alternatives.

L. Measures to discourage, and provide alternatives to, vehicle trips and trips by single-occupancy vehicles made by residents of and visitors to Cambridge are also necessary to further the goals of the Clean Air Act.

M. Some of the measures contained in this chapter will achieve immediate reductions in vehicle miles travelled; others are designed to collect information and otherwise lay the foundation for future actions to reduce vehicle miles travelled and improve air quality. To maximize air quality benefits, some types of transportation control measures must be adopted and applied on a regional basis. (Ord. 1139 (part), 1992)

Section 10.17.030 Definitions.

A. "City" means the City of Cambridge, Massachusetts.

B. "Clean fuel" means any fuel or power source used in a vehicle that complies with the applicable standards for clean fuel vehicles contained in Sections 241-245 of the Clean Air Act, 42 U.S.C. §§ 7581--7595.

C. "Clean-fuel vehicle" means a vehicle in a class or category of vehicles which has been certified to meet the applicable clean-fuel vehicle standards as defined by and pursuant to the federal Clean Air Act Amendments of 1990.

D. "Fleet" means ten or more vehicles which are (i) owned, leased, controlled or operated by a single person or entity; or (ii) parked at the same location, excluding vehicles held for lease or rental to the general public, vehicles held for sale by dealers, vehicles used for law enforcement or emergency purposes.

E. "Ozone standard" means the National Ambient Air Quality Standard for Ozone established pursuant to Section 109 of the Clean Air Act, 42 U.S.C. § 7409.

F. "Region" means those communities east of, or through which Route 128 passes.

G. "Selected employers" means those employers in Cambridge who voluntarily agree to participate in the pilot survey of employee commuting characteristics set forth in Section 10.17.130.

H. "Throughtrips" means vehicle traffic on City of Cambridge streets attributable to trips that neither originate nor end in the City of Cambridge.

I. "Transportation control measures" are transportation control strategies aimed at reducing transportation related emissions of pollutants and controlling the growth of future vehicle trips and vehicle miles travelled.

J. "VMT" is an abbreviation for vehicle miles travelled.

K. "AER" is an abbreviation for automobile efficiency rate, a rate determined as set forth in Section 10.17.130(D).

L. "Base AER" is a term for the automobile efficiency rate for the City of Cambridge, more fully described in Section 10.17.130(E). (Ord. 1139 (part), 1992)

Section 10.17.040 Expanded commuter mobility program.

In addition to continuing activities currently in progress, the Commuter Mobility Coordinator shall develop and submit to the Assistant City Manager for Community Development and the City Manager a schedule for implementing additional programs including, but not limited to:

A. A bicycle commuter program, in conjunction with the Traffic and Parking Department and the Bicycle Advisory Committee involving consultation with Cambridge residents and businesses;

B. A program to assist employers in establishing bicycle commuting incentives;

C. A feasibility study of the potential use of an in-City paratransit system of jitney services or shuttles to transit locations, areas of major employment, and major commercial/retail destinations; and

D. A program for publicizing successes achieved by businesses and institutions in decreasing the number of single-occupancy vehicle commuters to their establishments;

E. An education program, including newspaper articles, cable television programs, and public meetings, to inform residents and employees of the need for, and the benefits to be realized from, changes in commuting behavior;

F. The beginning of a commuter ride-share program;

G. A program to encourage businesses to offer discounts on T passes.

The City will provide adequate resources to enhance the ability of the commuter mobility program to work to reduce the vehicle miles travelled in Cambridge. (Ord. 1139 (part), 1992)

Section 10.17.050 Bicycle and pedestrian mobility program.

The position of Bicycle and Pedestrian Coordinator is created within the Traffic and Parking Department. The City Manager shall, within one month of the effective date of this provision, designate the Bicycle and Pedestrian Coordinator. The Bicycle and Pedestrian Coordinator shall devote at least fifty percent of his/her time to carrying out the tasks required by this provision. The Bicycle and Pedestrian Coordinator shall, in conjunction with the Commuter Mobility Coordinator and the City's existing Bicycle Advisory Committee, (i) design and implement a program to encourage greater use of bicycles as alternatives to single-occupancy vehicles within the city and, (ii) focus the attention of the City on the needs of pedestrians. The program will include, but is not limited to:

A. Development of a Cambridge Bicycle Master Plan;

B. Development of a Cambridge Pedestrian Master Plan;

C. Development and evaluation of recommendations for a regional network of bicycle paths and bicycle priority streets favoring both bicycles and pedestrians;

D. Consultation with Cambridge residents, businesses, institutions and property owners;

E. Funding of bicycle amenities and storage facilities;

F. Funding for pedestrian amenities; and

G. Provision of bicycles for use by City police and Traffic and Parking Department.

The program shall be funded at an initial level of twenty-five thousand dollars annually; these funds shall be in addition to, and not utilized for, the salary of the Bicycle and Pedestrian Coordinator. (Ord. 1139 (part), 1992)

Section 10.17.060 Restrictions on visitor passes.

A. Official City Visitor Passes. The Citywide visitor passes that have been distributed to authorized individuals will be invalid thirty days after the effective date of the ordinance codified in this provision. The Traffic and Parking Department is authorized to issue stickers to individuals or organizations or who would be authorized to receive a Citywide visitor pass. A list of all recipients of Citywide visitor passes shall be maintained by the Traffic and Parking Department and shall be made available for public inspection upon request. In order to be effective, a sticker must be affixed to a vehicle and must display the vehicle registration number and an expiration date. These stickers shall be easily distinguishable from the stickers issued to City residents. No Official City Visitor Sticker shall be issued that is valid for a time period longer than one year. The names of individuals and organizations shall be available to the public upon request. The list shall be updated by the Department at least quarterly.

B. Residential Visitor Passes. Beginning on the January first following the effective date of this provision, each residential visitor pass issued by the Traffic and Parking Department shall be designed to display a calendar for the year during which it is valid. To be valid on a given date, the pass must be displayed in the windshield and the date of use must be circled. (Ord. 1146, 1992; Ord. 1139 (part), 1992)

Section 10.17.070 Fees for residential parking stickers.

The fees for residential parking stickers shall be eight dollars per permit per household. (Ord. 1147, 1992)

Section 10.17.080 Study of zoning revisions.

The Cambridge Planning Board (the "Board") shall consider revising the required parking space ratios specified in the City Zoning Ordinance and shall evaluate the effectiveness of such revisions in reducing VMT and traffic congestion and encouraging the increased use of commuting alternatives other than by single-occupant vehicles. The Planning Board shall evaluate the need to reduce the allowed densities to achieve the goal of reduced vehicle miles travelled and shall also consider eliminating the exclusion of parking in the calculation of gross floor area. The Board shall also consider the economic impact of such revisions. Consideration shall be given, without limitation, to such potential revisions as reduction of minimum and maximum parking requirements, special provisions for carpools and vanpools, and encouragement of mixed-use developments.

The Board shall invite testimony from residents, businesses, institutions, and property owners and shall publicly report its recommendations within one year of the effective date of this provision. (Ord. 1139 (part), 1992)

Section 10.17.090 Improved coordination with MBTA.

The City Manager shall initiate meetings with the General Manager of the MBTA to map out a strategy for close cooperation between the City and the MBTA on increasing public transportation services to and within the City. The management of the MBTA will be asked to work to improve existing services and to look into ways in which the MBTA can be of assistance to the City in exploring possible development of a local para-transit system. There shall be a goal of establishing a working joint committee to implement the needed improvements.

The Commuter Mobility Staff shall undertake a survey of residents and commuters to identify barriers to use of the MBTA. The Commuter Mobility Staff shall also conduct widely-advertised public forums in neighborhoods throughout the City. Based on the survey and the results of the public meetings, the Commuter Mobility Staff will make recommendations for improving MBTA service. The recommendations will be available to the public for comment. The Commuter Mobility Staff will request that the MBTA hold one or more public meetings to discuss the recommendations.

The Department of Traffic and Parking and the Commuter Mobility staff shall work with MBTA to (i) improve public transportation schedules and routes; (ii) to improve bus stop signage; and (iii) to review placement of bus stops. The Cambridge Traffic and Parking Department shall also cooperate with the MBTA in an attempt to have the MBTA, at the sites selected by Cambridge, erect bus stop signs that are used in other cities and towns.

Meetings with representatives of the MBTA should also focus on conversion of buses to clean fuels. (Ord. 1139 (part), 1992)

Section 10.17.100 Regulation of idling buses, trucks, and taxis and automobiles.

The Police Department shall promptly review and improve its enforcement of the statutory prohibitions against idling by busses, trucks and taxis and automobiles set forth at G.L., ch. 90, § 16A. Within two months of the effective date of the ordinance codified in this provision, the Commissioner of the Police Department shall report to the City Manager on the Department's implementation of this provision. (Ord. 1139 (part), 1992)

Section 10.17.110 Taxicab improvements.

The License Commission, through the Taxicab Advisory Committee shall consult with the taxicab industry, residents, and commercial establishments in the City and prepare recommendations:

A. To make taxicabs more accessible for use by multiple passengers with different destinations. The object of this recommendation shall be to decrease single-occupant use of taxicabs by providing monetary incentives for the taxicab drivers and reducing the cost for passengers; and

B. About the potential role of taxicabs in a paratransit system for the City; and

C. About conversion of taxi fleets to clean fuels;

D. for new or relocated taxi stands; and

E. For policies or actions that would encourage Cambridge residents to use taxicabs that are licensed in Cambridge instead of taxicabs from other cities. (Ord. 1139 (part), 1992)

Section 10.17.120 Alewife Station and Garage.

The Assistant City Manager for Community Development or his designee shall consult with Alewife neighborhood groups, employers, and other interested persons concerning the demand for (i) a commuter rail station at Alewife, (ii) an expansion of the Alewife garage, and (iii) shuttle bus or van service between Alewife Station and nearby employment sites and stores. The Assistant City Manager shall report his findings to the City Council within one year of the effective date of this provision. (Ord. 1139 (part), 1992)

Section 10.17.130 Pilot survey of commuting characteristics of City employees and employees of selected employers.

A. The City, in consultation with the Selected Employer Steering Committee, shall develop an Employer Survey Kit which may include an Employee Survey Form, administration plan, and Automobile Efficiency Rate ("AER") (defined below) calculation sheet, designed to elicit commuting data from all City employees and employees of Selected Employers which will permit the calculation of an actual AER for each Selected Employer and City Department and will also provide the statistical basis for determining such other characteristics of commuting patterns as may be useful in designing measures to achieve the goals of the Clean Air Act. The Employer Survey Kit shall be prepared and distributed to City Departments and Selected Employers within six months of the effective date of the ordinance codified in this provision. Each City Department and Selected Employer shall distribute copies of the Employee Survey Form to, and as a goal shall endeavor to collect completed forms from, seventy-five per cent of its employees. Each City Department and Selected Employer shall, no later than three (3) months from the date the Employer Survey Kit is distributed, submit to the Assistant City Manager for Community Development all completed Employee Survey Forms, provided that, any Selected Employer may instead submit a report of the results of the employee survey on a standard AER calculation sheet, signed and certified as to its accuracy by an officer of the Company. A Selected Employer that does not submit the Employee Survey Forms shall retain such forms for a minimum of three years. These forms shall be made available to the Assistant City Manager for Community Development or his designee, upon request.

B. The Selected Employer Steering Committee shall:

1. Participate with the City in the design of the pilot survey;
2. Assist in educating and encouraging participation of the selected employer group;
3. Review with the City the results of the pilot survey; and
4. Participate in the design of any City-wide employer based vehicle trip reduction program.

C. Each City Department and Selected Employer shall cooperate with the Assistant City Manager for Community Development and the Commuter Mobility Staff in providing information about plans and programs being utilized to encourage commuter travel modes other than by single occupancy vehicles. At such time as the City implements or enforces an employer-based vehicle trip reduction program on a city-wide basis, each City Department and Selected Employer which has cooperated with the Community Development Department and the Commuter Mobility Staff

and which has complied with paragraph "A" hereof shall be entitled to use the AER reflected in its initial Employer Survey Response as its baseline AER regardless of the extent of improvements in its AER produced as a result of its cooperation with the Community Development Department or its own commuter mobility initiatives.

D. The Assistant City Manager for Community Development shall make arrangements with the Commuter Mobility Staff to coordinate: (i) participation of the Selected Employers; (ii) preparation and distribution of the Employer Survey Kits; (iii) calculation of the base AER; (iv) review and tabulation of the pilot employer survey responses; (v) recalculation of the base AER based on review and analysis of the pilot employer survey responses. The Assistant City Manager for Community Development shall have the authority to engage the services of technical consultants to assist with these tasks.

E. The phrase Automobile Efficiency Rate ("AER") shall mean the figure calculated by dividing the number of employees who report to a worksite within the City of Cambridge between six a.m. and ten a.m. (inclusive Monday through Friday to achieve a five consecutive weekday average) by the number of vehicles used by those employees to reach the worksite during those hours. Bicycles, public transit vehicles, and approved clean-fuel vehicles shall be excluded from the vehicles counted. Motorcycles and light trucks shall be included in the vehicles counted.

F. The City shall define and make calculations of a base AER for the City of Cambridge as a whole. Such base AER shall initially be derived from the 1990 Census modal share data and travel statistics, the results of the pilot survey of selected employers, and such other data as may be relevant. Subsequently, the City may develop other AERs for categories such as geographical areas of the City, employer types, employer sizes, and the like, as may be determined through the consultative process provided for in Section 10.17.140. The City may also, through the same consultative process, periodically recalculate the base AER or such other AERs to reflect additional data or changes in data as become available.

G. The term "carpool" shall mean a private motor vehicle occupied by two to six employees travelling together for at least seventy-five percent of their commute trip distances.

H. The term "commute alternatives" shall mean carpooling, vanpooling, private bus service, use of public transit, bicycling and/or walking.

I. The term "employee" shall mean any person hired by a public or private employer, including part-time and seasonal employees, who reports to work at least two days a week during five or more months of the year.

J. The term "worksite" shall mean a building or grouping of buildings which are located within the City of Cambridge and are on physically contiguous parcels of land or on parcels separated solely by private or public roadways or rights-of-ways and which are owned, operated, or leased by the same Employer. (Ord. 1139 (part), 1992)

Section 10.17.140 Consultation with employers and residents about employer vehicle trip reduction program.

The Assistant City Manager for Community Development or his designee shall consult with Cambridge businesses, institutions, City departments, the Selected Employer Steering Committee, and residents to evaluate recommendations for a regional employer-based vehicle trip reduction program. During this consultation process, issues to be considered shall include:

A. Whether different areas of the City should be subject to different AER goals, depending on their proximity to public transit;

B. What the annual rate of improvement in the AER goal should be;

C. which, if any of the vehicle trip reduction plan elements identified in Section 10.17.170 should be required to be implemented by all employers in the City;

D. The definition of base AER and the potential appropriateness and definition of AERs for categories such as geographical areas of the city, employer types, employer sizes, and the like;

E. Ways to recognize the uniqueness of employers and their differing needs for employee mobility;

F. Appropriate AER or other references to be used in setting goals for Cambridge employers within a regional vehicle trip reduction program;

G. Whether employers should be required to achieve a base or other AER goal within a specified time period or whether penalties should only be imposed for an employer's failure to implement its plan;

H. Identification and development of mechanisms for transferring and/or sharing use of parking spaces as demand for parking spaces decreases at a given worksite;

I. Evaluation of potential impacts on employment and economic impacts on affected employers and on the City of any proposed measures; and

J. Whether any categories of employers should be exempt. (Ord. 1139 (part), 1992)

Section 10.17.150 Use of fees.

One hundred percent of the funds raised through the sale of residential parking stickers shall be used for implementing the tasks and programs specified in this chapter. (Ord. 1139 (part), 1992)

Section 10.17.160 Recommendations for a SIP amendment applicable to all communities in the Commonwealth.

In order to ensure that the vehicle trip reduction measures in the ordinance codified in this chapter achieve their intended effect of reducing vehicle miles traveled and enhancing air quality in the Commonwealth, the City shall include in its submittal to the Metropolitan Planning Organization ("MPO") and DEP recommendations for an amendment to the State Implementation Plan under the federal Clean Air Act applicable equally to all communities in the Commonwealth. These recommendations shall include, but not be limited to:

A. A proposal for an employer-based vehicle trip reduction program;

B. A proposal for measures applicable to new development projects to mitigate the traffic impacts of such projects and reduce vehicle miles travelled to and from such projects;

C. A proposal for revising state taxing policies concerning employer-paid transportation and parking subsidies;

D. A proposal for evaluating the utility of imposing fees on single-occupant commuter vehicles and/or commuter parking;

E. A proposal for achieving appropriate convenient public transportation from the west and north to Cambridge, including but not limited to support of a circumferential transit system;

F. Preventing the diversion of traffic oriented toward Cambridge to other areas with more limited transit availability;

G. Assuring that Cambridge is not placed at a competitive disadvantage within the region or the Commonwealth;

H. Reducing the growth in volume of throughtrips on Cambridge roadways which is outside the control of the City; and

I. Improved and extended use of water taxis.

Notwithstanding the foregoing, the City in its submittal shall note the absence of consensus about the vehicle trip reduction ordinance as originally proposed. The City shall engage in a further consultation process as outlined in Section 10.17.140. The City shall continue to update the State concerning that process. (Ord. 1139 (part), 1992)

Section 10.17.170 Municipal vehicle trip reduction plans.

Based on its review of the employee survey forms collected pursuant to Section 10.17.130, the Commuter Mobility Staff shall prepare a vehicle trip reduction plan for implementation by City Departments. The plan shall contain a program of measures identical to the program developed after consultation as set forth in Section 10.17.140 which shall be designed to reduce vehicle trips and vehicle miles travelled by municipal employees and thereby improve the City's AER, as computed on the annual AER calculation sheets. The plan may include a variety of measures including, but not limited to:

A. Dissemination and periodic updating of information on all available transit service to and from the worksite;

B. Advertising, promoting and making available for purchase on the worksite any pass program offered by transit authorities;

C. Recommendations to individual employees of employee-specific travel options to reduce VMT;

D. Incentives and assistance for bicycle commuting including secure parking facilities, shower/changing facilities, and education and training programs;

E. Coordinating, facilitating and providing subsidies for employer-sponsored rideshare programs;

F. Preferential parking for carpools and vanpools;

G. Transportation allowances;

H. Expanding opportunities for alternative work schedules including four-day weeks and flexible schedules to facilitate ridesharing;

I. Elimination or reduction of parking subsidies for single-occupant vehicles;

J. Shuttle service to transit stops; and/or

K. Elimination of employee parking spaces.

After consultation with the Assistant City Manager for Community Development and the City Manager about the plan, the Commuter MobilIty Staff shall promptly distribute it to City Departments for implementation. The Commuter Mobility Staff shall assist City Departments with implementation of the plan. (Ord. 1139 (part), 1992)

Section 10.17.180 Expansion of local employment opportunities.

To demonstrate and further its commitment to increase the number of Cambridge residents employed by Cambridge businesses and reduce vehicle miles associated with work commutes, the annual budget for expansion of local employment opportunities shall be increased to two hundred thirty thousand dollars. That budget shall be applied as follows:

A. To continue and expand the Cambridge Employment Program within the Community Development Department;

B. To sponsor an annual job fair to inform residents of local employment opportunities;

C. To sponsor and coordinate educational partnerships between Cambridge employees and schools in Cambridge; and

D. To develop a Local Employment Opportunity Plan.

These functions shall be coordinated and carried out by the Community Development Department in conjunction with the Department of Human Services and under the supervision of the Assistant City Manager for Community Development. The Local Employment Opportunity Plan shall be developed within one year of the effective date of the ordinance codified in this provision

[THE FOLLOWING SECTIONS, 10.17.190 THROUGH 10.17.220, ONLY TAKE EFFECT AFTER STATE AND FEDERAL ACTION TO ADOPT A REGIONAL OR STATE-WIDE PROGRAM]

Section 10.17.190 Further expansion of commuter mobility program.

The Assistant City Manager for Community Development, in consultation with the City Manager, shall have authority to hire additional staff to implement the tasks and programs specified in this Chapter. Within three months of the effective date of this provision, at least one additional Commuter Mobility Staff member shall be hired. The Commuter Mobility Coordinator shall develop and promptly implement additional programs including but not limited to:

A. A program encouraging the use and sharing of computer ride-sharing information between and among businesses and institutions in the City;

B. A program to encourage commercial and retail businesses to offer discounts to patrons with MBTA transit passes; and

C. Implementation of an in-city paratransit system, to the extent funds are available, to supplement MBTA services.

The Commuter Mobility Coordinator shall develop and recommend additional programs, including but not limited to, a residential trip reduction program for apartment and condominium complexes of fifty or more units. (Ord. 1139 (part), 1992)

Section 10.17.200 Restrictions on parking supply.

A. Expansion of Parking Regulation. Within six months of the effective date of the ordinance codified in this provision, the Traffic and Parking Department shall submit to the City Manager an updated written inventory of all on-street parking spaces specifying the restrictions applicable to each such parking space. As to any space which has not been restricted or removed from the supply of on-street spaces pursuant to Section 10.16.071 of this title, the Traffic and Parking Department shall prepare a recommendation for restriction of each such space to discourage its use for long-term commuter parking. These restrictions may include, without limitation an absolute prohibition against parking, installation of parking meters, imposition of time restrictions, and/or restrictions for use by residents with permits. The Director of Traffic and Parking shall make the recommendations available for public review and shall schedule one or more public meetings, as appropriate, for public discussion of the recommendations. Within one month after the public meetings, the Traffic and Parking Department shall submit its revised recommendation to the City Manager. After consultation with the City Manager, the Traffic and Parking Department shall promptly implement the recommendations.

B. Municipal Parking Rates. The rates for daily and monthly parking at all City-owned off-street parking facilities shall be increased by twenty-five percent over current rates, to be effective within sixty days of the effective date of this provision.

C. Exclusive Residential Parking Near MBTA Stations. The Traffic and Parking Department, in consultation with neighborhood groups, residents, commercial establishments, and the City Manager, shall prepare a proposal for establishing exclusive residential parking zones on primarily residential streets located near MBTA stations. The object of the proposal shall be to limit residential parking on targeted streets close to MBTA stations to residents of those neighborhoods by means of appropriate signage and special resident stickers. The Traffic and Parking Department shall convene a public meeting on its proposal within four months of the effective date of this provision. Within one month after such public meeting, and after consultation with the City Manager, the Director of Traffic and Parking shall cause the proposal to be implemented. (Ord. 1139 (part), 1992)

Section 10.17.210 Promotion of clean fuels.

The Department of Public Works shall study, promote, encourage, and identify incentives for the use of clean fuel in fleets of vehicles operating within the City. The study shall include an evaluation of the use of such fuels as methanol, com- pressed natural gas, and reformulated gasoline based on characteristics of fleets in Cambridge and implementation costs. The study shall also identify reasonably available incentives which could be offered by the City, such as tax credits, to encourage use of clean fuel in fleets of vehicles. The sum of fifteen thousand dollars shall be appropriated for this program. (Ord. 1139 (part), 1992)

Section 10.17.220 Development of traffic policy.

The Assistant City Manager for Community Development and the Director of the Traffic and Parking Department, or their designees, shall within one year of the effective date of this provision, conduct a study of major highways, city through streets, streets with schools, different types of residential streets, and streets at the borders of the City. Based on that study, they shall prepare a written recommendation of:

A. Appropriate speeds and volumes for Cambridge streets; and

B. Means of encouraging travel and traffic patterns that reduce VMTs.

This written recommendation shall be submitted to the City Council for review and appropriate action. (Ord. 1139 (part), 1992)

Section 10.17.230 Sunset clause.

The provisions of this chapter shall cease to be effective ninety days after the date the Department of Environmental Protection or the U.S. Environmental Protection Agency adopts a final rule or regulation that imposes transportation control measures including parking supply management measures in Cambridge which do not have an equal impact on the Region. The purpose of this sunset clause is to give the City the opportunity to decide whether to continue to implement the numerous provisions of this chapter in the event that the final rule or regulation puts the City at a competitive disadvantage in the region. (Ord. 1139 (part), 1992)

Chapter 10.18 of the Cambridge Municipal Code: PARKING AND TRANSPORTATION DEMAND MANAGEMENT PLANNING; PARKING SPACE REGISTRATION

Section 10.18.010 Purpose.

(a) It is the purpose of this Chapter to regulate and control atmospheric pollution from motor vehicles by formalizing parking and transportation demand management planning, programs, and coordination which have been ongoing for a number of years. This Chapter will reduce vehicle trips and traffic congestion within the City, thereby promoting public health, safety, and welfare and protecting the environment. This Chapter requires parking and transportation demand management (PTDM) plans for commercial parking facilities and other types of non-residential parking facilities over a specified size as set forth in 10.18.050 and 10.18.070. This Chapter also establishes a process whereby City officials will be able to track the number, use and location of off-street parking spaces in the City.

(b) A Parking and Transportation Demand Management Planning Officer will be designated by the City Manager with the responsibility for reviewing, conditioning, approving and/or denying PTDM plans. Any project subject to the requirements of this Chapter shall not be qualified to receive a permit from the Planning Board, a commercial parking permit from the Commercial Parking Control Committee, a special permit or variance from the Board of Zoning Appeal, a building permit from the Commissioner of Inspectional Services, a certificate of occupancy from the Commissioner of Inspectional Services, or an operating license from the License Commission absent written approval of its PTDM plan from the PTDM Planning Officer or evidence of registration of its parking spaces with the Department of Traffic, Parking, and Transportation.

Section 10.18.020 Definitions.

"Commercial Parking Space" means a parking space available for use by the general public at any time for a fee. The term shall not include (i) parking spaces which are owned or operated by a commercial entity whose primary business is other than the operation of parking facilities, for the exclusive use of its lessees, employes, patrons, customers, clients, patients, guests or residents but which are not available for use by the general public; (ii) parking spaces restricted for the use of the residents of a specific residential building or group of buildings; (iii) spaces located on public streets; or (iv) spaces located at a park-and-ride facility operated in conjunction with the Massachusetts Bay Transportation Authority.

"Commercial Parking Facility" means a parking facility owned or operated by a commercial entity whose primary business is the operation of a parking facility and at which there are at least five (5) Commercial Parking Spaces.

"Commercial Parking Permit" means a (i) permit issued under chapter 10.16 of the Cambridge Municipal Code, authorizing the use of a designated number of parking spaces at a specified location as Commercial Parking Spaces; (ii) a permit or approval issued prior to the effective date of this Chapter pursuant to the Procedures, Criteria, and Memorandum of Agreement dated November 15, 1984; (iii) a Controlled Parking Facility Permit that expressly authorizes use of the parking facility for Commercial Parking Spaces; or (iv) a letter from the Director confirming the number of spaces at a specified location that were in existence and being used as Commercial Parking Spaces as of October 15, 1973.

"Controlled Parking Facility Permit" (CPFP) means a permit issued by the Director prior to the effective date of this Chapter, which authorized the construction or operation of a parking space or the construction, operation, or modification of a parking facility.

"Determination of Exclusion" means a determination made by the Director that a parking facility or a parking space did not require a controlled parking facility permit.

"Director" means Director of the Cambridge Department of Traffic, Parking, and Transportation.

"Effective Date" means the date of final adoption of this Chapter of the Cambridge Municipal Code.

"Existing Parking Facility" shall mean a parking facility for which (i) a certificate of occupancy was issued by the Commissioner of Inspectional Services; (ii) an operating license was issued by the License Commission; or (iii) the Director issued a letter confirming the number of spaces at that location which spaces were in existence and being used as commercial parking spaces as of October 15, l973 (a "Director's Letter").

"New Project" means a project to construct or operate parking spaces within a new facility or an existing parking facility which will cause such facility to have a net increase in the number of spaces for which a certificate of occupancy, operating license, variance, special permit, or Director's Letter has not been issued as of the effective date of this Chapter.

"Parking Facility" means any lot, garage, building or structure or combination or portion thereof, on or in which motor vehicles are parked and in the case of university or college campuses, the stock of parking spaces maintained within the City by the university or college which supports university or college activities within the City.

"Person" means and includes a corporation, firm, partnership, association, executor, administrator, guardian, trustee, agent, organization, any state, regional or political subdivision, agency, department, authority or board, and any other group acting as a unit, as well as a natural person.

"Planning Officer" means the City official responsible for PTDM plan reviews.

"PTDM" means Parking and Transportation Demand Management.

"Small Project" means a project to construct or operate five (5) to nineteen (19) non-commercial, non-residential parking spaces within a new facility or an existing parking facility which will cause such Facility to have a net increase in the number of spaces for which a certificate of occupancy, operating license, variance, special permit, or Director's Letter has not been issued as of the effective date of this Chapter. To qualify as a Small Project, the total number of non-commercial, non-residential parking spaces at the parking facility must remain at or below nineteen (19).

Section 10.18.030 PTDM Planning Officer.

Within thirty (30) days of the effective date of this Chapter, the City Manager shall designate a Parking and Transportation Demand Management Planning Officer who shall have responsibility for reviewing, conditioning, approving, and/or denying PTDM plans and who shall report to the City Manager. Said officer shall be a Cambridge resident within six months of employment in this position. Prior to rendering his/her determination(s), the Planning Officer shall consult with the PTDM plan applicant, the Director and the Assistant City Manager for Community Development.

Section 10.18.040 Registration of All Parking Spaces.

(a) No person shall build, expand, or reconfigure a parking facility for non-residential parking spaces resulting in a net increase in the number of parking spaces or a change in the use of such

spaces based on the caegories of use listed below at paragraphs b(v) and (vi), without first submitting a parking registration form to, and obtaining acceptance from, the Director.

(b) The registration form shall be prepared by the Director and shall be available at 57 Inman Street. The form will require the following information:

(i) name and address of parking facility owner;

(ii) name and address of parking facility operator;

(iii) address of parking facility;

(iv) total number of existing parking spaces;

(v) number of existing parking spaces in each of the following categories:

- residential
- commercial
- non-commercial
- customer
- employee
- patient
- student
- client
- guest

(vi) number of parking spaces proposed to be added to the parking facility in each of the following categories:

- residential
- commercial
- non-commercial
- customer
- employee
- patient
- student
- client
- guest

(vii) identification of any existing parking permits for the parking facility; and

(viii) explanation of any enforcement actions against the parking facility.

(c) The Director shall accept or return a registration form to the registrant with a request for additional information within thirty (30) days after the form was filed.

(d) The License Commission shall not issue a license and the Commissioner of Inspectional Services shall not issue a building permit or certificate of occupancy for a parking facility subject to this section without evidence either (i) that the registration form has been accepted by the Director; or (ii) that the facility has a PTDM Plan approved by the Planning Officer.

Section 10.18.050 Parking and Transportation Demand Management Plans.

(a) No person shall build, expand, or operate a parking facility subject to the Parking and Transportation Demand Management (PTDM) Plan requirements of this Chapter absent a PTDM Plan approved by the Planning Officer.

(b) The PTDM requirements of this Chapter shall apply to each of the following:

(i) any commercial parking facility for which a certificate of occupancy or operating license, variance or special permit was not obtained prior to the effective date of this chapter;

(ii) an existing commercial parking facility at which the number of parking spaces is increased after the effective date of this chapter;

(iii) any parking facility at which the use of existing or permitted parking spaces is changed to commercial use after the effective date of this chapter;

(iv) any new project to build or operate twenty or more non-residential parking spaces; and

(v) any new project to expand an existing parking facility resulting in a total number of non-residential parking spaces of twenty (20) or more.

(c) The PTDM Plan shall be designed to minimize the amount of parking demand associated with the project and reduce single-occupant vehicle trips in and around Cambridge. The PTDM Plan shall be based on the following facts, projections and commitments:

(i) Facts and Projections:

- nature of development and property use;
- proximity of project to public transit;
- availability of and accessibility to offsite parking spaces which could serve the project;
- number of employees and their likely place of origin; and
- type and number of patrons/users of proposed parking supply and their likely place of origin.
- number of vehicle trips expected to be generated by the project and description of measures to reduce associated traffic impacts on Cambridge streets; and
- other factors published by the Planning Officer.

(ii) Commitments:

- commitment to work with the Cambridge Office of Work Force Development;
- commitment to implement vehicle trip reduction measures including some or all of the following:

subsidized MBTA passes and other incentives; shuttle services; ride-sharing services; bicycle and pedestrian facilities; flexible working hours; preferential parking for LEV/ZEV/bicycles/carpools/vanpools (Note: this list is not meant to preclude implementation of other types of vehicle trip reduction measures). This commitment must be accompanied by a detailed description of the measures proposed to be implemented; and

- commitment to establish and make reasonable efforts to achieve a specified, numeric reduction (or percent reduction) in single-occupant vehicle trips in and around Cambridge. The percent reduction will be based on PTDM practices successfully implemented in reasonably comparable environments and as identified in professional and academic literature and based on analysis of existing trip reduction measures in Cambridge.

Each PTDM Plan shall identify the total number of existing and proposed parking spaces at the facility and specify how many existing and proposed spaces fall within each of the following categories (explain how many spaces are used for multiple purposes):

- residential
- commercial
- non-commercial
- customer
- employee
- patient
- student
- client
- guest

Where the parking facility includes or proposes a combination of commercial and non-commercial parking spaces, the Plan shall specify how the parking facility will prevent commercial use of the non-commercial parking spaces.

Each PTDM Plan shall contain the following certification from a responsible corporate officer: "I hereby certify that a commercial parking permit has been obtained for each space being used for commercial parking. None of the other existing or proposed parking spaces at this parking facility have been or will be available as commercial parking spaces until a commercial parking permit therefor has been obtained."

(d) The Planning Officer shall review, conduction, approve and/or deny the PTDM Plan based on the above-listed facts, projections, and commitments. The Planning Officer shall issue his/her decision in writing within 60 days of receipt of the proposed PTDM Plan. The required time limit for action by the Planning Officer may be extended by written agreement between the proponent and the Planning Officer. Failure by the Planning Officer to take final action within said sixty (60) days or extended time, if applicable, shall be deemed to be approval of the proposed PTDM plan. If the project proponent elects to make a request pursuant to 10.18.060, the decision of the Planning Officer shall be expanded to include a recommendation about whether offsite parking should be allowed at distances greater than those allowed in the Zoning Ordinance and/or whether fewer

parking spaces than the minimum required in the Zoning Ordinance should be allowed, Decisions of the Planning Officer may be appealed by the project proponent to a review committee composed of the City Manager, or his designee, and two other City staff members designated by the City Manager none of whom may have participated in the initial review of the Plan.

(e) The Planning Officer shall also make available standardized PTDM plans which a project proponent may adopt, upon approval by the Planning Officer.

(f) No permit, commercial parking permit, special permit, variance, building permit, certificate of occupancy, or operating license shall be issued for any project subject to 10.18.050 by the Planning Board, Commercial Parking Control Committee, Board of Zoning Appeal, Commissioner of Inspectional Services, or License Commission absent a written decision indicating approval from the Planning Officer of the project proponent's PTDM Plan. Any such permit or license shall be consistent with, and may incorporate as a conduction, the decision of the Planning Officer and shall include written notice of the requirements of 10.18.050 (g) and (h), below. Nothing in this ordinance shall be construed to limit the power of the Planning Board or Board of Zoning Appeal to grant variances from or special permits under the provisions of the Zoning Ordinance. No project proponent shall be required by the Planning Officer to seek such relief under the Cambridge Zoning Ordinance.

(g) Approvals issued by the Planning Officer shall be automatically transferrable by and among private parties, provided that the proposed new owner (the "Transferee") shall continue to operate under the existing PTDM Plan and shall submit to the Planning Officer within thirty (30) days of the title transfer a certification that the existing PTDM plan will remain in effect. The certification shall be submitted on a form issued by the Planning Officer and shall certify that such Transferee commits to implement the existing PTDM plan, as approved; and acknowledges that failure to implement the plan is subject to the enforcement provisions of this Chapter. Where such certification is submitted, the approved plan shall remain in effect as to the Transferee. The Transferee may elect instead to and consult with the Planning Officer within thirty (30) days of title transfer regarding appropriate revisions to the existing plan. Based on such consultation, the Planning Officer may require information from the Transferee concerning proposed changes in use of the parking facility and associated buildings and the relevant facts and projections regarding the proposed changes. Within thirty (30) days of receipt of such information, the Planning Officer may issue a written approval of the revised plan and obligations to the Transferee, or the Planning Officer may require submittal of a new PTDM Plan from the Transferee for review, condition, approval and/or denial. Until such time as a new or revised plan has been approved, the existing PTDM plan shall remain in effect.

(h) Each PTDM Plan approval issued by the Planning Officer shall contain, at a minimum, the following conditions:

(i) The parking facility owner and operator each commit to implement all elements of the PTDM Plan, as approved, including annual reporting requirements, and to maintain records describing implementation of the Plan;

(ii) The City shall have the right to inspect the parking facility and audit PTDM implementation records; and

(iii) The parking facility owner and operator each commit to notify and consult with the Planning Officer thirty (30) days prior to any change in ownership, use or operation of the facility.

Section 10.18.060 Reduction in Minimum Parking and Maximum Distance Requirements.

(a) A project proponent may elect to request that the Planning Officer include as an element of its PTDM Plan a plan for fewer parking spaces that the minimum set forth in the Zoning Ordinance. Upon the written request of the project proponent, based on an evaluation of the facts, projections, and commitments listed at 10.18.050 (c), the Planning Officer may make a written recommendation about the maximum number of parking spaces for the project. This recommendation shall remain subject to review and approval by the Planning Board or Board of Zoning Appeal as appropriate.

(b) A project proponent may elect to request that the Planning Officer include as an element of its PTDM Plan a plan for utilizing off-site parking spaces that are farther from the project site than the maximum distance requirements set forth in the Zoning Ordinance. Upon the written request of the project proponent, based on an evaluation of the facts, projections, and commitments listed at 10.18.050 (c), the Planning Officer may make a written recommendation about how many parking spaces serving the project may be appropriately located at an off-site location and at what distance from the project site. This recommendation shall remain subject to review and approval by the Planning Board or Board of Zoning Appeal as appropriate.

Section 10.18.070 Requirements Applicable to Small Projects.

The owner or operator of each Small Project shall implement at least three (3) PTDM measures and maintain records of such implementation. A list of acceptable types of measures may be obtained from the Traffic Department, the Inspectional Services Department, the Community Development Department, or the License Commission. The Planning Officer shall create and periodically update this list, which shall include: T-pass subsidies; bicycle parking; changing facilities; carpools/vanpools; financial incentives not to drive alone; or other similar measures.

Section 10.18.080 Enforcement.

(a) The Director shall enforce the provisions of this Chapter. If the Director has reason to believe that any provision of this Chapter is being violated, the Director shall investigate the possible violation. If after investigation the Director determines that any provision of this Chapter is being violated, s/he shall provide a first written notice of violation to the person charged with the violation, or the duly authorized representative thereof, of the determination of violation and shall order that the violation cease within thirty (30) days of the issuance of the first written notice. If the violation is not cured within the thirty (30) days after issuance of the determination of violation, the Director may proceed to assess the fines established in this chapter as well as any other remedies available to the city. In addition to all other remedies, if the violation has not ceased within thirty (30) days after the first written notice, then the Director may order shutdown of the parking facility. Second or subsequent written notices to a facility for the same violation shall be immediately effective and shall not provide the thirty (30) day opportunity to cure contained in the first written notice. A determination and order of the Director may be appealed to the City Manager by the person charged with the violation within thirty (30) days of issuance of the Director's determination and order.

(b) In addition to other remedies available to the City, any person who builds or modifies a parking facility without complying with the provisions of this Chapter shall be subject to a fine of up to $10.00 per day per parking space for every day that such parking space was operated without a registration accepted by the Director or without a PTDM Plan approval issued by the Planning Officer or in non-compliance with an approved PTDM Plan. On a determination, after investigation, by the Director that this Chapter is being violated, and the exhaustion of any appeal to the City Manager in accordance with (a) above, the Director shall take steps to enforce this chapter by causing complaint to be made before the district court and/or by applying for an injunction in the superior court.

(c) In addition to other remedies available to the City, a determination that a facility is operating in violation of the provisions of this Chapter shall be ground for revocation by the Director of the facility's parking permit or other form of approval.

(d) The Planning Officer shall have independent authority to inspect a parking facility and audit its records to determine whether it is in compliance with its PTDM Plan. The Planning Officer shall issue a finding of non-compliance in writing and provide copies to the parking facility owner and operator and to the Director.

Section 10.18.090 Evaluation.

This ordinance shall expire three years from the date of enactment unless the City Council votes prior to the expiration of said three years to extend the validity of the ordinance.

CLEAN AIR ACT OF 1990

Due to the length of this Act it is not included in this Appendix. It can be found online at: http://thomas.loc.gov/cgi-bin/query/z?c101:S.1630.ENR:

U.S. Congress. Senate. "Clean Air Act of 1990." 101st Congress, 2nd Session, S.1630. Congressional Record, Volume 136. n.d. <http://thomas.loc.gov/cgi-bin/query/z?c101:S.1630.ENR:> (24 Jan 2002).

Implementation of the 1990 Federal Clean Air Act Amendments: A Massachusetts Status Report, April 2000

Due to the length of this document it is not included in this Appendix. It can be found online at: http://www.state.ma.us/dep/bwp/daqc/files/1990caaa.htm

Massachusetts Department of Environmental Protection: Bureau of Waste Management. "Implementation of the 1990 Federal Clean Air Act Amendments: A Massachusetts Status Report, April 2000." Air Program Planning Unit Publications. 25 April 2000 <http://www.state.ma.us/dep/bwp/daqc/files/1990caaa.htm> (1 Feb 2002).

Map of East Cambridge

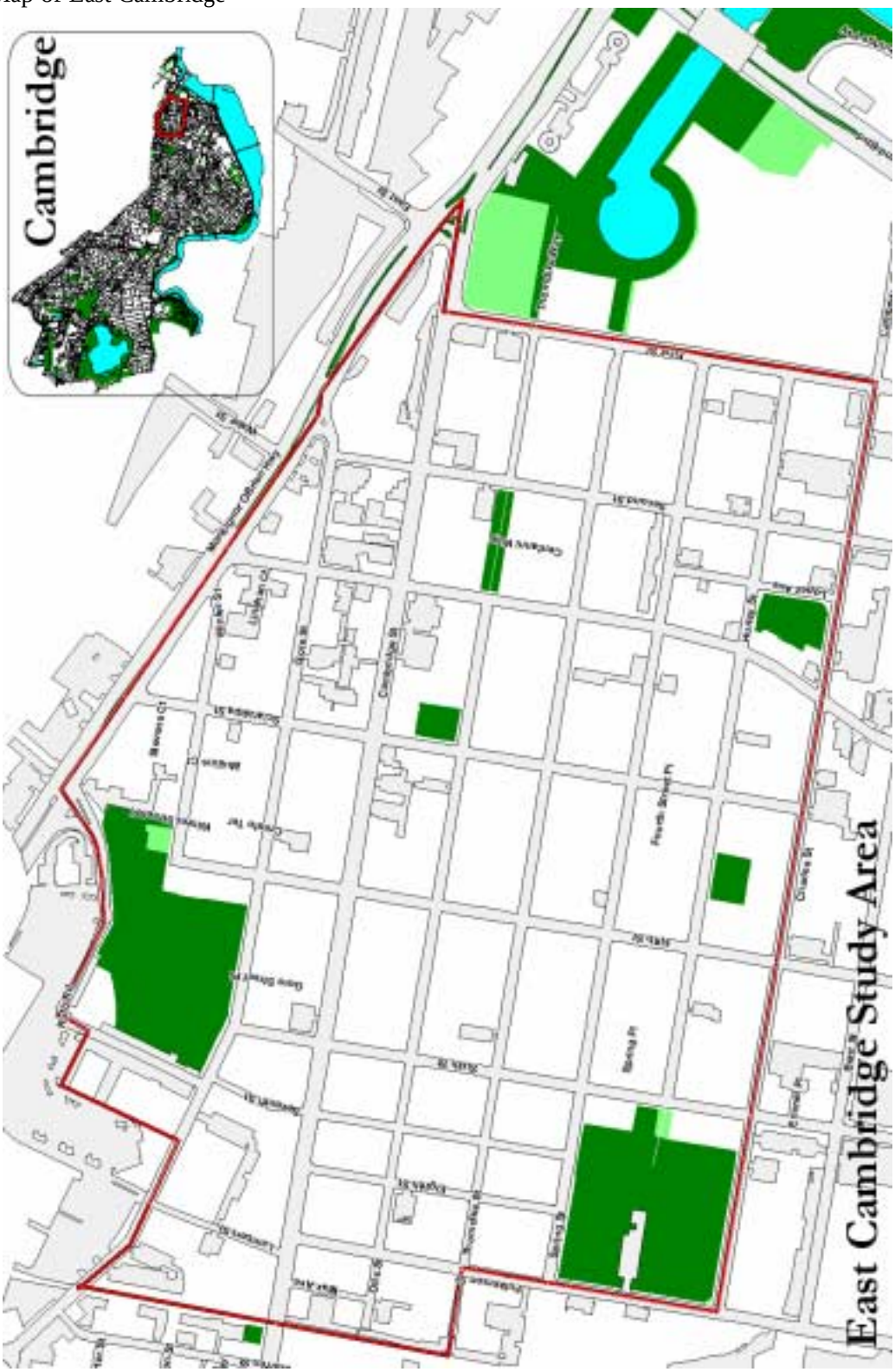

Figure 17: Map of Study Area

Appendix E: Database Structure, Entry Forms, and Map Layers

Figure 18: Off-Street Facility Data Entry Form

Figure 19: Example of Off-Street GIS Map Layer

Figure 20: On-Street Curbside Regulation Zone Data Entry Form

Figure 21: Example of On-Street Curbside Regulation GIS Map Layer

Figure 22: On-Street Metered Parking Data Entry Form

Figure 23: Example of Meter GIS Map Layer

Columns

Name	Type	Size
Post_ID	Text	11
Date	Date/Time	8
Neighborhood	Text	50
Street_On	Text	50
Cross_Street_From	Text	50
Cross_Street_To	Text	50
Side_of_Street	Text	50
Distance	Long Integer	4
Time_Limit	Text	50
Post_Type	Text	50
Meter_A_ID	Text	50
Meter_A_Model	Text	50
Meter_A_Condition	Text	50
Meter_B_ID	Text	50
Meter_B_Model	Text	50
Meter_B_Condition	Text	50
Notes	Text	255

C:\TrafficGIS\Database\Parking_Database.mdb
Table: On-Street_Parking_Database

Columns

Name	Type	Size
Zone_ID	Text	18
Date	Date/Time	8
Street_On	Text	50
Cross_Street_From	Text	50
Cross_Street_To	Text	50
Side_of_Street	Text	10
Neighborhood	Text	35
Regulation	Text	50
Regulation_ID	Text	2
Time_Limit	Text	10
Time_of_Day	Text	20
Days_of_the_Week	Text	7
Tow_Zone	Yes/No	1
Overlapping_Regulation_ID	Text	2
Zone_Beginning	Long Integer	4
Zone_Ending	Long Integer	4
Zone_Length	Long Integer	4
Notes	Text	255
No_of_Spaces	Long Integer	4

Columns

Name	Type	Size
Record ID	Text	15
Facility ID	Text	15
Street Name	Text	50
Other Name	Text	50
Old_ID	Long Integer	4
Street #	Text	50
Neighborhood	Text	50
Assessor Block	Text	50
Assessor Lot	Text	50
Date Modified	Date/Time	8
Modifier	Text	50
Data Source	Text	50
Inventory Year	Text	50
Square Feet	Long Integer	4
Structure	Text	75
Total Spaces	Long Integer	4
Employee Spaces	Long Integer	4
Commercial Spaces	Long Integer	4
Customer or Visitor Spaces	Long Integer	4
Vacant Spaces	Long Integer	4
Institutional Spaces	Long Integer	4
Residential Spaces	Long Integer	4
Fee Type	Text	50
Access Restrictions	Text	50
Notes	Text	255
Description Notes	Text	255
Discrepancy?	Yes/No	1
Current?	Yes/No	1
User	Text	50
Owner	Text	50
Patrol Sector	Long Integer	4
PCO Route	Long Integer	4
Zoning District	Text	50
Census Tract	Double	8
Census Block	Double	8
Entrance Street 1	Text	50
Entrance 1 Picture(s)	Text	100
Entrance Street 2	Text	50
Entrance 2 Picture(s)	Text	100
Additional Pictures	Text	100
Contact	Text	100
Contact Title	Text	50
Contact Company	Text	50
Contact Address1	Text	50
Contact Address2	Text	50
Contact Address City	Text	50
Contact Address State	Text	50
Contact Address ZIP	Text	50
Contact Phone	Text	50
Contact Fax	Text	50
Contact Email	Text	50
Selected_Set?	Yes/No	1

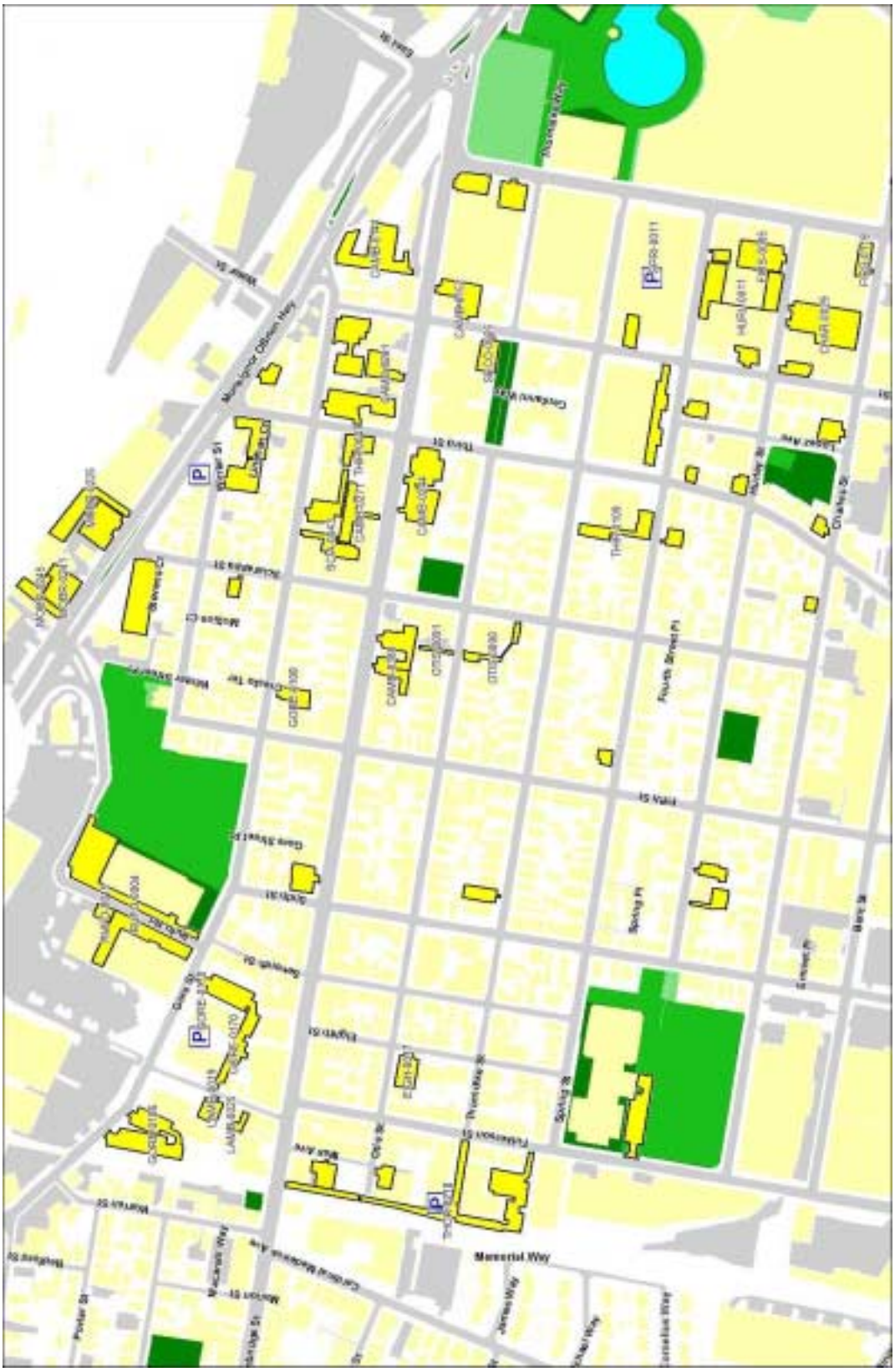

Figure 24: Complete Off-Street Parking Facility Inventory

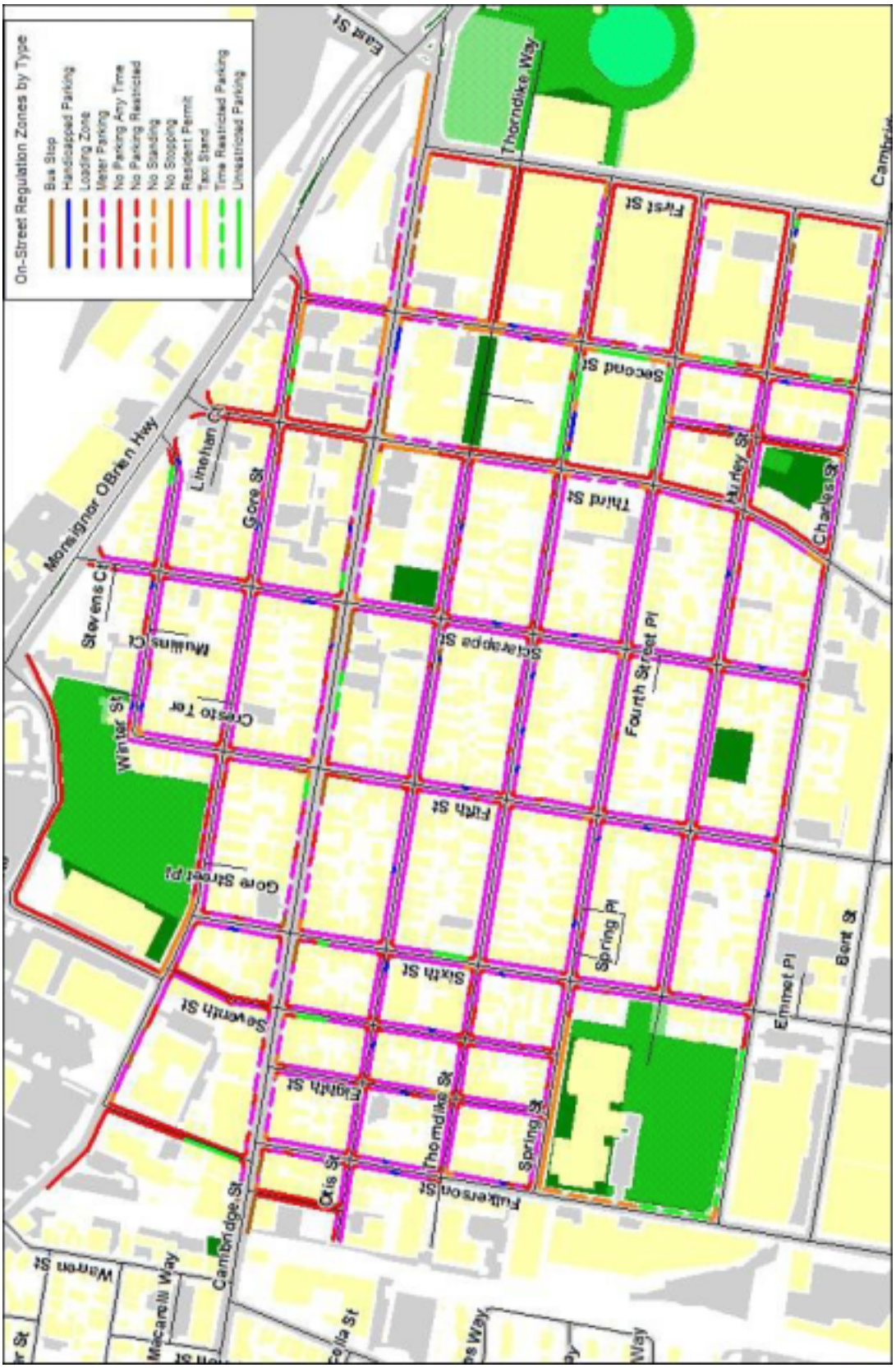

Figure 25: Complete On-Street Curbside Parking Inventory

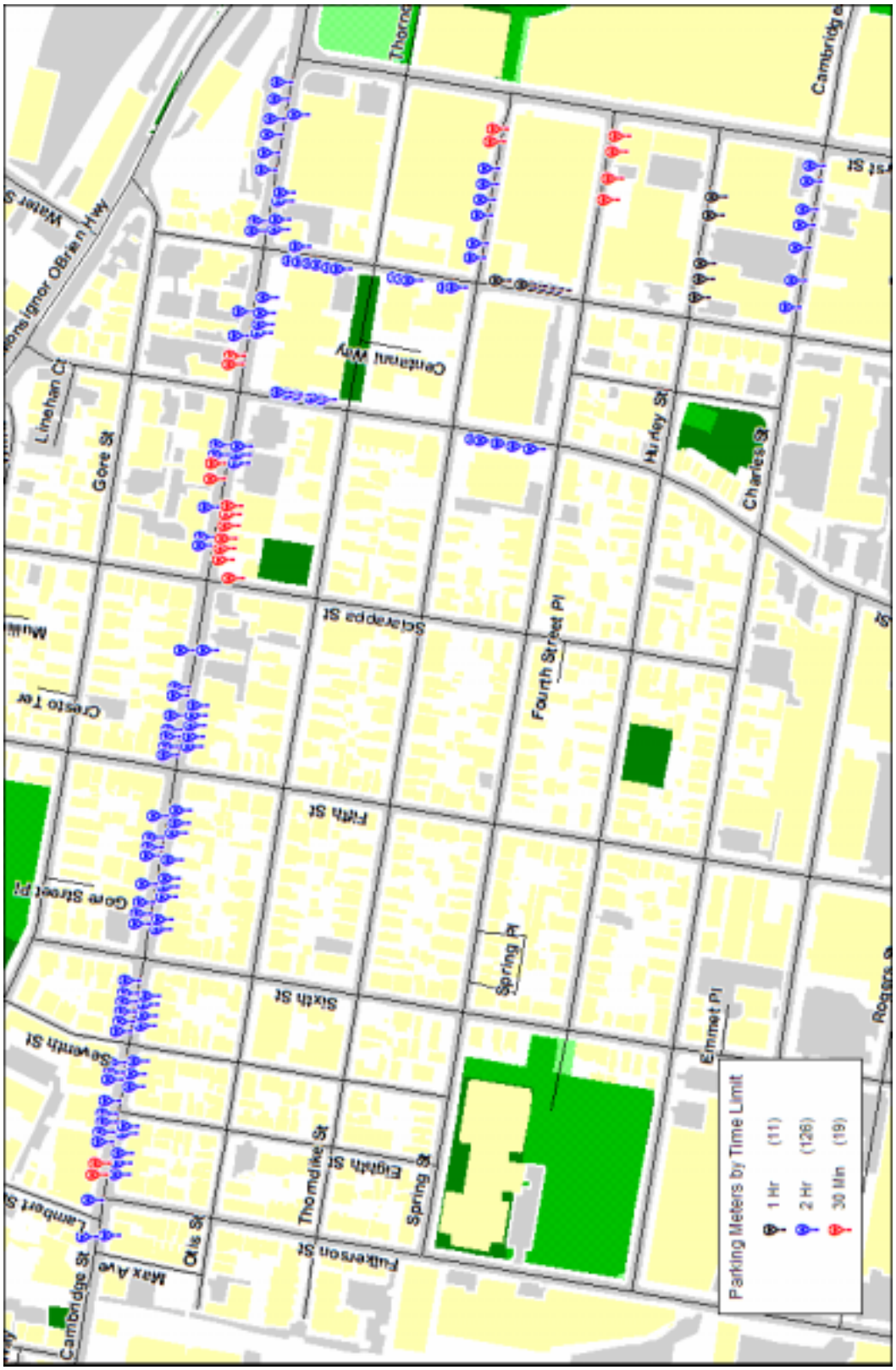

Figure 26: Complete On-Street Metered Parking Inventory

Appendix F: Data Collection Forms

On-street data collection form goes here

Appendix G: Standard Operating Procedures

Standard Operating Procedure for Off-Street Parking Facilities

Contents

Purpose

The purpose of this document is to establish a set of guidelines for data collection and entry that will standardize the format of the collected data and allow for improved ease of understanding as multiple people contribute to this information resource.

Materials

- 2 Clipboards
- Pens
- Digital camera (set to 1280 x 960 resolution)
- Highlighters
- Data collection forms

Preparation

1. Gather **Materials**.
2. Select geographic area in ArcView.
3. Run a query to get the names of the facilities in the region.
4. Bring the names into Access and run macro to send current and discrepant records for those lots to the print form.
5. Order the records in the print form by alphabetical or any other convenient order.
6. Print out the records. These print out on the Off-Street Parking Facility form.
7. Print out maps of the blocks that you plan to visit. Include a layer with labels of the facility IDs.
8. If lot outlines and/or layouts exist for the lots, it might be helpful to print those out on a separate sheet.

9. Write numbers on maps to keep track of maps and create overview map with numbers on individual blocks corresponding to individual map numbers. It may be helpful to number or arrange the maps in the order that you plan to visit the blocks.
10. If helpful, write street names on the individual maps.
11. Place record sheets on one clipboard and map sheets on a separate clipboard

Field Data Collection

1. Go to southwest corner of a city block and find map for the block.
2. Identify the lots that you expect to find using the map of the block with the facility codes.
3. Walk around the block looking for entrances of any parking facilities on that block.
4. If you find an entrance to a parking facility, check if it is qualifies to be recorded. See below for Qualities for Recorded Parking Facilities. If you finish a circumference of the block and do not find any more off-street parking facilities, then go to the next block and go back to Step 13.
5. If the facility does not qualify to be recorded then go back to Step 3 and search for the next off-street parking facility.
6. Observe the layout of the parking spaces in the lot and draw these on your map of the block. Also trace the outline of the parking facility onto the map. To determine which parking spaces to record on the map, see Heuristics for Deciding which Parking Spaces to Count. To make clear which lines are the outline of the entire lot, you may want to highlight the outline of the lot and with a yellow highlighter.
7. Take pictures to record relevant characteristics of the parking facility. See **Picture-Taking Heuristics**. On the Off-Street Parking Facility form, write down numbers to indicate which pictures in the series of all pictures taken are for this parking facility.
8. If there was a previous record for this parking facility address associated with the parking facility has changed since the last inventory, then indicate this on the Off-Street Parking Facility form. If there was not a previous record for this facility then write down the address for this facility. Unless the parking facility is marked with its own address, let the facility address be the same as that for the building which controls/uses the facility.
9. Fill in the Off-Street form with information that can be observed about the facility. If there was a previous record for the parking facility update the data Off-Street Parking Facility form which has changed. Fields that you are likely to be able to fill in the field include: Total Spaces (and divisions of spaces), Structure, Fee type, Access Restrictions, User, Neighborhood, Notes, Entrance Street Names, and Picture numbers.
10. Indicate on the form the date on which you made an observation of the facility and initial the form.
11. Go back to Step 3 and search for the next off-street parking facility.
12. After visiting all of the parking facilities in a geographic area, return to the office and download the pictures off of the digital camera.

Data Entry

1. Open the Off-Street Parking Facility form in the database and find the most recent previous record for the parking facility that you visited. Click on the Update Facility button to create a new record for the facility. If there is no previous record for the facility, then go to the end of the records and create a new record in a blank form.

2. Enter the current address of the parking facility.
3. If the facility was previous known by a different name or as a different address then add this other name to the Other Name field.
4. Update the Date Modified field to the day that the facility was observed.
5. Update Modifier to the last name of the person (or some other code to indicate a person/group) who observed the facility. If an agent of the Traffic and Parking Department did not directly observe the facility, then enter the name of the person who is performing the data entry for this record.
6. If a field agent observed the parking facility, then set Data Source to Field Observation. Otherwise indicate the method by which the department acquired the updated information.
7. If Inventory Year is not automatically completed, enter the year in which the information was acquired.
8. If a previous record existed for this facility and the address has changed since the last record, Record ID and Facility ID will not automatically to reflect the new address. To make these reflect the current address update the numbers indicating address. Note that in order to keep this ID scheme consistent with the previous records you will need to go into the old records and update the ID of those records to reflect the new address. Do not change the address or any fields other than Record ID and Facility ID in old records.
9. Do not fill in Old_ID. This field should remain empty for records created after April 2002.
10. Update the number of total spaces in the parking facility and indicate how many spaces are used for each category of use.
11. Indicate in the Structure field whether the facility is a parking lot a garage or a combination of the two.
12. Indicate in Fee Type how the users of the lot are charged for use of the lot.
13. Indicate in Access Restrictions how the facilities entrances restrict entry to entering cars.
14. Update User and Owner if these are known.
15. Indicate the Neighborhood in which the facility is located.
16. If this is a new facility, then use ArcView to determine the Assessors Block and Lot in which the facility is located and enter this information.
17. Enter any notes on the facility in the Notes field. The Description field can be used to indicate any extra information on how the lot is used or how the spaces in the lot are divided between different uses.
18. Find the pictures for the parking facility. Rename the pictures according to **Meter Post** Naming **Heuristics**. Indicate the streets on which the facility has entrances and exits and the names of the pictures that are associated with each of these entrances.
19. Enter contact information for the owners of the parking facility if any has been collected.
20. Is there a discrepancy? If the new information is consistent with a previous record, then unmark the Current check box on the previous record and mark the new record Current. If the new information indicates a possible parking ordinance violation based on the previous record for this facility, then check off the Discrepancy check box and leave the last record marked Current until a member of the Traffic and Parking Department has resolved the discrepancy. When there is not a previous record for a facility check aerial photos from previous years to see if the facility pre-existed the city ordinances that control these facilities.

21. Go back to Step 1 and enter a record for the next facility.

Mapping Facilities

The off-street facilities were represented using the symbols shown in

1. If the facility contains an open-air lot, then draw outline of parking facility as a polygon using the map from the field collection on the outline map layer. If the facility is a garage or contains a garage in addition to outdoor spaces in a parking lot, then place a point symbol on the garage map layer to indicate the location of the lot. In the facility outline layer or the garages layer, update the Facility_ID for the object drawn to match the Facility ID generated for the facility on the Off-Street Data Entry Form in the database. (Example: CAMB-1234).
2. Draw the layout of the individual spaces in the lot (unless the facility is a garage). Draw these spaces on the layouts map layer using polylines.

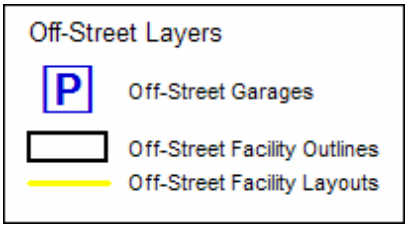

Figure 27: Off-Street Legend

Qualities for Recorded Parking Facilities

These are the heuristics that we followed to decide if an off-street parking facility qualified as something to be recorded.

1. Is there already a record for this facility? If a record from a previous inventory already exists for this parking facility, then create a new record for this facility. Otherwise, go to next step.
2. Does the facility contain only residential parking? If the facility contains non-residential parking spaces, then go to step 4. Otherwise go to next step.
3. Does the lot contain 5 or more parking spaces? If so, then create a record for the lot. If spaces are not stripped estimate the number of cars that would appear to reasonably parking in the facility. If there are less than five spaces, then
4. Does the lot appear to be an automobile mechanic shop or car sales lot? If the parking facility appears to be used solely for storing cars and does not contain any hourly, daily, or weekly parking spaces, then do create a record for the facility. If some spaces are for parking and some are for car storage, then count the spaces that are for parking. The reasoning for the parking study is to track parking spaces that generate vehicle trips. (Finalization of this step is pending review by Jason.)

Heuristics for Deciding which Parking Spaces to Count

1. Is the parking facility a garage or does it contain some spaces that are within a garage? If so, do not record the layout of these spaces. Do record the location of all spaces outside Do record the location of parking spaces if a building hangs over them but they are not within an enclosed garage.

2. Does the parking lot have stripped parking spaces? If there are not stripped parking spaces, then approximate what appears to be the normal parking configuration in the lot based on the cars that are parked in the facility. Make a note in the Notes section of the Off-Street Parking Facility form if the parking spaces are not stripped and you are not able to gauge the parking capacity of the lot with a fair degree of certainty.
3. Are the cars parking in the stripped spaces? Unless noted otherwise, it is assumed that the spaces recorded on the maps and forms correspond to the spaces as they are stripped on the pavement of the parking lot and that cars normally park only within those stripped spaces.
4. If cars are mostly parking within the stripped spaces, but it appears that cars normally park outside of the spaces as well, then map the spaces as they are stripped and indicate in the Notes section of the facility form that cars appear to park regularly outside of the marked spaces.
5. If the lot is stripped and the cars do not appear to park according to the stripped configuration, then approximate the layout of the lot as it appears to be regularly used and make a note that the recorded layout of the is based on how cars appear to normally park and not on the stripes on the ground.

Picture-Taking Heuristics

1. When possible, take pictures with a digital camera at a resolution of 1280x960 pixels to give the pictures a standard appearance.
2. Take pictures of all entrances and exits of the parking facility. A picture of an entrance or exit should include the entire width of the curb opening through which cars can drive. If the entrance or exit has any signs, then the picture should show where those signs are relative to the entrance.
3. An optimal location for taking a picture of an entrance is on the sidewalk directly across the street from the entrance to the parking facility. Pictures can be taken from different angles if necessary to view the entire entrance or if the setup of the street or traffic on the street interferes with picture-taking.
4. If a parking facility has multiple entrances on a single street, taking a separate picture for each break in the curbstone is a useful practice for producing pictures with consistent appearance in terms of proportion.
5. Take pictures of any signs around the entrances to the lot that indicate important information such as who may use the lot, the price rates for parking, the owner of the lot, or the company that will tow cars from the lot.
6. When taking a picture of a sign, try to stand close enough to the sign such that the sign fills most of the view of the picture. This is done to make give a standard appearance to pictures of signs and ensure that the print on the sign is clear, but is not necessary if the signs are posted out of reach.
7. For each set of a picture of an entrance and pictures of associated signs make a note on the Off-Street Parking Facility form to indicate that these picture are a group for that entrance and record the name of the street on which the entrance sits. The Off-Street Parking Facility form has a few rows to indicate sets of pictures and the street name associated with each entrance to the lot. It also includes a row labeled Additional Pictures for pictures that are not associated with a single entrance.

8. Take a picture of each type of sign within the parking facility that indicate the parking restrictions on how the parking spaces may be used. For example, you may take a picture of a sign that illustrates how the marks employee parking and residential parking.
9. Taking pictures of handicap parking signs is not necessary since this system does not track handicap spaces.

Facility ID Naming Heuristic

1. The ID for a facility is a four-letter code based on the Street name plus a four-digit code equal to the address. The letter codes of the streets are equal to the first four letters for most streets. In cases where there were conflicts between street names, a different four-letter code was chosen. The codes for the streets are listed in the database in the table Lookup_Street_Code.

Picture Naming Heuristics

These are the heuristics that we used to name the pictures that we took of the off-street parking facilities.

Scheme for setting the first 12 characters of the picture code:

1. First characters and digits are the facility code:
   CAMB-1234…
2. The next four digits are the year that the picture was taken:
   CAMB-1234-2002…

Scheme for setting the last two digits of the picture code:

3. The last two digits are used to uniquely identify the picture for that lot and year:
   CAMB-1234-2002-01, CAMB-1234-2002-02, CAMB-1234-2002-03…
4. Start with 01 for the picture of the primary entrance.
5. Use the next number(s) for sign(s) at the main entrance. (example: 02)
6. If there is a secondary entrance (or exit):
   Use the next number for the picture of the primary entrance. (example: 03)
   Use the next number(s) for sign(s) at the secondary entrance (example: 04, 05)
7. If there is a third entrance/exit:
   Use the next number(s) for the entrance and signs around the entrance and put these under the Additional Pictures field.
8. Use the next numbers for any pictures of important signs posted within the lot or other issues that should be recorded by picture within the lot.
9. When there are more than two entrances and there entrances on two different streets:
   Consider one entrance (or exit) from each street to be the first and second entrances so that the record will have both streets listed as entrance streets in the database.
10. If pictures are taken for multiple inventories of a single lot within one year:
    Begin numbering the pictures from the next number in the list.
    (For example, if the picture CAMB-1234-2002-07 already exists and a second inventory is done in 2002, then the next picture of the lot can be CAMB-1234-2002-08. If the next inventory is done in 2004, then the first picture from that inventory can be CAMB-1234-2004-01).

Off-Street Data Collection Form

Key for Off-Street Data Entry Form

Unit of Observation:
Off-street parking facility that can fit at least 5 cars.

ID:
A code to track items as we measure them in the field.

Data Source:
Field Observation – used for any data collected in the field by an agent of the Traffic and Parking Department
Permit or Application
Registration Form

Structure:
Lot - Indicates that parking facility is not enclosed by a structure
Garage - Indicates that the parking facility is enclosed by a structure with a roof and walls or is underground
Lot/Garage - Facility is composed of a combination of a Lot and a Garage

Fee Type:
Free
Permit / Special Card – cars parked in lot appear to be registered for use of the lot in some manner
Meters
Pay Facility

Access Restrictions:
Attendant
Actuated Gate
Closed - Parking facility appears to be permanently closed
Gate/Chain - Facility can be closed by a hand-drawn gate or chain
Mechanical Roll-up
Open - Facility does not have any type of gate barring entrance
Ticket

Standard Operating Procedure for On-Street Parking Regulations Inventory

Contents

Purpose

The purpose of this document is to establish a set of guidelines for data collection and entry that will standardize the format of the collected data in order to ensure compatibility with the parking management tool developed by the team and to allow for improved ease of understanding as multiple people contribute to this information resource.

Materials

- Clipboard
- Pen
- Measuring Wheel (calibrated in feet)
- Highlighter
- Data Collection Forms

Preparation

12. Gather listed **Materials** required for data collection.
13. Calibrate the wheel to measure its accuracy. An accuracy of >95% is acceptable for the data collection tasks.
14. Decide which city blocks are to be covered and enumerate them.
15. Print a blank data collection form and make four copies for each block to be covered on the field, plus sufficient extra forms to make up for errors and blocks that require more than four forms.
16. Prepare the data collection forms. Set aside four forms for each city block that will be covered and fill in the ‘Zone’ field with the block number. Complete the ‘Street On’, ‘Cross-Street From’, ‘Cross-Street To’, ‘Side of Street’, ‘Neighborhood’ and ‘Date’ fields on these forms. To ensure uniformity and compatibility with data already collected, proceed in a clockwise circle.
17. Arrange the data collection forms in the order that you plan to visit the blocks.

Field Data Collection

13. Walk to the southwest corner of the first city block to be covered to gather data on its west side. Confirm if fields filled in on the data collection form are correct.
14. Reset the counter on the wheel to zero.
15. Place the wheel at a distance of two feet from the curb and maintain this distance when rolling the wheel to ensure accuracy.
16. Measure the distance from the curb to the property corner which is assumed to be the reference point and hence is at zero feet.
17. Record this distance as negative feet from the property corner.
18. Reset the counter on the wheel to zero and begin rolling the wheel. Stop at the first parking regulation sign you come to.
19. Note the distance on the wheel and record it as the beginning or ending of the zone as indicated by the sign. At the same time record all the details for that particular zone, such as type of restriction, day and time restrictions, and whether or not the zone is a tow zone. If a sign is missing and it is clear that a zone begins or ends at that point, record the distance as the zone demarcation and note this assumption in the 'Notes' field.
20. Note the distances of any fire hydrants you come across and take these into account when recording the beginning or ending of zones next to it, since ten feet on either side of a fire hydrant is a 'No Parking Any Time' zone.
21. Also stop when you reach any parking meter posts and note the distances from the property corner that they are located at. Fill in the 'Post Type' and 'Meter ID' fields for each meter on the post as well as the 'Meter Type' and 'Condition' fields.
22. Continue recording this data until you reach the building corner of the 'Cross-Street To' curb. Record this distance and also that for the actual curb.
23. Upon recording data for the west side of the block repeat the entire process for the north, east and south sides of the block. This will complete the on-street data collection task for the entire block.
24. Repeat the process for the remaining blocks.

Data Entry

The data-entry process involves entering both the regulation zones data and the meter posts data into two separate tables.

On-Street Regulation Zones

22. Open the On-Street Parking Data Entry form in the database.
23. Match zone beginning and ending on the data collection form.
24. Calculate the demarcations for those zones that were not explicitly recorded, such as 'No Parking Any Time' zones on street corners.
25. Enter the Zone ID for the zone and start with the sequence code '005' for the first zone. Complete all the fields listed for each zone using the drop down lists provided. When the user begins to type in the value, auto-completion will complete the entry automatically with most likely value. Ensure that this value is correct before moving on to the next field.
26. Repeat this process for all the zones recorded, remembering to increment the sequence code by five for every zone on the same side of the block.

Meter Posts

1. Open the Metered Parking Data Entry form in the database.
2. Fill in all the fields for each of the posts on the data collection forms.
3. The Post ID field should be filled in with the same code as that of the lower of the two Meter IDs for double-headed posts. For single-headed posts, the Post ID is the same as the Meter A ID.
4. Any fields for which the data is not available should be left blank.

Mapping Facilities

The mapping component of the data entry involves creating objects on the respective map layers so as to provide a visual inventory of the parking resources in the city.

3. For the on-street parking zones add a polyline for each zone onto the on-street parking map layer. The only data that is added to the objects layer is the Zone ID for each of the zones. The zones are color-coded according to the scheme illustrated in the figure below.

Figure 28: Regulation Zones Color-Coding

4. The meter posts will be created on the metered parking map layer as point objects. In this case too, the only data that is associated with the objects is the Post ID.

Zone ID Naming Heuristic

Each parking regulation zone is designated by a unique fifteen-character code based on its location.

1. Each unique code consists of four parts separated by hyphens, the first of which is a four-letter code for the street that the zone is located on (for example, CAMB-XXXX-XXXX-XXX where CAMB is the four-letter code for Cambridge Street).
2. The next two parts are a pair of four-letter codes representing the cross-streets from and to which the measurements were made (for example, CAMB-SCIA-FIFT-XXX where SCIA and FIFT indicate the section of Cambridge Street from Sciarappa Street to Fifth Street).
3. The final part of the code is a three-digit number representing the zone's position in the sequence of zones on that side of the block (for example, CAMB-SCIA-FIFT-015, where 015 is the sequence code). This code is assigned in multiples of five, i.e. the first zone's sequence code is 005, the second's is 010 and so on. Doing so allows future changes in regulation zones to be effortlessly recorded without having to change sequence codes for all the zones on that side of the block.

The letter codes of the streets are the first four letters of the street name for most streets, except in those cases where there existed multiple names with the same first four letters. For these a different four-letter code was chosen. Codes for all the streets are listed in the database in the table Lookup_Street_Code.

Meter Post Naming **Heuristics**

Each meter post in the database is designated by a unique ID based on the meter ID on the meter's physical label. These meter IDs consist of a three to six letter code, assigned by the City, representing the street the meter post is located on and a four-digit sequence number that is either the set of even numbers or the set of odd numbers depending on the side of the street (for example, THDK-0530 where THDK is the code for Thorndike Street and 0530 indicates the meter sequence number, or FOURTH-0002 where FOURTH represents Fourth Street and 0002 is the sequence number).

For singled-headed posts the unique ID is simply the meter ID of the only meter on the post. For double-headed posts the lower numbered meter ID was selected to be the unique ID for the post.

Appendix not included
in original submission

IQP/MQP SCANNING PROJECT

On-Street Data Collection Form

Appendix H: Time Study Calculations