An-Najah National University

Faculty of Graduate Studies

Developing a Safety Management Tool Using a Geographic Information System (GIS)

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By

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إهداء

حمدا لله على نعمه التي لا تحصى، وشكرا له على ما انعم به علي من قدرة أعانتني على التفكير، وقوة أعانتني على الدرس والتحصيل، وما أمدني به من صبر وجهد للوصول إلى نتائج متواضعة قد تنفع الدارسين في الوصول إلى نتائج أوسع في هذا المجال.

اهدي خلاصة جهدي هذا الى اعز الناس لقلبي (أمي وأبي)، و إلى جميع أفراد أسرتي الذين لم يألوا جهدا ولم يدخروا وسعا في تهيئة الظروف الملائمة لي لأتمكن من الدراسة والبحث.

تم تطبيق هذا البحث من خلال إنشاء قاعدة معلومات جغرافية خاصة بحوادث السير في مدينة نابلس خلال العامين 1997-1998، باستخدام برنامج (TransCAD) الذي يعمل ضمن أنظمة المعلومات الجغرافية المتخصصة بمواضيع الطرق والمواصلات.

يمكن تقسيم هذا البحث إلى عدة مراحل: مرحلة إنشاء قاعدة معلومات مفصلة تشمل على بيانات عدة حول حوادث السير، وأخرى حول الطرق نفسها (كالعرض، حالة الرصفة، حجم السير عليها، الخ.)، ربط هذه القاعدة بأنظمة المعلومات الجغرافية، تطوير وتعريف بتطبيقات أل GIS في إدارة وتحسين السلامة على الطرق.

تبين من نتائج هذا البحث أن هنالك إمكانية كبيرة لاستخدام أنظمة المعلومات الجغرافية (GIS) كإحدى أدوات إدارة وتحسين السلامة على الطرق.

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ABSTRACT

Road safety is an important issue as it involves large numbers of people, vehicles and road sections, and as such is a complex issue to understand and to manage. The collection and analysis of data accidents are fundamental to the design of safe roads and proper traffic control measurement programs. Using such data helps in understanding why accidents occur, identifying accident prone-location, and aiding in the choice of proper safety programs or countermeasures.

In this study, a geographic information system (GIS)-oriented database using TransCAD software was developed as a tool in improving quantitative accidents data analysis. The database was applied for a two-year study period (1997-1998) for Nablus City. This database is of great use in road safety improvements and management.

This study included a number of phases: establishment of detailed database with information on accidents, traffic characteristics and physical road data; integration of these databases into a GIS; and definition and development of GIS-based applications to road safety and management.

The results of this study clearly showed the applicability and potential of using GIS as a tool in road safety management and improvement.

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Chapter One

INTRODUCTION

1.1 Background

The traffic safety problems over the past century caused enormous economic and social costs. It is commonly accepted that there are many costs associated with vehicular mobility such as air pollution, noise, visual intrusion, and crashes. However, the economic and social costs associated with road accidents greatly exceed other mobility costs due to the pain, grief, loss of property, injury, and deaths attributed to road accidents. Consequently, the importance of reducing the social and economic costs of road accidents cannot be overstated.

Recognizing this importance, highway safety programs are directed toward identifying locations that have safety problems "hazardous locations" and establishing countermeasures to evaluate and correct them. The investigation of safety problems at a site requires that accident patterns be identified to aid in identifying the extent of the safety problem and to facilitate the establishment of proper countermeasures.

A Geographic Information System (GIS)-oriented database (which identifies where an object is and provides information about it) can be of great benefit in performing spatial and statistical analysis. This system can be used to answer accident-related inquiries and to identify the number of accidents at each location. Geographic Information Systems have proven to be more efficient and the information is better understood than traditional methods of visually inspecting paper maps and running database inquires.

1.2 Aims and Objectives

The general aim of this study is to develop a safety management tool by establishing an accident database for the City of Nablus using Geographic information System (GIS). This database has the ability to deal with systematic statistical analysis of accidents, safety management, and the evaluation of safety improvements. The following are the specific objectives of this study:

1. Establishment of an integrated spatial database of accidents and includes information of road-physical and traffic flow characteristics, etc.

2. Generation of periodic reports or special reports on the accident situation by any category of accident variables.

3. Application of the system to the analysis of a number of specific road safety issues such as pedestrian accidents, children accidents near schools, and area-wide analysis in a certain neighborhood.

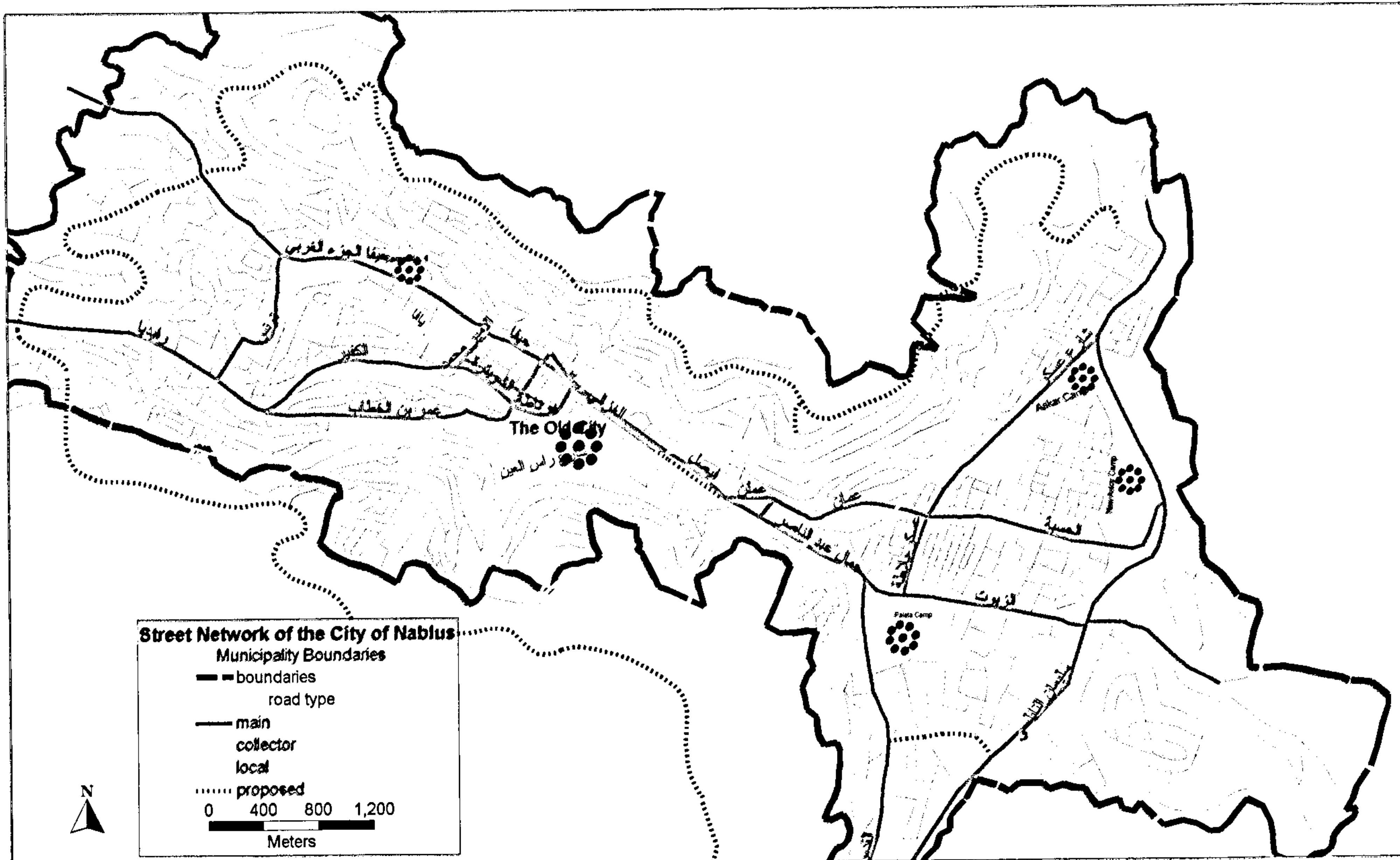
4. Identification of hazardous locations in the study area.

1.3 Study Area

Nablus City is taken as a case study to perform the study. Nablus City is the economic capital of the Palestinian territory.

The structure of the road network of Nablus is affected by the nature of the city and its topology. Figure 1.1 shows the road network in the city. This network forms the framework for the circulation of traffic in Nablus and the connection of the different parts of the city. It should also be mentioned that the distinguished location of Nablus at the heart of the northern area of the West Bank makes it at the cross-road of major north-south and east-west

Figure 1.1: Street Network of the City of Nablus



national corridors. Thus, Nablus attracts all kinds of people using various traffic modes.

1.4 Report Outline

This report is composed of seven chapters. Chapter One contains the background of road safety, aims and objectives, study area, and the study outline. Chapter Two deals with GIS definition, components, data structure, and available software.

A review of the developments made so thus far in the application of GIS to the transportation sector, especially road safety, as well as some other studies concerning safety, prepared in Palestine are presented in Chapter Three. Chapter Four describes the data collection efforts.

The design and development of the geographic database is presented in Chapter Five. Chapter Six deals with the analysis and applications of the system.

Finally, Chapter Seven presents the recommendations and conclusions.

Chapter Two

LITERATURE REVIEW

2.1 Road Safety Studies

2.1.1 Introduction

Traffic accidents are an inevitable occurrence in any highway transportation system. Accidents result from three primary factors: driver error, vehicular failure, or highway environment which includes weather and/or facility deficiencies. Traffic safety has reached alarmingly high rates in the Palestinian areas in recent years. For the period of 1968 to 1987, the percentage of fatal road accidents ranged between 10 and 15 percent of the total vehicle accidents *(PCBS, 1997)*. This percentage has dropped slightly in recent years. However, the accident fatality and severity rates are still high in the West Bank and Gaza Strip.

2.1.2 The Highway Safety Problem

It is not easy to describe the highway safety problem. Engineers like to describe it as a combination of an engineering problem, an education problem, and an enforcement problem. In fact, the problem is much more complex, because one could obviously consider it to be a social problem, because of its profound effect on society. It could be considered, at the same time, as an economic problem, and the list could go on.

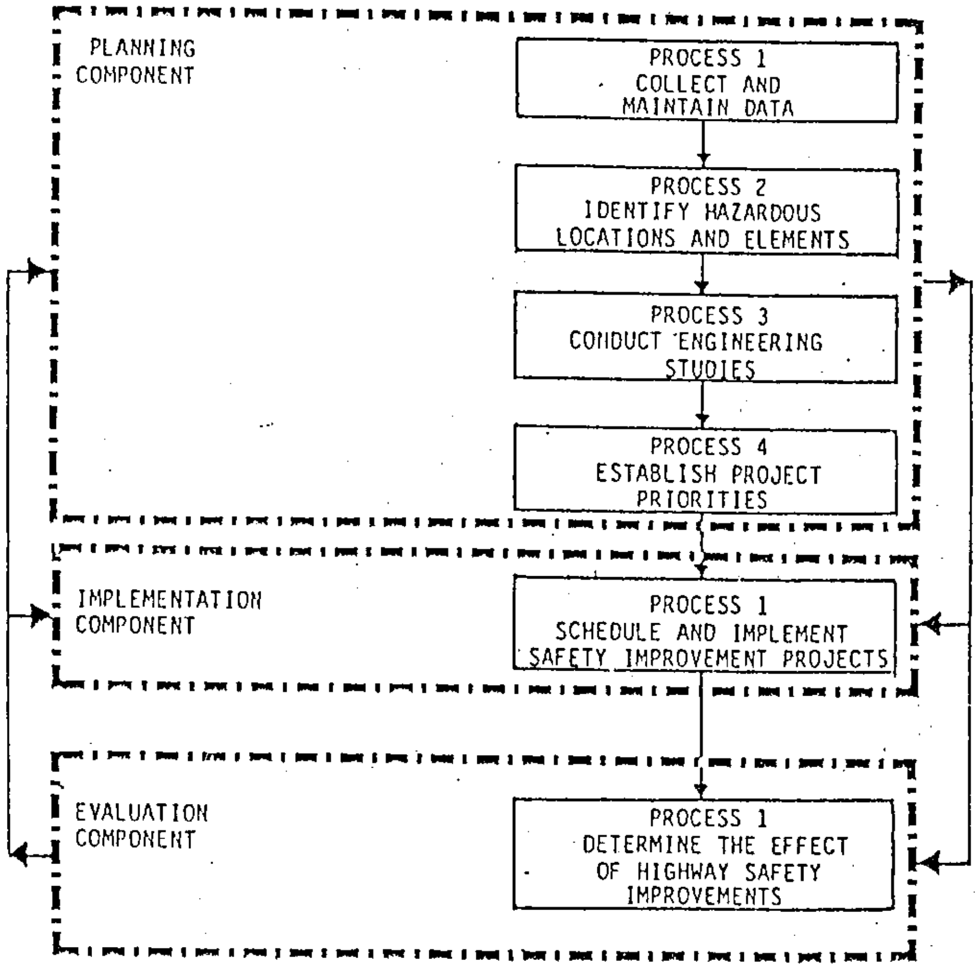
Regardless of which formula one uses to compute the monetary loss and the psychological stress due to these accidents, the true cost to society is so great that it defies comprehension. Yet society seems to accept this problem as a part of life.

2.1.3 Highway Safety Improvement Programs

In order to study and evaluate road safety issues and to assess the success or failure of highway improvements and countermeasures, it is necessary to collect data regarding the frequency and severity of accidents at accident locations. A Highway Safety Improvement Program (HSIP) consists of three components: (1) planning, (2) implementations, and (3) evaluation *(Garber and Hoel, 1996)*.

The planning component of the HSIP consists of four processes as shown in Figure 2.1. These are (1) collecting and maintaining data, (2) identifying hazardous locations and elements, (3) conducting engineering studies, and (4) establishing project of priorities. Figure 2.1 shows that the information obtained under the planning component serves as input to the two other components, and that results obtained from the evaluation component may also serve as input to the planning component.

Figure 2.1: Highway Safety Improvement Program



Source: (Garber and Hoel, 1996).

2.1.4 Accident Databases

Data is defined as factual information (measurement or statistics) used as a basis for reasoning, discussion or calculation. A database is defined as a collection of stored operational data used by the application systems of some particular enterprise. A database is thus simply a collection of information relating to a specific task.

A database based on data of accidents for the purpose of the study, investigation, and prevention of accidents is termed an accident database. The ideal database for road safety would contain everything about the accident compiled by entering each accident variable item and attribute only once to avoid duplication. A comprehensive accident database should be made up of data on all traffic accidents, traffic volumes, roadway characteristics, and any other data which will help in the analysis and investigation of accidents (Peled and Hakkert, 1993).

2.1.5 Uses of Accident Databases

Any effective local or national program for reducing road accidents requires the capability to:

1. Identify the safety problem,
2. Develop and implement appropriate countermeasures, and

3. Evaluate the results of the chosen countermeasures.

To achieve these, it is required to keep records on the incidence of all road accidents. These records must be organized properly so that they can be assessed and analyzed. It is thus seen that historical accident data are a significant source of information used by engineers and safety experts to establish safety programs and implement safety countermeasures.

Localities also need to keep records of accidents for the efficient management and operation of safety programs. Clearly, the key to maximizing the use of the limited resources is reliable information about the nature and scope of the road safety problem to be addressed. With this information, safety administrators can presumably direct their resources towards the most serious problems or towards those that have the greatest potential of reward. Also many projects are competing for the limited resources on hand, it is important for road safety officials to be able to justify road safety programs. Traffic and accident data are the sources of information needed to support the request for funds from various governmental and local sources for these programs. Accident databases also provide the backbone information for research into the investigation and prevention of road accidents. It also enables to determine estimates of the economic loss due to road accidents to a country *(Peled and Hakkert, 1993)*.

2.1.6 Accident Investigation

The majority of accident investigation and analysis work concerns consideration of road traffic accidents in which personal injury results. All injury accidents are required by law to be reported to the police. It is therefore the police who collect data on all accidents on specially prepared accident forms. These data form the basis of all road safety and accident studies. There are two main branches of accident investigations - accident reduction and accident prevention.

Accident reduction is the reduction of the number and severity of accidents on existing roads by employing low cost engineering measures, publicity and the education and training of all classes of road users, advice guidance and the enforcement of traffic laws. Accident prevention relates to the application of safety principles in new design, whether it will be the provision of new roads or the improvement and maintenance of existing roads which arises out of the need to satisfy traffic or environmental demands.

There are four alternative approaches to accident investigation. These are single site, mass action, route action, and area action *(Peled and Hakkert, 1993)*. Each of these is presented below.

- **Single site**

These are locations considered to be hazardous because of the total number of accidents recorded within a specific period. It may be a junction or a short length of road.

- **Mass action**

Accident data for a whole area or district is searched for locations with accidents having factors in common for which there is a well tried engineering remedy. For example; head on collisions, darkness, skidding on wet roads, excessive speeds approaching roundabouts, single vehicle runoffs, etc. Normally a number of sites are selected where the number of accidents are high so that a statistically large enough sample can be treated.

- **Route action**

The distribution of accidents on all routes of a particular type (e.g., two-way rural roads) is determined in order to identify those sections which have accidents greater than the norm. It is normal to search a length of at least 0.5 to 1.5 km. Further detailed investigations into the clusters are then carried out.

- **Area action**

By computer analysis and plotting, areas are examined to try to determine the neighborhoods having an accident rate above a predetermined level. This technique is generally used only in urban conditions. Norms are determined by a statistical examination of lengths of roads or a particular type of junctions. Reaction criteria can then be determined from this work, though often in practice, the reaction criteria are determined by the budget available. To justify safety improvement schemes, objectives are set to obtain certain percentages of accident reductions. Actions are taken according to priorities in accident reduction. These priorities are set on the basis of maximum likely benefits from expenditure and sites are tackled in this order.

2.2 Road Safety Studies in Palestine

A number of limited studies regarding road safety were prepared in Palestine. The following subsections represent a brief of some of these studies.

2.2.1 Road Safety in the West Bank

This study outlined and analyzed the developments in road traffic safety in the West Bank during the period 1970-1991 *(Abu-Eisheh, 1993)*. A number of parameters presenting general road safety statistics were studied. In addition, the study investigated a number of relevant issues regarding traffic safety in the West Bank, including the main components of accidents, as well as the factors which contribute to them. The study compared road safety parameters for the West Bank with those for other countries, indicating that although road fatality rates were relatively high in the West Bank, these rates were decreasing considerably with time. The study concluded with recommendations of short- and long-term means and strategies to improve road safety conditions in the West Bank, including the establishment of bodies concerned with traffic safety, increasing safety education programs, and implementing strict traffic enforcement policies.

2.2.2 The Behavior of Road Users in Gaza, Palestine

This study attempted to focus on the behavior of drivers and pedestrians on the roads of Gaza City in Palestine *(Sarraj, 1998)*.

A questionnaire was randomly distributed to a sample of drivers and pedestrians in Gaza to get first hand information about how drivers and pedestrians see their own general attitude and behavior on the roads as well as the attitude and behavior of other road users.

To investigate the causes of these behaviors of road users in Gaza Strip many statistics were examined (e.g., increase in car ownership, traffic flow, and traffic accidents).

Regarding traffic accidents, it was found that as a result of the great increase in traffic demand and in car ownership, the number of traffic accidents also increased. Statistics showed that the number of passenger injury accidents increased from 599 in 1991 to 1721 in 1995 with an increase of more than 180%. This trend continued as the number of passenger injury accidents reached 1891 in 1997. It was believed

This study highlighted some of the aspects of the interaction between pedestrian and vehicular traffic, especially those related to pedestrian safety and the flow-related impedance. The results of the study led to the following two conclusions:

- Pedestrian accidents formed a considerable share of total accidents on both the national and urban levels.
- The very young and the old age groups were exposed to the highest level of pedestrian accident risks, which can be reduced through education and enforcement.

2.2.4 Proposal for an Action Plan for Road Safety in Palestine

This study is part of the proposed plan of establishing a Palestinian Central Road Administration (*Dornier SystemConsult, 2000*). It proposed an action plan for road safety in Palestine, which consisted of a proposal of physical improvements of national road, and a proposal for traffic regulations.

The following were the proposed guidelines for the identification of traffic accidents by traffic accident reports:

♦ **Accident Recording System**

This study showed that the current accident recording procedure in Palestine is inadequate for establishing a traffic safety program. This study indicated that the current accident reports lack the basic information needed for conducting meaningful accident analysis studies. Therefore, the accident recording system should be improved. The existing accident reports are not uniform throughout the Palestinian controlled territories. Therefore, the first task should be to make the police accident report uniform for Palestine.

The study recommended that the existing accident report out to be changed. Many additional items should be added to achieve an efficient system of accident recording, retrieval and analysis. The accident report should include, as minimum, the following items:

- Name of street or intersection at which an accident takes place
- Weather conditions
- Information about drivers
- Vehicle characteristics
- Road characteristics
- Collision type
- Number of fatalities and injures or property damage estimates
- Contributing pauses of the accident

- Illumination conditions (if the accident takes place during the night)
- Description of existing traffic control devices at accident site
- Collision diagram
- Police officer's inspection of the causes of accident

The study recommended two traffic accident forms shown in Appendix A. The first proposed accident report is simple and easier to use. The second proposed accident report; however, is more comprehensive and ready for use in the computerized database system. Therefore, the second proposed accident report was recommended

♦ **Proposed Filling Systems**

This study proposed the construction of filing system as follows:

- **Manual Filing**

For the manual filing, it was recommended to store copies of accident reports which are stored at the Traffic Police Department at the governorate's (where the accident occurred) motor vehicle licensing office as well as at the PCRA.

- **Filing by Location**

It was recommended that accident records must be easily retrievable for some time. Therefore, accident files must be organized by location. All accidents occurring at specific location should be stored in one file.

- **Storage of Files and Records**

The study indicated that The central (governorate) accident files should generally be kept current (active) for one year. After records are removed from the active files, they should be retained in inactive files for a period of five years. After this period, all records could be discarded or removed to storage place.

- **Computerized Accident System**

This study proposed to construct a computerized system which should not replace the manual accident system. It rather complements it. Information from accident reports should be interpreted, coded, key punched and subsequently stored on computers. (The proposed accident report was designed to facilitate this coding). This computer system is expected to allow rapid generation of statistics reports at regular intervals, as well as special summaries of accidents by location.

2.3 GIS Applications in Transportation

With the advent of GIS technology, limitations that have initially been imposed by data availability and quality will begin to diminish and the creativity of the end-user backed by management support will govern GIS applications. In the transportation field, these applications will follow the traditional areas of highway agency responsibilities namely: pavement management, highway traffic engineering and safety, highway inventory, bridge maintenance, planning and transportation modeling, hazardous materials routing, project tracking and field office support.

In general, applications can be viewed as involving either: data retrieval; data integration; or data analysis.

The data retrieval phase uses of GIS enhance decision making by retrieving data and transforming the existing information into a compact easily understood graphic display, for example the retrieval of and plotting of signals, bridge locations, and accident locations in map form.

Data integration involves combinations of mapped variables to build and analyze new variables. In other words, the use of two or more databases to develop the required information. For example, by integrating an accident record system and roadway management system, accidents of a particular type of severity can be viewed in relation to pavement conditions or any other road physical features.

Data analysis is defined as using the GIS system to perform all the necessary analysis by linking programs or fiscal decision to the transportation system *(For more details about GIS see Appendix B).*

The following are some of the general GIS-T applications:

- **Pavement Management**

Pavement management includes the planning, design, construction, maintenance, evaluation and rehabilitation of pavements. GIS-T is a logical approach for managing this program, whereby analysis of pavement section descriptions and pavement deficiencies collected in pavement condition surveys could be maintained by location *(Abkowitz, 1990)*. Also, Pavement management system records the construction and maintenance history as well as the location of road segments and assists decision-makers in selecting appropriate treatments for deficiencies.

Many states and countries had developed and redesigned their highway inventory system to support GIS-T applications *(Michael and Wayne, 1992)*. An example of such application is that of Iowa State, which has embarked on a project to develop a statewide pavement management system (PMS) *(Smadi, Hans, and Maze, 1998)*.

- **Traffic Engineering**

Traffic engineering departments can be expected to be heavy users of GIS-T. Typically, numerous computer files exist that are keyed on the location coordinates of county, road, and milepost. It is likely that new location coordinates could also be established to take advantage of the analysis capabilities inherent in a GIS-'I'.

For example, in Baton Rouge Parish in Louisiana State, a prototype geographic database (and associated procedures) was developed to identify and request existing traffic-related data and engineering reports *(Quiroga and Bullock, 1996).*

- **Planning and Research**

Dramatic improvements in efficiency can be expected in the map production function typically carried out by Planning Departments. Whereas historically, these maps were produced through manual process, GIS-T permits the automation of this process.

Another major function of planning and research is the highway performance monitoring system (HPMS) reporting requirement. As a limited amount of data is required for all maintained roads and an extensive amount of data must be collected for a sample of these roads, structuring the HPMS file in a GIS-T format presents several advantages over current practice.

Many states and countries *(see, for example, Baily and Lewis, 1992) and (Simkoitz, 1990)*, are using GIS in transportation planning applications, such as traffic assignment, O-D matrices, school bus applications, network allocation, etc.. For example, the City of Dallas has been operating a citywide GIS system for the past several years through the GIS Division of the Planning and Development Department. The GIS Division of the Planning Department developed and maintained a comprehensive spatial database of the City. The database included the following data sets: city limits, census tracts and blocks, council districts, service districts, parcels, street centerlines, hydrography, locations of schools, fire stations, police stations, digital orthophotographs of the City, etc. *(Durcanska, 1998).*

- **Bridge Maintenance and Management**

The application of GIS in bridge maintenance involve the preparation of bridge maps, and its update as they are added and removed from the system *(Abkowitz, 1990).* This process is currently done manually and so takes a long time to complete. Bridge inspection records could be maintained on laser disk and assessed through the GIS *(Simkwotz, 1989).* California State developed a bridge management system in response to the 1989 earthquake *(Hakkert, Peld, and Affum, 1993).*

- **Routing of Hazardous Materials**

The transportation of hazardous materials involves a tradeoff etween ost of transport and exposure to population centers. A GIS with the appropriate optimization algorithms can be used to find the "shortest path" between two points, where "shortest" is some function of cost, population exposure and risk. The GIS can then print out the route and suggest departure times to minimize the potential for traffic accidents *(Simkowitz, 1990)*. Colorado DOT has used GIS-T for hazardous waste routing. Wisconsin and Ohio are developing routing applications.

2.4 GIS in Road Safety

The use of Geographic Information Systems (GIS) in road safety analysis has increased rapidly in recent years. The following is a brief of a number of studies prepared in this field:

A PC-based GIS and databases were developed for Haifa City using Arc/Info software package to deal with road safety analysis, safety management, and evaluation of improvements *(Peled and Hakkert, 1993)*. The study included a number of phases: establishment of detailed databases with information on accidents, traffic characteristics, road-physical data, digitized locations of the road system, geographic names, integration of databases into a GIS, analysis definition, and development of GIS-based applications to road safety and management. Emphasis was put on road safety analysis including the generation of periodic reports on predefined accident types (e.g., by severity), analysis of specific road safety issues (e.g., child accidents). The following are a number of conclusions presented in this study.

- It is important that system design be open and amenable to expansion. It is generally impossible to arrange for all relevant and desirable information to be collected and included. It should be possible to include such a data easily at some later stages.
- Data collection is a crucial element of the system. It is generally expensive to collect data. Data accuracy is very important and locational accuracy, particularly, is of great importance.
- The level of sophistication in the implementation of the system will probably grow with its use.

In Singapore, GIS technology was used to test the capability of GIS in the accident database management. Arc/Info software package was used in this study. The scale of the map used was 1:25,000. This means that the locational accuracy of the accident location was relatively low *(Goh, 1993)*. The results were useful and encouraging. It was concluded that a more thorough prototype could be properly designed to meet specific needs of the local police requirements if a proper design is carried out.

In Leeds University, United Kingdom, a study was prepared about the roll of using the GIS technique to enhance the road safety analysis. This study described a number of additional applications that make use of a GIS and include methods to better identify mistakes in the police accident report forms, improve the selection of routes and areas suitable for remedial treatment, provide additional information on the safety of school-based journeys, and identify the home location of road accident casualties. It was concluded that these improvements in the quantity and quality of information should lead to a more accurate and efficient selection of engineering measures and road safety campaigns *(Austin, Tight, and Kirby, 1997).*

2.5 Methods of Identifying Accident-Prone Locations

There are several methods used by engineers and local authorities in the identification of accident-prone locations. These groups can be defined under deterministic and statistical methods. The following are some of these methods:

- **Deterministic Methods**

The following are some of the deterministic methods:

1. Spot Maps

A spot map method has been one of the earliest methods for identifying hazardous locations. This method is a simple and effective way to determine accident-prone locations qualitatively. A spot map can be created by marking the location of each relevant accident on a map. GIS easily allows spot maps of large areas or with large numbers of accidents to be updated and displayed on a monitor or plotted on a map. Analysts can use different colors and sizes of graphical symbols to represent different types or seventies of accidents or to represent "multipliers" of accidents. Spot maps are very useful for specialized situations such at pedestrian accidents or parked-car accidents.

2. Accident Frequency

Accident-prone locations can be identified through lists of locations (spots sections, intersections, etc.) ranked by the number of reported accidents. The primary virtues of this approach are that it is simple and that it makes intuitive sense. If the goal is to minimize total accidents, attacking the locations with the most accidents seems logical *(Robertson, Hummer, and Netson, 1994).*

The main disadvantage of this method is that it cannot be used to compare various locations in terms of safety performance. Obviously, various sections can carry substantially different traffic volumes and/or have different lengths. None of which is taken into consideration in the identification of accident frequency *(Abdelwahab, 1997).* As a result, this method is biased towards sites with high flows. It usually selects sites with high flows but which normally have limited potential for accident reductions.

3. Accident Rates

Accident-prone locations can also be defined through lists of locations ranked by accident rate. Usually roadway section accident rates are computed in terms of accidents per 100 million-vehicle-kilometers using the formula

$$RSEC = \frac{100{,}000{,}000 \times A}{365 \times T \times V \times L} \qquad (2\text{-}1)$$

Where

RSEC	= accident rate for the section
A	= number of reported accidents
T	= time frame of the analysis, years
V	= AADT
L	= length of the section, kilometers

For intersections, the accident rate is calculated usually in terms of accidents per million entering vehicles using the equation

$$RSP = \frac{100{,}000 \times A}{365 \times T \times V} \qquad (2\text{-}2)$$

where RSP is the accident rate for the intersection, V is the sum of the average daily approach volumes for an intersections, and A and T are as defined in equation (2-1).

Obviously, ranking locations by accident rate requires traffic volume data. The time period of the volume data should match the time period of the accident data being analyzed. Analysts may use volume data somewhat outside the accident data time period if they adjust the volumes for temporal variation (growth).

Accident rates account for exposure, which is the chance that an accident will happen to a particular driver, vehicle, or roadway segment. Many studies have used AADTs or entering volumes as a general measure of exposure. There are methods to estimate exposure that are not based on traffic volumes but these methods are more appropriate for research studies. Engineers have developed computer programs to search accident files and rank locations automatically by accident rates or frequencies. For example, the FHWA developed HISAM program to manage medium-sized and small accident databases and to perform such tasks as ranking locations. HISAM, which runs on a microcomputer, is somewhat user friendly, and requires a minimum of field data to install and maintain *(Robertson, Hummer, and Netson, 1994).*

Ranking by rate method is biased towards locations with low traffic flows which usually record low numbers of accidents. Any improvements at these sites are likely to result in limited benefits since the total accident reduction is very restricted due to the low number of accidents recorded. In addition, the lack of accident severity information is also another weakness associated with relying on accident rates only.

4. The Frequency Rate Method

To address the weakness of using either the rate or the frequency measures, several researchers suggested using both the frequency and accident rate to identify accident prone (hazardous) locations. Usually, locations that meet the frequency criteria is first selected and then ranked using the rate criteria. However, some agencies use the rate to select locations and the frequency for ranking. Other agencies, define a double criteria where a location must meet or exceed both predefined crash frequency and rate *(Abdelwahab, 1997).*

5. Accounting for Severity

Analysts can adjust accident frequencies or accident rates to reflect the greater costs of injury and fatal accidents. One common method of taking severity into account before ranking locations is to compute the number of equivalent property damage only (EPDO) accidents. The method uses the number of PDO accidents that mean the same to society as a fatal accident or an injury accident. Different agencies use different equivalency factors. There is no methodological reason that prevents agencies from applying frequency, rate, or other methods to only injury and fatal or only fatal accidents. However, small sample sizes of injury and especially fatal accidents sometimes makes analysis difficult *((Robertson, Hummer and Netson, 1994) and (Khisty and Lall, 1998)).*

♦ Classic Statistical Methods

The following are the three main classical statistical methods used in analyzing hazardous locations:

1. Confidence Interval Method

After ranking locations of interest by frequency or rate (adjusting for severity if necessary), analysts could choose the top *n* locations for further detailed analysis. They could choose *n* arbitrarily, where there appears to be a real "break" in the list, by tradition, according to the labor available to perform the detailed analyses, or for some other reasons. However, a more scientific means of selecting locations is to assume that the number of accidents at locations of interest follows a standard normal probability distribution. Then analysts can select those locations that appear to be significantly higher than the mean frequency or rate. Using this procedure, analysts will select a location if it satisfies the inequality

$$OB_i > XA + K \times S \qquad (2\text{-}3)$$

where

OB_i = accident frequency or rate at location i

XA = mean frequency or rate for all locations under consideration

K = constant corresponding to a level of confidence in the finding

S = sample standard deviation for all locations

Agencies commonly use 90, 95, and 99% levels of confidence, which correspond to K values of 1.282, 1.645, and 2.327, respectively. The forces listed above that guide the nonscientific choice of n locations also guide the choice of a particular level of confidence. The greater the number of sites chosen, by whatever method, the greater the probability that a truly hazardous location is flagged and the greater the probability that a truly non-hazardous location is also flagged.

The reliability of this method has been questioned since it is apparently very sensitive to the sample mean and standard deviation of the population accident frequency or rates. Another problem with this technique is the normal distribution assumption which does not account for the special nature of accidents as rare and random events.

2. Rate Quality Control Method

A variation on the classic statistical method described above is the rate quality control method. A number of agencies have used the rate quality control method for several years. It differs from the classic statistical method in several important ways, as presented below:

- It applies only to accident rates, not frequencies.
- It assumes that the number of accidents at a set of locations follows a Poisson distribution.

3. Bayesian Method

Researchers have identified problems with the classic statistical method and the rate quality control method. They point to the arbitrary nature of the choice of a confidence level. They also cite the fact that the methods are unable to combine information rom revious tudies r nformation bout he ocation haracteristics with current accident information during analysis. Finally, they worry that those methods do not flag truly hazardous sites often enough. In response to those concerns, researchers have developed methods of identifying accident-prone locations based on Bayesian statistics. Bayesian statistics use the concept of a conditional probability, which is the probability that something is true given the knowledge that something else has occurred (Bayes' Theorem). In accident studies, analysts want to know the probability that a location is truly hazardous given the accident history, traffic volumes, and physical characteristics of the location *(Robertson, Hummer, and Netson, 1994).*

Chapter Three

DATA COLLECTION

3.1 Required Data

A traffic safety study, which is to be performed utilizing a GIS environment, would require data that may be classified under the following main categories:

- Road system data
- Data related to accidents
- Data on selected activity centers (schools, markets, main shopping centers, etc.). In this study, only schools are taken into consideration.

These data will be illustrated below.

3.2 Road System Data

The identification of road system is the backbone of geographic location of a traffic accident, which is to be opertionalized through a GIS system.

This was considered the best available source for data on the road system for Nablus. Due to the lack of proper geodetic controls in this map, its positional accuracy is not considered very high.

It was found during the data collection phase that Nablus Municipality does not have a systematic way of collection and storage of data on the street network in the city. Hence, physical characteristics of only the main and collector streets were obtained from the Traffic System Management Study (TSM) for the City of Nablus *(Dornier SystemConsult and Universal Group, 1998)*. Data collected includes, selected road physical features (width of the street, number of lanes, availability of pavement sidewalks, and traffic direction (one-way, two-way)), street names, and intersection traffic volume counts.

The traffic volume counts on the main links (street segments between intersections) were calculated from the data of the intersections traffic volume counts shown in Appendix C and prepared by the TSM study. This study contains the peak hour volume at the main intersections in the middle of 1998. Thus, this volume was expanded to represent the required Average Daily Traffic (ADT). More details are presented in section 4.2.1.

3.3 Accident Data

Accident data used are recorded primarily by the Traffic Police Department reports forms, soon after an accident occurs. One police report form is filled out per accident. Most countries have a standard accident form used by all traffic police forces within the country. The form requests information on the drivers, the passengers, the vehicles, the roadway, and the conditions at the time of accident. Some forms require a sketch of the accident showing vehicle paths and objects struck and a narrative describing the accident.

3.3.1 Accident Record System in the Palestinian Territory

The Palestinian National Authority (PNA) took over the task of transportation and traffic from the Israeli occupation when civil matters were handed to the Palestinian National Authority by the end of 1995. Traffic Police Department was established for enforcement of traffic laws and regulations, and to enhance the roadway safety. This department is responsible for accident record keeping, improving safety measures at intersections and on roads within cities, as the inter-urban highways are not yet under the Palestinian control. Due to financial problems and political reasons, the achievements of Traffic Police Departments have been limited.

3.3.2 Accident Reporting in the Palestinian Territory

As mentioned before, the study area is Nablus City, so the following description of accident reporting will reflect the methodology used in the Traffic Police Department in Nablus District. This might be slightly different from reporting practices in other districts, due to the differences in the forms used in other Traffic Police Departments.

Accident Reports in the Traffic Police Department of Nablus District are classified into five categories: Court reports, closed reports, without complaint reports, property damage only reports, and public damage reports. Each of these categories of reports is briefly presented below:

1. Court Report

This report is considered as the most accurate one, because it is the most detailed report. This report contains the following information:

- Time of accident
- Location of accident
- Weather condition
- Road conditions
- Involved vehicles characteristics
- Damages and estimates
- Narrative summary

An accident condition diagram on a graphic paper is also included in this type of accident reports.

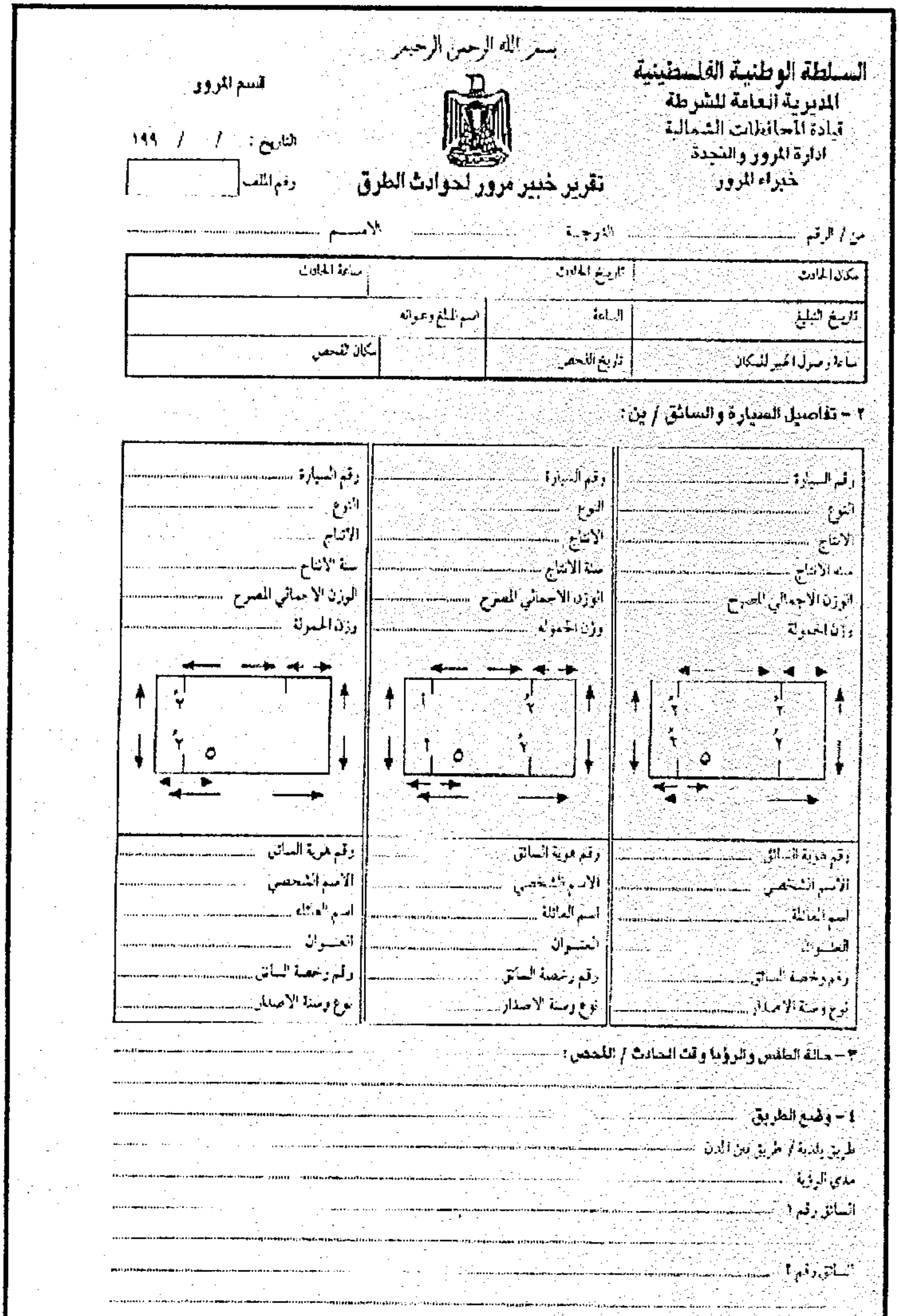
Figure. 3.1 shows a copy of a Court form. The Police Department prepares two copies of this report; one for the Court and the other for the traffic police documentation. Unfortunately, the Traffic Police Department prepares one copy of the accident diagram and sends it to the Court. Attached to this type of reports some other documents such as medical reports for injuries, and death reports for fatalities. Sometimes there are more details about the accident represented by the certification of drivers, injuries, or witnesses.

Figures 3.2 and 3.3 show the driver/witness and injury or his deputy declarations, respectively.

2. Closed Report

This type of reports contain the same information as the Court report, but the main difference is that the Traffic Police Department does not send a copy of this report to the Court. In other words the case is closed in the Traffic Police Department according to the desire of the involved persons in the accident.

Figure 3.1: The Court report



بسم الله الرحمن الرحيم

السلطة الوطنية الفلسطينية
المديرية العامة للشرطة
قيادة المحافظات الشمالية
ادارة المرور والنجدة
خبراء المرور

قسم المرور

التاريخ : / / ١٩٩

رقم الملف

تقرير خبير مرور لحوادث الطرق

من / الرقم .... الوجهة .... الاســم ....

مكان الحادث	تاريخ الحادث	ساعة الحادث
تاريخ التبليغ	الساعة	اسم المبلغ وعنوانه
ساعة وصول الخبير للمكان	تاريخ الفحص	مكان الفحص

٢ - تفاصيل السيارة والسائق / ين :

رقم السيارة	رقم السيارة	رقم السيارة
النوع	النوع	النوع
الانتاج	الانتاج	الانتاج
سنة الانتاج	سنة الانتاج	سنة الانتاج
الوزن الاجمالي المصرح	الوزن الاجمالي المصرح	الوزن الاجمالي المصرح
وزن الحمولة	وزن الحمولة	وزن الحمولة
رقم هوية السائق	رقم هوية السائق	رقم هوية السائق
الاسم الشخصي	الاسم الشخصي	الاسم الشخصي
اسم العائلة	اسم العائلة	اسم العائلة
العنوان	العنوان	العنوان
رقم رخصة السائق	رقم رخصة السائق	رقم رخصة السائق
نوع وسنة الاصدار	نوع وسنة الاصدار	نوع وسنة الاصدار

٣ - حالة الطقس والرؤيا وقت الحادث / الفحص : ....

٤ - وضع الطريق ....

طريق بلدية / طريق بين المدن ....

مدى الرؤية ....

السائق رقم ١ ....

السائق رقم ٢ ....

Figure 3.1(continued): The Court report

٥ - تفاصيل الأضرار تم الكشف عليها وقت الفحص نتيجة الحادث :

سيارة رقم ١

سيارة رقم ٢

سيارة رقم ٣

٦ - اضرار بعد الحادث :

سيارة رقم ١

سيارة رقم ٢

سيارة رقم ٣

٧ - اضرار بالممتلكات بما فيها الحيوانات المشتركة بالحادث :

٨ - فحص السيارات فحصت (كتابة اذا كانت صالحة ، إذا وجدت اعطال - تفاصيل الاعطال وسببها :

سيارة رقم ١

سيارة رقم ٢

سيارة رقم ٣

٩ - الموجودات واهميتها (نقط دم ، تبعثر رمل ، قطع زجاج ، اشياء من المصابين ، أشياء اخرى :

١٠ - آثار بريك ، آثار عجلات - النتائج وتحديد السرعة :

Figure 3.1(continued): The Court report

١١ - صور / مضبوطات :

١٢ - خطة الارشادات الضوئية :

١٣ - إشارات وعلامات طرق (المسافة من مكان الحادث وملاحظات لحظة الاشارات الضوئية) :

١٤ - النتائج :

Figure 3.1(continued): The Court report

إضافات لاستعمال الخبير :

....

....

تم تسجيل هذا التقرير بيدي بتاريخ .... حسب الموجودات التي ضبطت بتاريخ ....

أنا الموقع أدناه ، خبير سير أقدم تقريري الفني بشأن حادث طرق الذي حصل بالتاريخ والمكان المبين في هذا التقرير وأقدم تقريري هذا بدل إفادة بالمحكمة وأنا أعرف جيداً أحكام القانون الجزائي بشأن الإفادة تحت القسم بالمحكمة .

تفاصيل الشهادة : حائز على شهادة خبير حوادث من تاريخ ....

خبرة العمل : العمل الفعلي كخبير حوادث من تاريخ ....

رأي الخبير

فحصت موجودات الخاصة بالحادث المذكور وسجلتها بهذا التقرير / ورسمت مخطط ، وصورت صور وتقارير عمل أخرى مرفقة والموقعة بيدي وهو جزء لا يتجزأ من هذا التقرير .

توقيع الخبير ....

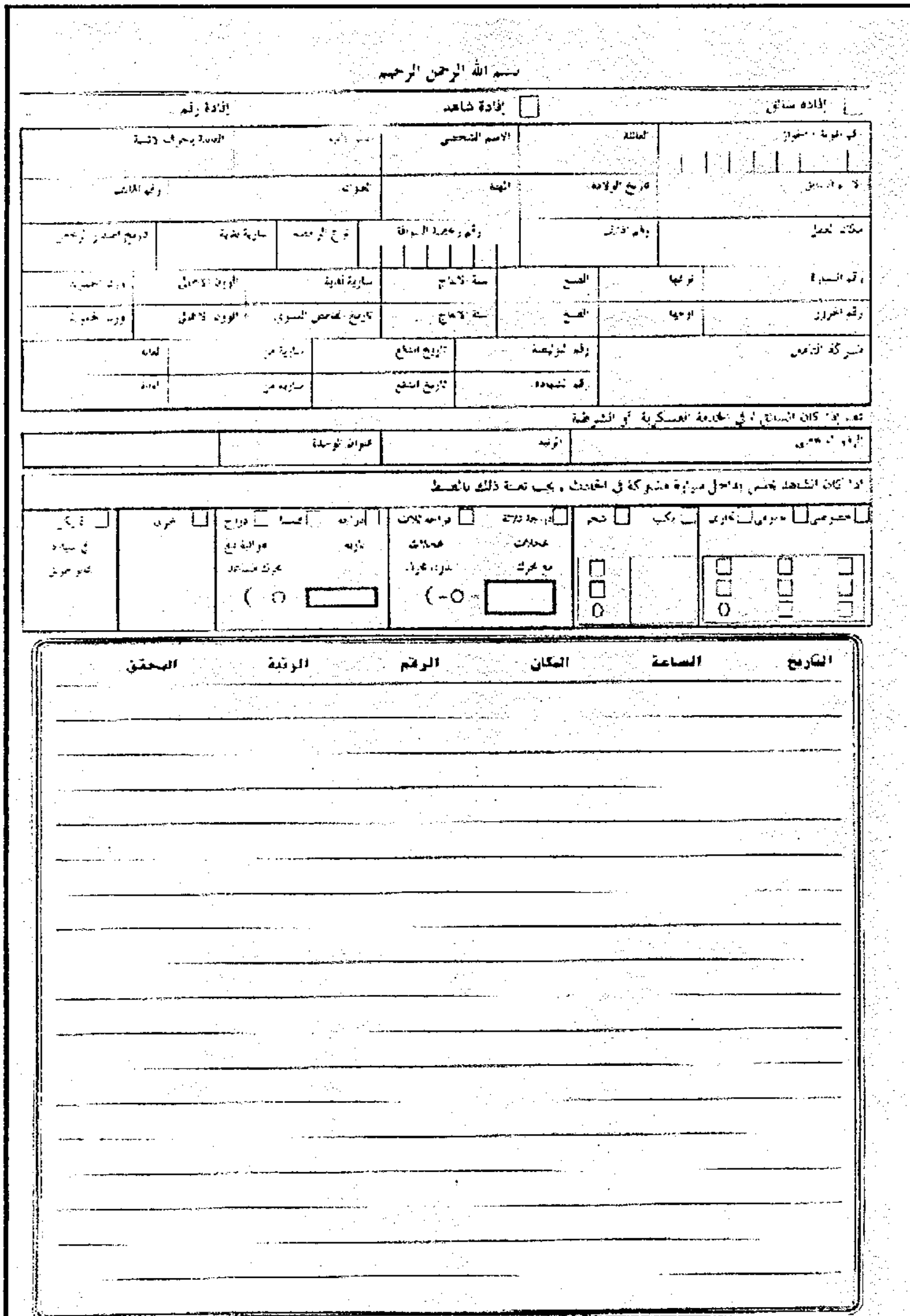
تصديق ضابط الحوادث

أنا ....

الرقم الشخصي .... الرتبة .... الاسم ....

اصادق على توقيع الخبير .... توقيع الضابط ....

Figure 3.2: Driver/Witness Declaration



3. Without Complaint Report

Without complaint reports forms approximately one third of the total reports. This type of reports does not contain an expert report, nor an accident condition diagram. This means that the data related to the environmental condition, surface condition, and type of accident is not presented in this report. Also the Traffic Police Department does not send a copy to the Court. The Police Department decides to use this form of report only when the severity of the accident is slight, and if the injured person decides to give up his rights without going to Court.

It was noticed that there is no specific form in the Traffic Police Department regarding Without Complaint Report.

4. Property Damage Only Report

This type of reports forms the highest percent of those related to total accidents. This report is the least detailed one. No accident condition diagram is prepared for property damage accident, except those which will be sent to the Court (only when persons involved in the accident do not reach a compromise). A form of this report is shown in Figure. 3.4.

Figure 3.4: Property Damage Only Report

السلطة الوطنية الفلسطينية
المديرية العامة للشرطة
إدارة المرور والنجده / نابلس
قسم حوادث السير

الرقم :
التاريخ : / / ١٩

تقرير عمل حادث سير أضرار فقط

السيد: ....

بواسطة: ....

إسم الخبير	الرتبه	تاريخ الحادث	الساعة	مكان الحادث

تفاصيل السائقين المشتركين بالحادث :

رقم السيارة ونوعها	١.	٢.	٣.
إسم السائق			
عنوانه			
رقم الهوية			
رقم الرخصة			
شركة التأمين			
رقم البوليصة			
إنتهاء التأمين			
إنتهاء رخصة المركبة			
التوقيع للسائقين			

بيانات الحادث " كيفية وقوع الحادث وسببه " ....
....
....

رقم مخالفة المسبب للحادث ونوعها " محكمة " " غرامه " ....

توقيع مقدم التقرير	ساعة الإنتهاء	تاريخ إنتهاء الإجراءات

ملاحظات ضابط الحوادث: ....
....

توقيع ضابط الحوادث

As for the other accident reports (without claim, property damage only, or closed cases), they were classified into accidents which occurred inside or outside the Municipality borders. The data required from each record was then documented manually in the Traffic Police Department, then asserted by revising through the personal status file that had been found at the Traffic Police Department which contains all kinds of cases that occurred.

3.4 Selected Activity Data

In this study, only schools were taken into consideration from all activity centers. The locations of schools were added to the base-map as a separate layer based on a hard-copy map which contains these locations prepared by Nablus Municipality.

- route system layers that maintain routes as collections of geographic features to facilitate route definition and network development, enhance the quality of route displays, and provide for storage of route-based tabular data; and
- tools for maintaining, displaying, and performing spatial queries on linearly-referenced attribute data, including comprehensive dynamic segmentation functions.

TransCAD can be used to manipulate these data types in conjunction with the more traditional GIS entities in a natural, convenient, and powerful manner *(Caliper Corporation, 1996).*

3. Transportation Analysis and Modeling

The complete TransCAD package includes a core set of transportation network analysis and operations research models, a set of advanced analytical models for specific applications, and a set of supporting tools for statistical and econometric analysis. This modular approach gives a great flexibility to address specific modeling and data issues.

TransCAD software is considered as an integrated GIS and transportation analysis tool. The GIS makes it possible to display and visualize both the inputs to a particular model and the model outputs. This allows for evaluating the quality of

- Creating add-ins or macros that extend the capabilities of TransCAD or that automate repeated operations
- Building user applications with a completely different user interface and customized program operation.

GISDK also allows the user to launch other applications and communicate with other applications and programs written by the user or by third parties. This capability makes TransCAD a powerful platform for developing and testing new analytical procedures. TransCAD also provides a complete solution for the development of decision support systems *(Caliper Corporation, 1996).*

4.2 Types of Databases Used

As mentioned in chapter three, the main types of data used in the study are: street data, accident data, and schools data. Each of these is presented below.

4.2.1 Street Data

The street network for Nablus City was divided into links and nodes. Nodes representing intersections and links representing the street section between two nodes. Two main data files were created: one for the street segments (links) known as LINK.DBF and the other for the street intersections known as INTER.DBF.

Following is a description of these data files, their various items, and how they are defined in the GIS database.

- Link Database File

Shown in Table 4.1 are the various types of variables collected for only the main and some collector links and used as attribute data to create the links layer, with a brief description of each field.

Field 1 "ID" is the default identification number of each link. When adding a link to the map, it is registered directly in the database. This field is a read only, consists of a corresponding ascending order numbers.

Field 2 "LENGTH" describes the length of the link.

Field 3 "DIR" indicates whether the street segment is operating as one-way or two-way and the direction of traffic movement. Description of the DIR item codes is found in Table 4.1.

Field 4 "DATA" is also a default identification number for each link. When saving the file as a "compact geographic file", which is a method used to solve errors in the file, this field is registered directly to the database. This field can be used to add feature ID.

Table 4.1: Road Database Structure, 1997-1998

ID	Field Name	Field Description	Field Type*/Width
1	ID	Default identification number	N/10
2	Length	Length of the link	N/10
3	Dir	Direction	N/10
		0: Two way 1: One-way in the same direction in which the coordinates of the line feature are stored (topological direction) -1: One-way in the opposite direction from which the coordinates of the line feature are stored (reverse topological	
4	DATA	Default identification number	N/10
5	CLASS	Road classification:	N/10
		1: Main street	
		2: Collector street	
		3: Local street	
		4: proposed main street	
6	NOLANE	Number of lanes in both directions	N/2
7	WIDTH	Width of lanes on both directions	N/10
8	MEDIAN	Existence of Median	N/2
		1: There is a median	
		2: No median	
9	SIDEWALK	Existence of Sidewalk	N/2
		1. There is sidewalk on both directions	
		2. This is partially sidewalk on both directions	
		3. There is sidewalk on one direction only	
		4. No sidewalk	
10	STREETCOND	Street condition	N/2
		1. Good	
		2. Fair	
		3. Poor	
11	SIDECONDIT	Sidewalk Condition	N/2
		1. Good on both direction/one direction if the street is one way	
		2. Fair on both direction/one direction if the street is one way	
		3. Poor on both direction/one direction if the street is one way	
		4. Good on one direction and fair on the other	
		5. Good on one direction and poor on the other	
		6. Fair on one direction and poor on the other	
12	VOLUME97	Average daily traffic (ADT) in 1997	N/10
13	VOLUME98	Average daily traffic (ADT) in 1998	N/10
14	VOL9798	Average of (ADT) in 1997 and 1998	N/10
15	NOOFACC	Number of accidents on this link	N/10
16	RATE	Rate of accidents (accident/10^6 km-vehicles)	N/10

*: N means number, and C means character

Fields 5-11 (“CLASS”, “NOLANE”, “WIDTH”, “MEDIAN”, “SIDEWALK, and “STREETCOND”) show road classification, number of lanes on both directions, width of lanes on both directions, availability of a median, availability and description of the sidewalks conditions, and description of the pavement condition of the link, respectively.

Fields 12-14 (“VOLUME97”, “VOLUME98”, and “VOL9798”) show the average daily traffic (ADT) on the link in 1997, in 1998, and the average of the (ADT) for both years, respectively. These fields were calculated using the data taken from the TSM study for the city of Nablus in the middle of 1998. The annual growth rate used was 5 percent per year, and the percent of the peak hour volume from the total daily traffic volume was considered to be 8% *(Douleh, 2000).*

Fields 15-16 (“NOOFACC” and “RATE”) were added to accommodate output from initial analysis by integrating the accident database and the link attribute database. NOOFACC and RATE are respectively variables for total number of accidents recorded for the two years and the annual accident rate per million vehicle kilometers for the link.

- Intersection Database File

This file is created by exporting the default end-points layer of the link layer as a compact geographic file, because the end-points file which represents intersections and automatically created when creating or importing the link layer is a read only one, and no additional field to describe any physical feature of the intersections can be added to this file.

Table 4.2 shows the fields used in the INTER.CDF file. The two fields (ID and DATA) are the same as the ones described in the LINK.CDF file.

A geographic reference is provided by Fields 2-3, which can help to identify the exact location of the accident. Field 3 identifies the longitude coordinate and Field 4 identifies the latitude coordinate of the intersection location. These two fields are specified automatically once the link is created.

Field 5-7 ("VOLUME97", "VOLUME98", "VOL9798") show average daily traffic at the main intersections as defined before.

Due to the fact that the available data related to intersections is limited to only the main intersections in the city of Nablus. These fields were calculated for the main intersections only using the data taken from the TSM study for the city of Nablus in the middle of 1998 *(Dornier SystemConsult and Universal Group, 1998).*

Table 4.2: Intersections Database Structure, 1997-1998

ID	Field Name	Field Description	Field Type*/Width
1	ID	Default identification number	N/10
2	DATA	Default identification number	N/10
3	LONGITUDE	Longitude coordinate	N/10
4	LATITUDE	Latitude coordinate	N/10
5	VOLUME97	Average daily traffic (ADT) in 1997	N/10
6	VOLUME98	Average daily traffic (ADT) in 1998	N/10
7	VOL9798	Average of (ADT) in 1997 and 1998	N/10
8	NOOFACC	Number of accidents on this intersection	N/10
9	RATE	Rate of accidents (accident/10^6vehicles)	N/10
10	NAME	Intersection name	C/10

*: N means number, and C means character

The annual growth rate used and the percent of the peak hour volume out of the average daily traffic volume were the same as the ones used for the traffic volume on the main links, as mentioned before.

Fields 8-9 ("NOOFACC", and "RATE"), were added to accommodate output from initial analysis as defined before.

Field 10 is added to describe the name of intersections. In this study the name of only the main intersections is recorded. Arabic language can be used to describe the name.

4.2.2 Accident Data

The 1997 and 1998 traffic accident database was designed based on the "Traffic Police Department" standards. Pertinent information from accident reports into specific fields within the database were recorded.

The data on the property damage only accidents occurring on all streets in the study area for the two years 1997-1998 were extracted from the parent database. Furthermore, since the accident records in Traffic Police Department reports contain many variables, some of which were considered not relevant to the study. Therefore, they were discarded and only those variables that were considered most appropriate were selected for the study. Appendix D shows the database structure of accident variables. Each field is numbered, named, and briefly described. These variables were used as attributes in the accident layer. The database consisted of 110 fields for each accident. There were 815 accidents, comprising 322 intersection accidents and 493 non-intersection accidents.

The accident database fields are described in Appendix D

4.2.3 School Data

The SCHOOLS.DBF file, which was created automatically when building the schools layer has four fields. These fields are described in Appendix D

4.3 Development of Base Map

TransCAD draws maps using data from geographic files stored on the computer, CD-ROM, or file server. When opening a geographic file TransCAD creates a new map window in which to display.

A geographic file is a collection of several files stored on the hard disk of the computer or on a CD-ROM. These files contain all the information recorded to display features on a map, and tabular data that describes each map feature.

Attributes in a DXF file are not stored in a standard row-and-column format. Some data are associated with blocks in the DXF file, and other data are associated with individual entities in the file. TransCAD creates either one or two row-and-column format tables for the attributes. The first table contains the ID of each feature, the name of the DXF layer from which it came, and the ID of the block in the DXF file to which it was assigned, if any. The world Coordinate System "Palestine Zone" was used when importing the DXF file.

After that, the line-editing tool was used. This tool is used to add, delete, modify, join, and split links. This was done to correct errors in the imported file and to insure that all links are connected with each other correctly. In other words, map editing is used to maintain and create topology. For example, the join command was used at each intersection to make sure that the links meet at a common point. It should be noticed that the attribute table, which is constructed automatically when creating any geographical file in TransCAD, is affected when editing the geographic file. Thus, the needed attribute data was added after finishing this stage.

The coordinates of all intersections in the study area were extracted from the coordinates of the links, because the intersections layer is actually the read-only end-point layer associated with the road layer. So the geographic file "end-point layer" was exported as a new compact geographic file, to make it possible to add attribute data to this layer.

Accidents layer was added to the base map by creating an empty point geographic file, then editing the location of each accident location using the point-editing tool.

The coordinates of the locations of accidents were obtained in two ways. The coordinates of accidents that occurred at intersections were obtained easily from their respective intersection coordinates. The problem was in identifying the locations of non-intersection accidents, because there is no available linear reference system used (e.g., mileposts system, or at least street numbering and house numbering system).

To solve this problem, most of these accident locations (more than 90%) were visited, and the distance from the neighboring intersection was measured to connect the accident location to an intersection.

The Traffic Police Department identified the location of non-intersection accidents when using the accident condition diagram by connecting this accident to neighboring houses, shops, school, etc. In addition to the description of the location.

In a similar fashion, the schools layer was created in a separate point geographic file.

4.3.2 Attribute Data linkage

The GIS uses two types of data sets: the spatial data and the non-spatial attribute data. A complete geographic database necessary for any kind of geographic analysis requires the integration of these two data sets.

To link the various attribute data to their respective layer attribute table (DBF) in the link, intersections, and schools layers, these data were filled directly to the dBase file (DBF), by adding the required fields for each table, using the filling, and modifying table commands.

The attribute data regarding the accidents layer was prepared using Excel Microsoft ware, and this file was linked to the dBase file by using a temporary ID, and the IDPOLICE for linking these two files.

Chapter Five

APPLICATIONS AND DISCUSSION OF RESULTS

5.1 Data Retrieval and Display

All types of data in the geographic database (e.g., accident of any type or category, street segments, schools location, etc.) can be retrieved, queried and displayed as an easily understood map on the screen or as high quality hardcopy maps using different symbols, colors, line types and line widths depicting the different categories of geographic features or items. These maps can be drawn or produced at any scale.

The integration of the accident database into GIS has helped in the display of accidents. For example, pedestrian accidents, children accidents, rear-end accidents, etc. can be displayed on separate maps or on one map, where the specific location of the accident can be identified using different colors or symbols to differentiate among them. This type of display would replace the much used, but yet expensive and time consuming plotting still used of accidents by many agencies. These displays are really an enhancement to developing safety programs and strengthen the decision-making capabilities of traffic safety administrators. Such data displays assist also in identifying the hazardous locations (black spots) in a very efficient and direct manner.

5.2 Generation of Reports

Organizations involved in road safety generally prepare two kinds of reports depending on the circumstances and usage during their day to day operations. These reports are grouped under periodic reports and special reports.

5.2.1 Periodic Reports

These are reports which are produced from time to time by the organization. They are generally produced either annually, quarterly, monthly or for any time frame deemed fit by the organization. The reports usually include executive accident summaries, trends and statistical tables. The reports can be produced in hardcopy map or tabular forms. These reports enable managers to know and understand the overall accident situation in their area, or at a particular location, and how it is changing at frequent intervals. It also enables staff members to determine traffic operational and capital investment solutions and to establish priorities for improvements on a regular basis. The tabular reports include frequency tables for any selected accident variable, cross-classification tables between any two accident variables, and summary accident statistics including accident rates.

Below are some of these reports generated using the system, and discussions of the results obtained. These include all accidents, intersection accidents, link accidents, pedestrian accidents, and children accidents. The analyses were done using the analysis columns of the user interface and specifying a TransCAD file to receive the output for each type and kind of analysis. The appearance and format of these reports are in Microsoft Word.

5.2.1.1 All Accidents

This section was separated into two analysis sub-sections. Traffic accident data was analyzed on a macro level or system-wide analysis for all accidents in the study area including "property damage only" accidents, although these are not located geographically. The traffic Police Department does not define the location of the "property damage only" accidents. The second sub-section deals with the accidents involving casualties.

- **System-Wide Analysis**

First, analyses involves accidents that occurred in Nablus city by severity (Table 5.1): property damage only, personal injury (one or more persons injured), and fatal injury (one or more fatalities) are presented. Of the 1825 traffic accidents reported in the study area in 1997-1998, about 55.3 percent of all accidents were "property damage only", and 44.4 percent of all accidents involved personal injury. Only 6 accidents (0.3 percent) involved fatalities. Figure 5.1 shows the severity distribution of these accidents.

Table 5.9: Traffic Accidents by Time of Day and Severity Classification, 1998

Time	Property Damage	Personal Injury	Fatal Injury	**Total Number**	**Percent of Total**
12:00 AM	2	0	0	**2**	**0.24**
1:00	1	1	0	**2**	**0.24**
2:00	1	1	0	**2**	**0.24**
3:00	0	0	0	**0**	**0.00**
4:00	1	0	0	**1**	**0.12**
5:00	2	1	0	**3**	**0.36**
6:00	3	1	0	**4**	**0.48**
7:00	6	13	0	**19**	**2.28**
8:00	36	13	0	**49**	**5.88**
9:00	34	19	0	**53**	**6.35**
10:00	36	24	0	**60**	**7.19**
11:00	33	21	1	**55**	**6.59**
12:00 PM	35	26	0	**61**	**7.31**
1:00	43	24	1	**68**	**8.15**
2:00	47	27	0	**74**	**8.87**
3:00	48	16	0	**64**	**7.67**
4:00	41	43	0	**84**	**10.07**
5:00	28	24	0	**52**	**6.24**
6:00	19	18	1	**38**	**4.56**
7:00	27	11	0	**38**	**4.56**
8:00	18	23	0	**41**	**4.92**
9:00	13	12	0	**25**	**3.00**
10:00	12	2	0	**14**	**1.68**
11:00	2	3	0	**5**	**0.60**
Not specified	9	11	0	**20**	**2.40**
Total	**497**	**334**	**3**	**834**	**100.00**

Table 5.10: Traffic Accidents by Time of Day and Severity Classification, 1997-1998

Time	Property Damage	Personal Injury	Fatal Injury	Total Number	Percent of Total
12:00 AM	3	1	0	**4**	**0.22**
1:00	1	1	0	**2**	**0.11**
2:00	3	3	0	**6**	**0.33**
3:00	1	2	0	**3**	**0.16**
4:00	2	0	0	**2**	**0.11**
5:00	3	3	0	**6**	**0.33**
6:00	7	8	0	**15**	**0.82**
7:00	22	32	0	**54**	**2.96**
8:00	57	39	0	**96**	**5.26**
9:00	60	42	0	**102**	**5.59**
10:00	74	64	0	**138**	**7.56**
11:00	73	42	1	**116**	**6.36**
12:00 PM	77	73	0	**150**	**8.22**
1:00	93	52	2	**147**	**8.05**
2:00	95	57	1	**153**	**8.38**
3:00	91	44	0	**135**	**7.40**
4:00	82	73	0	**155**	**8.49**
5:00	64	62	0	**126**	**6.90**
6:00	46	48	1	**95**	**5.21**
7:00	45	40	0	**85**	**4.66**
8:00	34	48	0	**82**	**4.49**
9:00	32	23	1	**56**	**3.07**
10:00	25	18	0	**43**	**2.36**
11:00	5	9	0	**14**	**0.77**
Not specified	15	25	0	**40**	**2.19**
Total	**1010**	**809**	**6**	**1825**	**100.00**

percentage of accidents. Next, the hours 2:00-3:00 and 3:00-4:00 had the second highest percentage of accidents. In 1998 the 4:00-5:00 PM hour had the highest percentage of accidents, next the 2:00-3:00 had the second highest percentage of all accidents; and 1:00-2:00 had the third.

It is illustrated that the highest percentage of vehicles involved in traffic accidents during the study period (1997-1998) was for private and commercial vehicles (70.10%), followed by taxis (11.56%), as shown in Table 5.11.

- **Injury Accidents**

There were 815 accidents recorded for the study area during 1997-1998 involving a total of 1263 casualties, giving an average of 1.55 casualties per accident. The locations of these accidents are shown in Figure 5.3. The total number of vehicles involved was 1210, thus an average of 1.48 vehicle per accident. The accident location distribution between the links and intersection was 536 (65.8%) on the links compared to 279 (34.2%) at intersections.

The annual variation of accidents number reduced from 478 accidents in 1997 to 337 accidents in 1998, indicating a reduction rate of 29.5% as illustrated in Table 5.12. The total number of casualties involved in accidents reduced from 759 casualties in 1997 to 504 casualties in 1998, indicating a reduction rate of 33.6%.

Table 5.11: Vehicles Involved in Traffic Accidents by Type, 1997-1998

Vehicle Type	1997		1998		Total	
	No.	%	No.	%	No.	%
Private and Commercial	1172	66.86	1133	73.81	**2305**	**70.10**
Taxi	132	7.53	248	16.16	**380**	**11.56**
Bus	22	1.25	26	1.69	**48**	**1.46**
Truck	131	7.47	100	6.51	**231**	**7.03**
Bicycle	19	1.08	10	0.65	**29**	**0.88**
Motorcycle	7	0.40	4	0.26	**11**	**0.33**
Other	11	0.63	3	0.20	**14**	**0.43**
Not Specified	259	14.77	11	0.72	**270**	**8.21**
Total Vehicles	**1753**	**100.00**	**1535**	**100.00**	**3288**	**100.00**

Figure 5.3: Plot of All Injury Accidents, 1997-1998

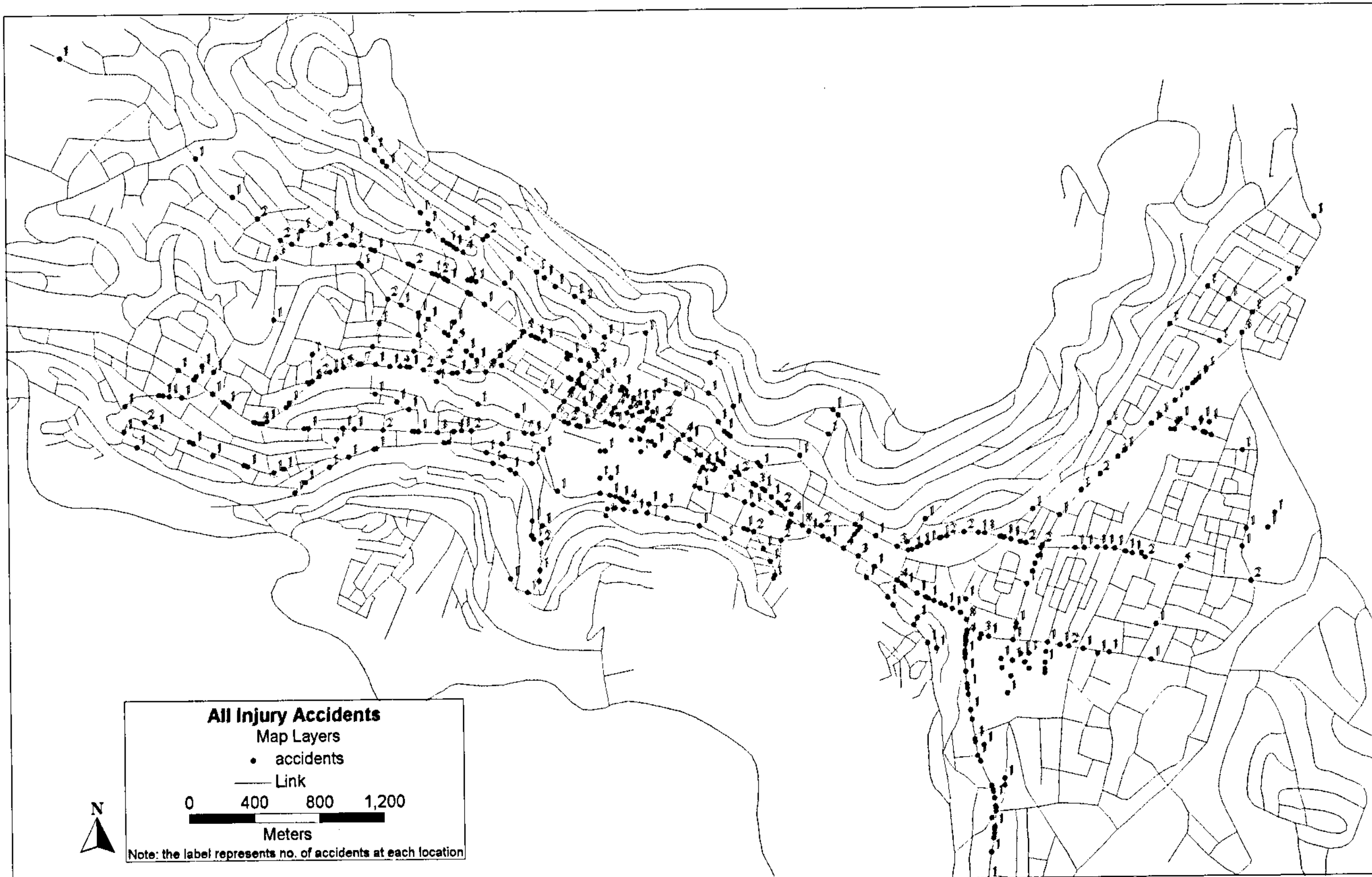


Table 5.12: Injury Accidents by Year, 1997-1998

Year	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
1997	478	58.6	759	60.0
1998	337	41.4	504	40.0
Total	**815**	**100.0**	**1263**	**100.0**

In other words, causalities followed the same trend of the total number of accidents due to the fact that most accidents involved only one casualty as illustrated in Figure 5.4.

The monthly variation of injury accidents showed that the highest percentage of accidents was in May (10.2%) followed by (9.7%) in January and July during the study period. On the other hand, December had the least percentage of accidents (6.3%), as illustrated in Table 5.13.

Although the number of accidents in some of the summer months were higher than those in winter months, the rate of casualties per accident was higher in winter than in summer as presented in Figure 5.5.

With respect to type of accident, Table 5.14 shows that pedestrian accidents alone accounted for 44.42 percent of all injury accidents recorded for the two years. This is due to the fact that pedestrians are a dominant type of road user in the area. Rear-end accidents accounted for 13.74 percent and right-angle accidents accounted for 7.61 percent of all accidents.

It was noticed that the type of accident for 16.69 percent of all injury accidents is not specified, due to the lack in filling this field in the Traffic Police Department. This affects the credibility of results, especially most pedestrian accidents and rear-end accidents can be defined easily from the reason of accident.

Figure 5.4: Injury Accidents and Involved Casualties by Year, 1997-1998

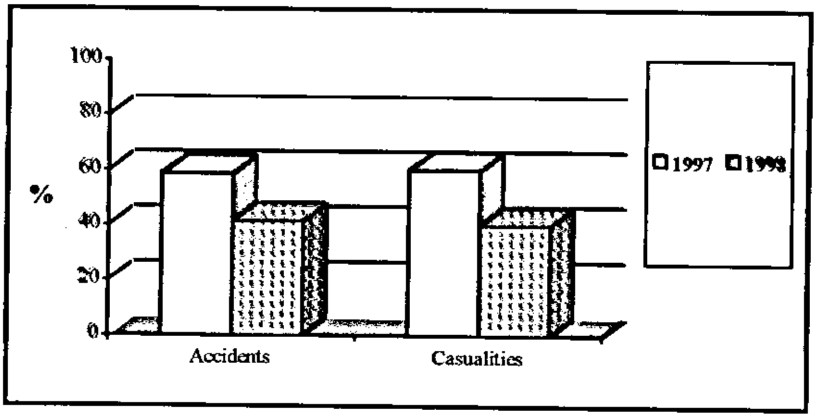


Table 5.13: Monthly Variation of Injury Accidents, 1997-1998

Month	Total number of accidents	Percentage of accidents	Number of casualties	Percentage of casualties
January	79	9.7	131	10.4
February	64	7.9	117	9.3
March	57	7.0	102	8.1
April	67	8.2	92	7.3
May	83	10.2	121	9.6
June	63	7.7	97	7.7
July	79	9.7	114	9.0
August	66	8.1	77	6.1
September	77	9.4	120	9.5
October	64	7.9	112	8.9
November	64	7.9	100	7.9
December	52	6.4	80	6.3
Total	**815**	**100.0**	**1263**	**100.0**

5.2.1.2 Intersection Accidents

For the Two-year study period, there were 322 intersection accidents recorded at 126 intersections. The average number of accidents per intersection (at which accidents occurred) was therefore, 2.55. Figure 5.6 shows intersection accidents with the number of accidents at each location indicated. Tables 5.15 through 5.17 present the results of the analysis of these accidents. From the results the following findings were noted:

The distribution of accidents by type during the study period, as illustrated in Table 5.15, shows that the dominant type of accident experienced at the intersections were pedestrian related accidents (28.75%), followed by right-angle accidents (15.22%) and rear-end accidents (13.66%). The same table shows that right angle accidents accounted for the highest percentage of casualties 20.00% of all casualties, followed by pedestrian related accidents, which accounted for 18.90 percent of all casualties.

With respect to accident severity, the majority of intersection accidents during the study period were slight injury (85.71%), as illustrated in Table 5.16. Accidents involving serious injuries formed 13.66 percent of all intersection accidents. Accidents with fatal injuries formed 0.63 percent of all accidents.

Figure 5.6: Plot of All Intersection Accidents,1997-1998

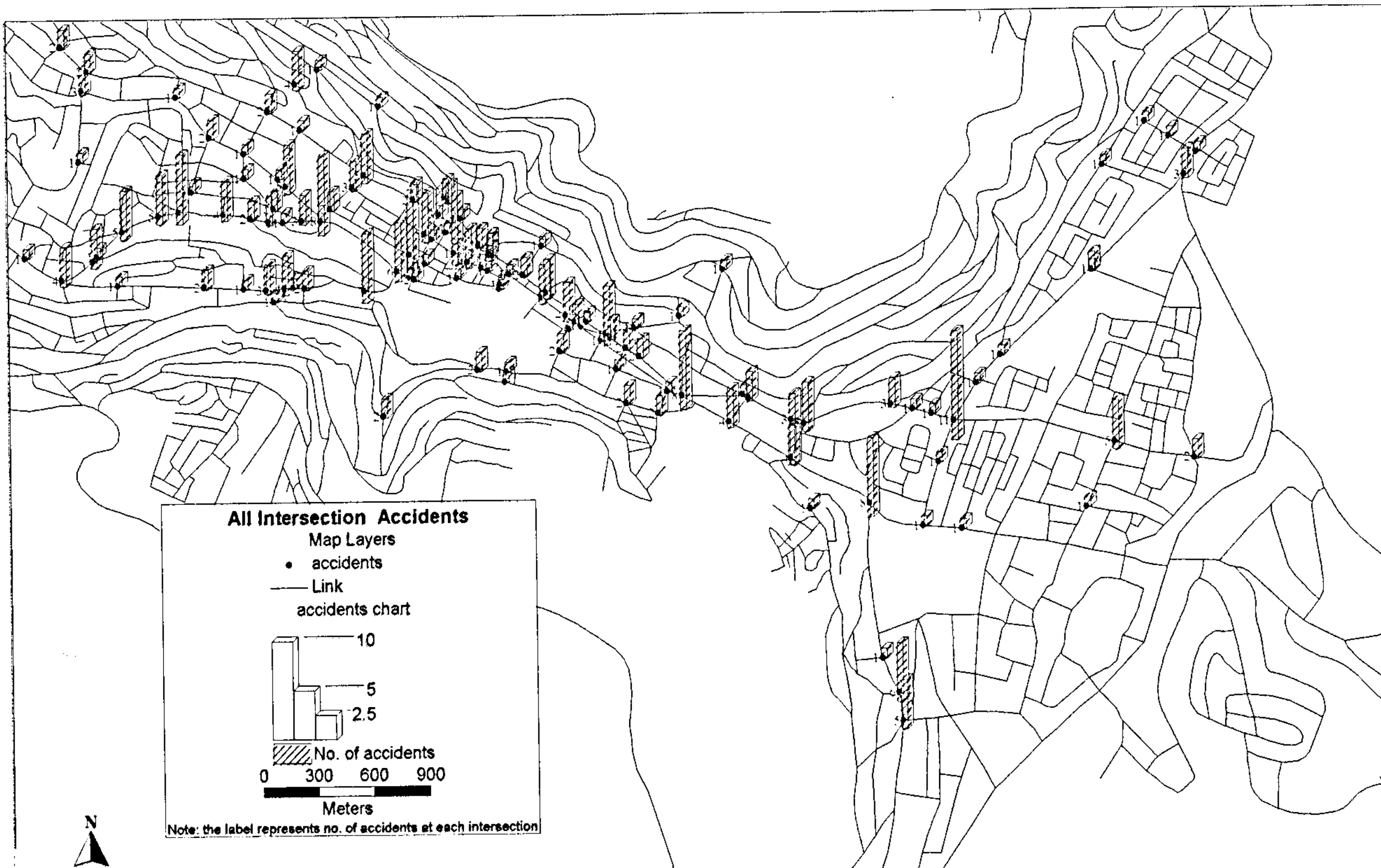


Table 5.15: Intersection Accidents Classified by Type of Accident, 1997-1998

Type of Accident	Total of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
Pedestrian-related	92	28.57	103	18.90
Right-angle	49	15.22	109	20.00
Rear-end	44	13.66	85	15.60
Left-turn	34	10.56	93	17.06
Bicycle-related	16	4.97	16	2.94
Head-on	11	3.42	33	6.06
Fixed object	10	3.11	21	3.85
Parked vehicles	3	0.93	6	1.10
Sideswipes	2	0.62	3	0.55
Run-off road	1	0.31	2	0.37
Not specified	60	18.63	74	13.58
Total accidents	**322**	**100.00**	**545**	**100.00**

Table 5.16: Intersection Accidents Classified by Severity of Accident, 1997-1998

Accident Severity	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
Slight	276	85.71	471	86.42
Serious	44	13.66	70	12.84
Fatal	2	0.63	4	0.74
Total	**322**	**100.00**	**545**	**100.00**

Table 5.17: Intersection Accidents Cross-Classified by Type of Accident and Accident Severity, 1997-1998

Accident severity	Type of Accident	Total Number of Accidents	Percentage of Accidents	Percentage of Casualties
Slight	Rear-end	43	13.35	97.73
Serious	Rear-end	1	0.31	2.27
Fatal	Rear-end	0	0.0	0.0
Slight	Right angle	48	14.91	97.96
Serious	Right angle	1	0.31	2.04
Fatal	Right angle	0	0.0	0.00
Slight	Left-turn	29	9.01	85.29
Serious	Left-turn	4	1.24	11.76
Fatal	Left-turn	1	0.31	2.94
Slight	Fixed object	5	1.55	50.00
Serious	Fixed object	5	1.55	50.00
Fatal	Fixed object	0	0.0	0.00
Slight	Sideswipes	1	0.31	50.00
Serious	Sideswipes	1	0.31	50.00
Fatal	Sideswipes	0	0.0	0.00
Slight	Pedestrian-related	64	19.88	69.57
Serious	Pedestrian-related	27	8.39	29.35
Fatal	Pedestrian-related	1	0.31	1.09
Slight	Run-off road	1	0.31	100.00
Serious	Run-off road	0	0.00	0.00
Fatal	Run-off road	0	0.00	0.00
Slight	Head-on	11	3.42	100.00
Serious	Head-on	0	0.00	0.00
Fatal	Head-on	0	0.00	0.00
Slight	Parked vehicles	3	0.93	100.00
Serious	Parked vehicles	0	0.00	0.00
Fatal	Parked vehicles	0	0.00	0.00
Slight	Bicycle-related	13	4.04	81.25
Serious	Bicycle-related	3	0.93	18.75
Fatal	Bicycle-related	0	0.0	0.00
Slight	Not specified	58	18.01	96.67
Serious	Not specified	2	0.62	3.33
Fatal	Not specified	0	0.0	0.00
	Total accidents	**322**	**100.00**	

A cross-classification of type of accidents and severity showed that serious accidents were most likely pedestrian accidents. This study showed that rear-end, right angle, and head-on accidents were likely to be slight accidents as shown in Table 5.17 and Figure 5.7.

5.2.1.3 Link (Mid-Block) Accidents

There were 493 of link accidents recorded forming 60.49 percent of total injury accidents. The exact locations of 37 accidents forming (7.5%) of all link accidents were not known, because most of them lie in the areas of refugee camps, the old city, buses stations, and squares where the roadway network in these areas were not taken into consideration while digitizing the base-map used in this study. The remaining 456 accidents occurred on 196 links in the study area giving an average (based on links which accidents occurred at) of 2.32 accidents per link.

Classification of these accidents according to type of accident is illustrated in Table 5.18. This indicates that pedestrian accidents accounted for 54.77 percent of link accidents, followed by the rear-end accidents (13.79%). The high percentage of pedestrian accidents on links can be attributed to the lack of proper pedestrian facilities (especially crosswalks) at mid-blocks.

Figure 5.7: Distribution of Type of Intersection Injury Accidents by Accident Severity, 1997-1998

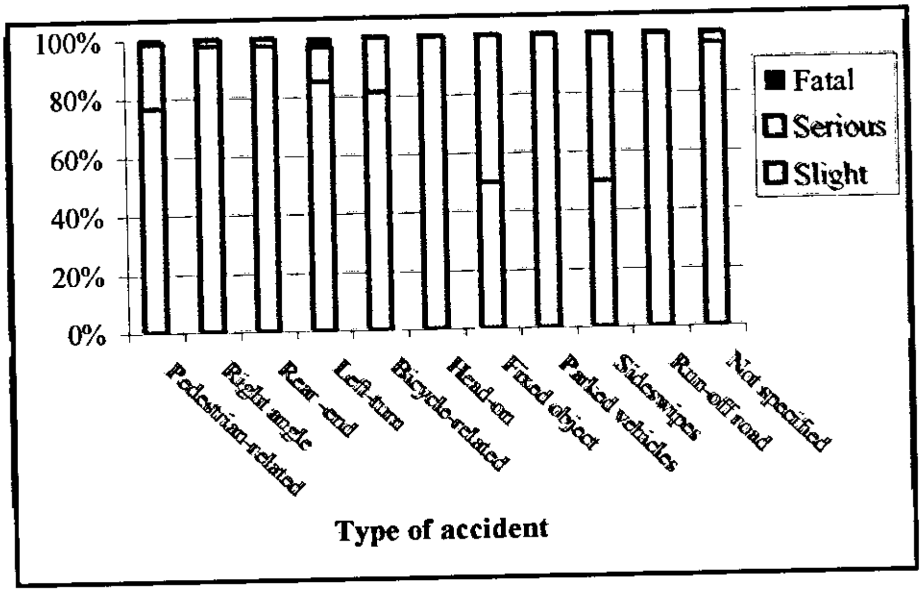


Table 5.18: Link Injury Accidents Classified by Type of Accident, 1997-1998

Type of Accident	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
Pedestrian-related	270	54.77	301	41.92
Rear-end	68	13.79	133	18.52
Head-on	18	3.65	43	5.99
Fixed object	14	2.84	36	5.01
Right angle	13	2.64	36	5.01
Left-turn	12	2.43	34	4.74
Bicycle-related	10	2.03	10	1.39
Parked vehicles	7	1.42	10	1.39
Run-off road	4	0.81	10	1.39
Sideswipes	1	0.2	5	0.70
Not specified	76	15.42	100	13.93
Total accidents	**493**	**100.00**	**718**	**100.00**

Figure 5.8 shows that the highest rate of casualties per accident by type of accident was for sideswipe accidents (5 casualties per accident), followed by left-turn and right-angle accidents (2.8 casualties per accident). The lowest rate was for bicycle accidents (1casualty per accident). But, it should be noted that there was only one recorded sideswipe accident, which means that this may be misguiding.

The results shown in Table 5.19 indicate that 78.3 percent of link accidents involved slight injuries, 20.89 percent involved serious injuries, and 0.81percent were fatal.

The monthly link accidents variation ranged from as low as 5.88 percent in October up to 11.76 percent in January, as presented in Table 5.20. On the whole, summer months recorded more accidents than winter months, except for January, probably due to the fact that there are more activities in Nablus City during the summer months than winter months.

From the daily distribution of link accidents, Friday recorded the lowest number of accidents (8.92%) while Saturday recorded the highest (20.69%) as shown in Table 5.21. The same table; however, indicates that the rate of casualties per accident on Friday is higher than any other day.

Figure 5.8: Rate of Casualties by Type of Link Accident, 1997-1998

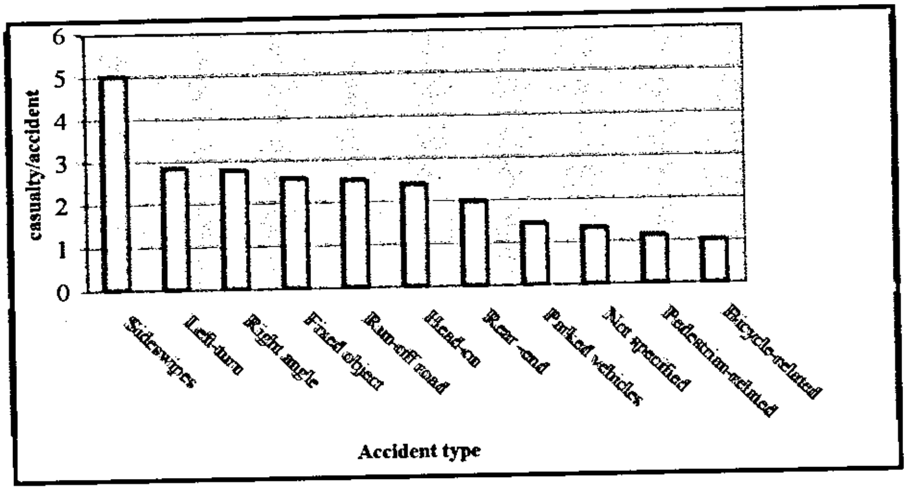


Table 5.19: Link Injury Accidents Classified by Severity of Accident, 1997-1998

Accident Severity	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
Slight	386	78.3	589	82.04
Serious	103	20.89	120	16.71
Fatal	4	0.81	9	1.25
Total	**493**	**100.00**	**718**	**100.0**

Figure 5.9: Link Accidents Classified by Severity of Accident, 1997-1998

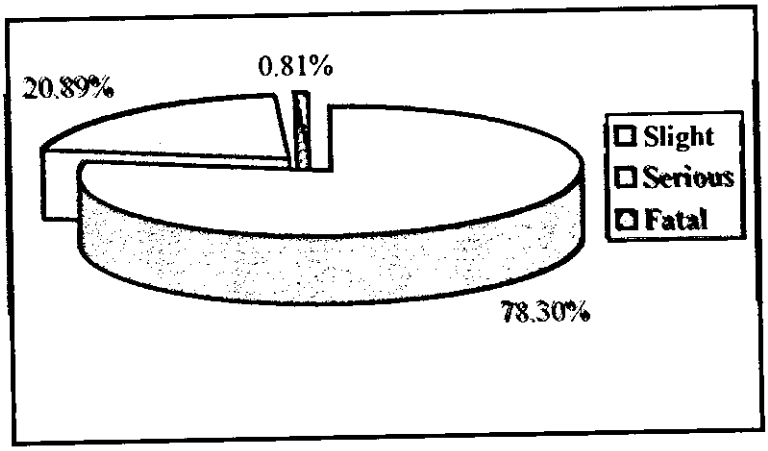


Table 5.20: Link Accidents Classified by Month, 1997-1998

Month	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
January	58	11.76	97	13.51
February	31	6.29	48	6.69
March	34	6.90	52	7.24
April	43	8.72	62	8.64
May	52	10.55	73	10.17
June	41	8.32	70	9.75
July	51	10.34	70	7.75
August	46	9.33	55	7.66
September	42	8.52	63	8.77
October	29	5.88	44	6.13
November	35	7.10	45	6.27
December	31	6.29	39	5.43
Total	**493**	**100.00**	**718**	**100.0**

Table 5.21: Link Accidents Classified by Day of Week, 1997-1998

Day	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
Saturday	102	20.69	152	21.17
Sunday	63	12.78	75	10.45
Monday	63	12.78	78	10.86
Tuesday	79	16.02	133	18.52
Wednesday	62	12.58	88	12.26
Thursday	80	16.23	109	15.18
Friday	44	8.92	83	11.56
Total	**493**	**100.00**	**718**	**100.0**

The hourly distribution of link accidents by frequency showed two peak periods; between 10:00 AM and 2:00 PM and between 4:00 PM and 6:00 PM as illustrated in Table 5.22. These periods coincide with the morning business hours and evening peak hours.

5.2.1.4 Pedestrian Accidents

There were 389 pedestrian accidents recorded during the study period in Nablus City. The locations of these accidents are shown in Figure 5.10.

These accidents are analyzed by year, month, day of week and time of day. The major findings as indicated in Tables 5.23 to 5.27 are as follows:

Pedestrian accidents formed approximately half of all accidents in the study area (47.73%). Table 5.23 shows that 74.04 percent of pedestrian accidents occurred on links, while only 25.96 percent of these accidents occurred at intersections.

As illustrated in Table 5.24, the total number of pedestrian accidents in 1998 was 162; a 28.6 percent less than 1997 (227 accidents).

Table 5.25 shows that the monthly pedestrian variation ranged from as low as 5.91 percent in December up to 11.06 percent in July. In general, there were more pedestrian accidents during the summer season. This may be attributed to

Table 5.22: Link Accidents Classified by Time of Day, 1997-1998

Time	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
2:00 AM	2	0.41	4	0.56
3:00	2	0.41	6	0.84
5:00	2	0.41	4	0.56
6:00	2	0.41	2	0.28
7:00	17	3.45	27	3.76
8:00	26	5.27	36	5.01
9:00	29	5.88	56	7.80
10:00	43	8.72	65	9.05
11:00	32	6.49	49	6.82
12:00 PM	46	9.33	55	7.66
01:00	35	7.10	45	6.27
02:00	35	7.10	43	5.99
03:00	25	5.07	29	4.04
04:00	45	9.13	51	7.10
05:00	36	7.30	50	6.96
06:00	35	7.10	53.00	7.38
07:00	24	4.87	40.00	5.57
08:00	26	5.27	48.00	6.69
09:00	11	2.23	20.00	2.79
10:00	8	1.62	17.00	2.37
11:00	4	0.81	7.00	0.97
Not specified	8	1.62	11.00	1.53
Total	**493**	**100.00**	**718**	**100.0**

Table 5.23: Pedestrian Accidents by Type of Location, 1997-1998

Type of location	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
Intersections	101	25.96	106	25.48
Links	288	74.04	310	74.52
Total	**389**	**100.00**	**707**	**100.0**

Table 5.24: Pedestrian Accidents by Year, 1997-1998

Year	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
1997	227	58.35	106	25.48
1998	162	41.65	310	74.52
Total	**389**	**100.00**	**707**	**100.0**

Table 5.25: Pedestrian Accidents Classified by Month, 1997-1998

Month	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
January	31	7.97	32	7.69
February	32	8.23	35	8.41
March	29	7.46	32	7.69
April	31	7.97	32	7.69
May	39	10.03	39	9.38
June	29	7.46	30	7.21
July	43	11.05	46	11.06
August	39	10.03	41	9.86
September	35	9.00	43	10.34
October	28	7.20	31	7.45
November	30	7.71	32	7.69
December	23	5.91	23	5.53
Total	**389**	**100.00**	**416**	**100.00**

the large exposure of pedestrians, during summer due to the good weather and due to school holiday season.

Classification by day of week as presented in Table 5.26 indicated that Friday, recorded the least number of pedestrian accidents (9.77%). On the contrary, Saturday recorded the highest number of accidents (19.79%). This directly related to traffic volume. Friday is the least traveled day with limited activity, and Saturday is the most traveled with high activity.

The hourly distribution of the pedestrian accidents showed that the 4:00-5:00 PM hour had the highest percentage of pedestrian accidents; next was 12:00-1:00 PM, followed by 10:00-11:00 AM.

5.2.1.5 Children accidents

There were 353 children accidents, forming 43.3 percent of total injury accidents recorded in the study period. Children were defined as the group of population with ages up to 18 years old. Children with ages between 3 and 7 years were found to be the most affected as they accounted for 45.9 percent of all the children accidents. Children of 18 years old alone accounted for 6.8 percent of the accidents as presented in Table 5.28.

Table 5.26: Pedestrian Accidents Classified by Day of Week, 1997-1998

Day	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
Saturday	77	19.79	81	19.47
Sunday	51	13.11	54	12.98
Monday	56	14.40	57	13.70
Tuesday	58	14.91	63	15.14
Wednesday	48	12.34	50	12.02
Thursday	61	15.68	65	15.63
Friday	38	9.77	46	11.06
Total	**389**	**100.00**	**416**	**100.00**

Table 5.27: Pedestrian Accidents Classified by Time of Day, 1997-1998

Time	Total Number of Accidents	Percentage of Accidents	Number of Casualties	Percentage of Casualties
6:00	2	0.51	14	3.37
7:00	13	3.34	21	5.05
8:00	20	5.14	15	3.61
9:00	15	3.86	35	8.41
10:00	33	8.48	20	4.81
11:00	20	5.14	44	10.58
12:00 PM	44	11.31	33	7.93
01:00	30	7.71	29	6.97
02:00	28	7.20	24	5.77
03:00	24	6.17	46	11.06
04:00	45	11.57	29	6.97
05:00	27	6.94	30	7.21
06:00	28	7.20	23	5.53
07:00	20	5.14	27	6.49
08:00	22	5.66	12	2.88
09:00	7	1.80	4	0.96
10:00	4	1.03	1	0.24
11:00	1	0.26	0	0.00
Not specified	6	1.54	7	1.68
Total	**389**	**100.00**	**416**	**100.00**

Table 5.28: Children Accidents Classified by Age (1997-1998)

Age (Years)	Total number of Accidents	Percentage of Accidents
1	13	3.68
2	18	5.10
3	34	9.63
4	38	10.76
5	27	7.65
6	32	9.07
7	31	8.78
8	16	4.53
9	18	5.10
10	12	3.40
11	13	3.68
12	15	4.25
13	15	4.25
14	10	2.83
15	13	3.68
16	12	3.40
17	12	3.40
18	24	6.80
Total	**353**	**100.00**

The monthly distribution of children accidents as illustrated in Table 5.29 showed that May was the month with the high percentage of children accidents (11.3%) and December had the least (5.38%).

The distribution of children accidents by day of week as presented in Table 5.30, showed that Saturday recorded the highest percentage (18.13%) followed by Thursday (16.15%), while Wednesday recorded the least percentage (11.9%).

The results shown in Table 5.31 indicate that the children accident occurrence spread throughout the day. 12.00-1:00 PM recorded the highest percentage (11.61%). This may be attributed to the fact that most children leave schools between 12:00 and 1:00 PM.

The distribution of children accidents by type of accidents indicated that almost 68 percent of these accidents are pedestrian related. Bicycle accidents alone accounted for one fifth of child accidents as shown in Table 5.32.

5.2.2 Special Request Reports

Often various organizations request specific reports on accidents on an issue of particular concern. For example, a request for information on pedestrian accidents occurring within a specific time period at a particular location, or people frequently complain about increases in accident occurrence of poor safety

Table 5.29: Monthly Variations of Children Accidents, 1997-1998

Month	Total number of accidents	Percentage of accidents
January	28	7.93
February	28	7.93
March	21	5.95
April	26	7.37
May	40	11.33
June	31	8.78
July	39	11.05
August	36	10.20
September	30	8.50
October	26	7.37
November	29	8.22
December	19	5.38
Total	353	100.00

Table 5.30: Children Accidents Classified by Day of Week, 1997-1998

Day	Total number of accidents	Percentage of accidents
Saturday	64	18.13
Sunday	45	12.75
Monday	48	13.60
Tuesday	52	14.73
Wednesday	42	11.90
Thursday	57	16.15
Friday	45	12.75
Total	353	100.00

Table 5.31: Children Accidents Classified by Time of Day, 1997-1998

Time	Total number of accidents	Percentage of accidents
12:00 AM	1	0.28
2:00	2	0.57
7:00	14	3.97
8:00	15	4.25
9:00	17	4.82
10:00	22	6.23
11:00	14	3.97
12:00 PM	41	11.61
01:00	26	7.37
02:00	20	5.67
03:00	14	3.97
04:00	35	9.92
05:00	34	9.63
06:00	29	8.22
07:00	19	5.38
08:00	21	5.95
09:00	13	3.68
10:00	7	1.98
11:00	3	0.85
Not specified	6	1.70
Total	353	100.00

Table 5.32: Children Accident Variation by Type of Accidents, 1997-1998

Type of Accident	Total number of accidents	Percentage of accidents
Rear-end	21	5.95
Right angle	14	3.97
Left-turn	13	3.68
Fixed object	8	2.27
Sideswipes	1	0.28
Pedestrian-related	239	67.71
Run-off road	3	0.85
Head-on	8	2.27
Bicycle-related	19	5.38
Not specified	27	7.65
Total accidents	353	100.00

standard in their localities. People may complain that there is an increase in children accidents around a certain school. To respond appropriately to such complaints requires accurate, reliable, and easily acquired information of all accidents of the locality in question.

The GIS accident database will help in the quick production of these reports in map and tabular forms.

In this study, three examples of special request reports are presented in sections 5.4.1 through 5.4.3.

5.3 Identifying Hazardous Locations

The theory of accident proneness has led to the belief that accidents are confined to accident-prone areas. Thus road accidents do not occur evenly along the road network. Some sections and locations experience more accidents than expected. Hazardous locations are defined as any location (section or intersection) that exhibits a higher potential for crashes than an established "norm". These locations are termed accident black spots. Considerable evidence suggests that the identification and remedial treatment of these sites can prove extremely cost effective in terms of accident reduction. However, the black-spot approach to accident reduction is only one of the alternative strategies in the road safety field.

5.3.1 Presentation and Approach Used

The geographic accident database is structured in such a way that the total number of accidents and accident rates on the links, at intersections, on a whole street length (route), or in an area are known or can be determined. Hence the system can be used to select all locations considered to be hazardous based on a set of selection criteria. In this study the set selection criteria were based on either the total number of accidents recorded on the accident rate, or on both. Other variables like minimum thresholds and standard deviations were also used for selection. The selected hazardous locations were presented in tabular and map forms. The selected hazardous locations can be highlighted on a map using different symbols, colors, line type and line width based on feature type or priority ranking. Figure 5.11 shows a plot of hazardous locations for all accidents based on a selection criteria of more than two accidents and an accident rate greater than 1.0 accident per million vehicle kilometers for links; and more than 4 accidents and accident rate of 0.15 accidents per million entry vehicles for intersections. According to this method, 36 links, and 13 intersection were considered to be hazardous in Nablus City during the study period.

Tables 5.33 and 5.34 represent the most hazardous intersections ranked in descending order of accident frequencies and rates, respectively, and groups based on the standard deviation calculated from the accident frequencies and rates, respectively. These tables, in addition to Figures 5.12 and 5.13, can also be used to

Figure 5.11: Hazardous Locations Based on Accidents, 1997-1998

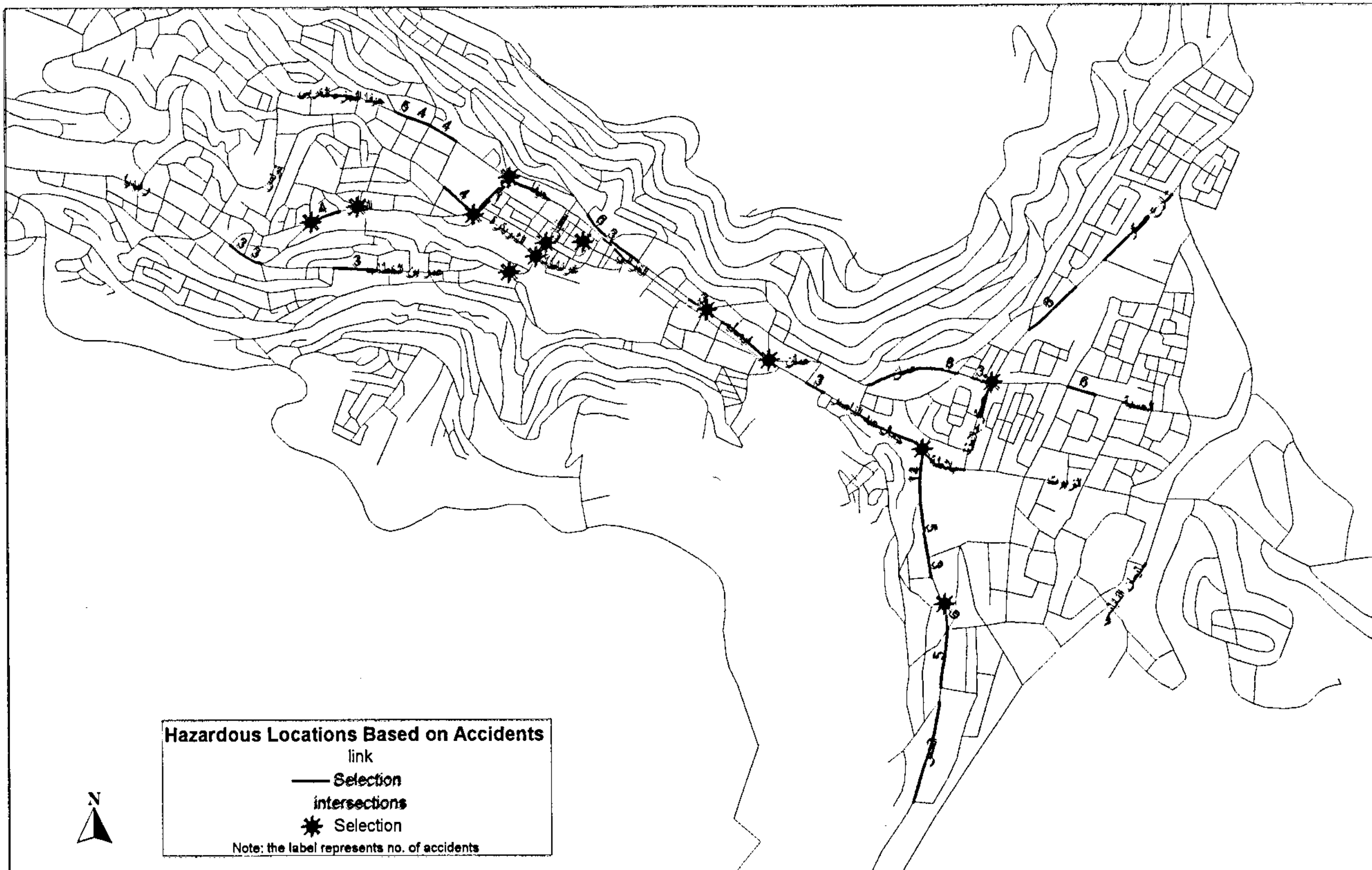


Table 5.33: Accident Statistics for All Intersections, 1997-1998

Intersection ID	Name	Rank	No. of Accidents	Group*
695	Al-Hesba	1	11	4
608	Abd-Al-Naser/Al-Quds	2	8	4
528	Al-Ashghal	2	8	4
444	Al-Adel	2	8	4
426	Palestine/Sufian	2	8	4
335	Al-Montazah Circle	2	8	4
324	Western Cemetery	3	7	4
266	Al-Kefair/Al-Mraj	3	7	4
586	Al-Hodhod Company at Al-Quds Street	4	6	4
118	Al-Haj Ma'zooz Mosque	4	6	4
339	Al-Fatemyia	4	6	4
962	Ektaba Company/Al-hesba	5	5	4
4843	Amman/Al-Matorat	5	5	4
581	Southern Intersection of Balata Camp/Al-Quds	5	5	4
434	Sufian street	5	5	4
367	Agnadeen/Haifa	5	5	4
334	Municipality Playground	5	5	4
262	Rafidia/Al-Mraj (Haroush Building)	5	5	4
184	Rafidia Hospital	5	5	4

* Mean accident frequency (χ) = 2.55 accidents
Standard Deviation (σ) = 2.05 accidents
Group 4: Frequency $\geq \chi + \sigma$

Table 5.34: Intersection Accident Statistics Based on Accident Rate, 1997-1998

Intersection ID	Name	No. of Accidents	Rate Acc./10^6-veh.	Group*
444	Al-Adel	8	0.927	4
695	Al-Hesba	11	0.791	4
586	Al-Hodhod Company at Al-Quds Street	6	0.679	4
426	Palestine/Sufian	8	0.679	4
266	Al-Kefair/Al-Mraj	7	0.581	4
335	Al-Montazah Circle	8	0.563	3
324	Western Cemetery	7	0.505	3
608	Abd-Al-Naser/Al-Quds	8	0.480	3
184	Rafidia Hosptial	5	0.408	3
339	Al-Fatemyia	6	0.368	3
161	Omar Ibn Al-Khtaab/Rafid	4	0.321	2
367	Haifa/Prince Mohammad	5	0.298	2
528	Al-Ashghal	8	0.256	2
415	Al-Anbeya'	4	0.244	2
118	Al-Haj Ma'zooz Mosque	6	0.205	2
92	Haifa-Jafa	2	0.205	2
637	Abd-Al-Naser/Health Directorate	4	0.163	2
338	Ahmad Al-Shaka'/Prince Mohammad	2	0.157	2
451	Al-Dowar/Old Balata Taxi Station	2	0.132	2
484	Al-Haj Nemer Mosque	2	0.131	2
2070	Fisal/Al-Rahebat	2	0.129	2
640	Othman Mosque	3	0.118	2
622	Enterance of Balata Camp	1	0.116	2
24	Al-Motanabi/Haifa	3	0.111	2
23	Faisal/Al-Hejaz	2	0.101	2
4846	Heteen Faisal	1	0.062	1
425	Ghernata/Al-Dowar	1	0.059	1

*Mean accident rate (χ) = 0.326 Acc./10^6-veh.
Standard Deviation (σ) = 0.244 Acc./10^6-veh
Group 1: $0.0 < \text{accident rate} \leq \chi - \sigma$
Group 2: $\chi - \sigma < \text{accident rate} \leq \chi$
Group 3: $\chi < \text{accident rate} \leq \chi + \sigma$
Group 4: $\text{accident rate} \geq \chi + \sigma$

Figure 5.12: Plot of Hazardous Intersections Based on Accidents Frequencies, 1997-1998

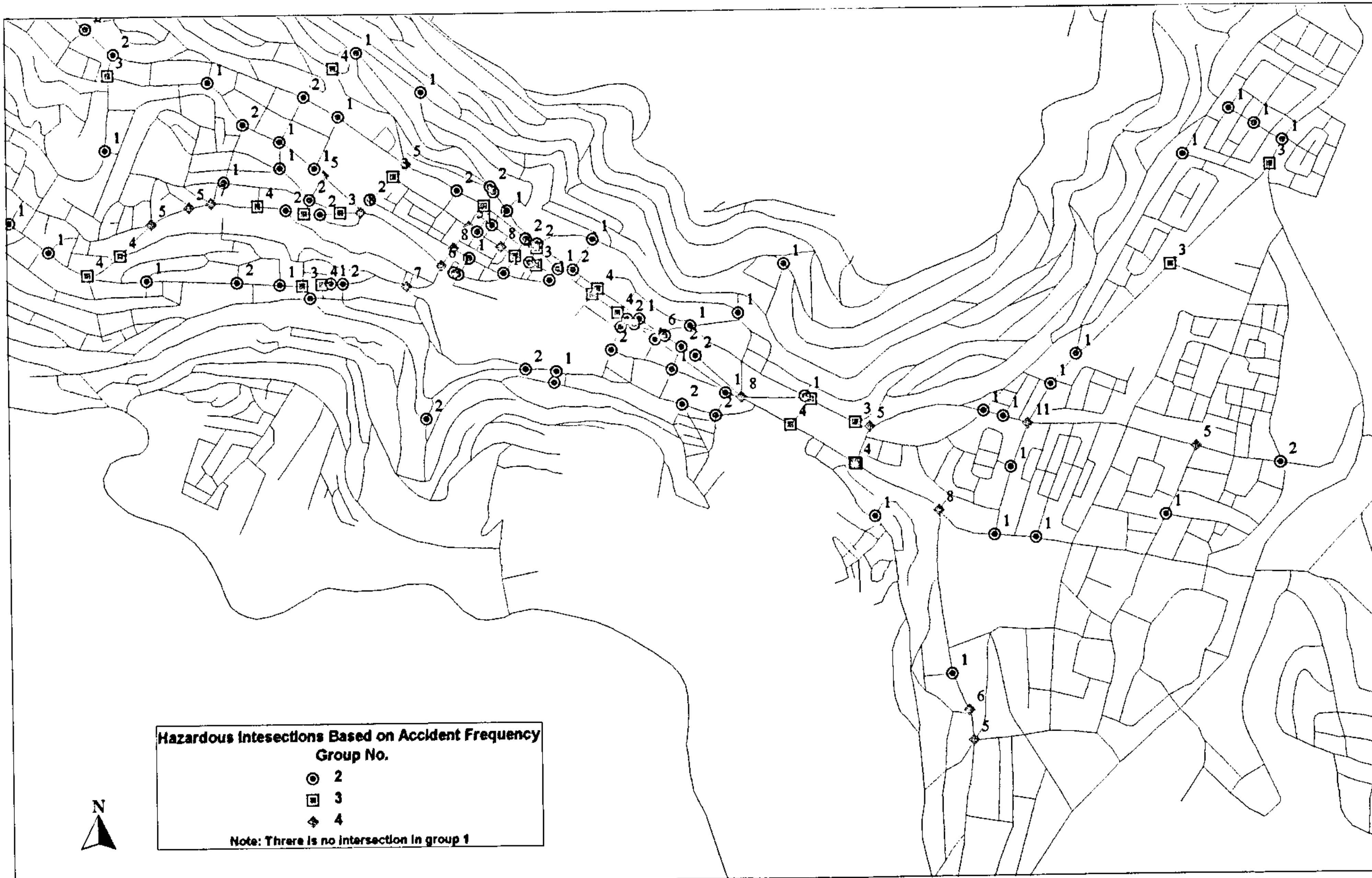
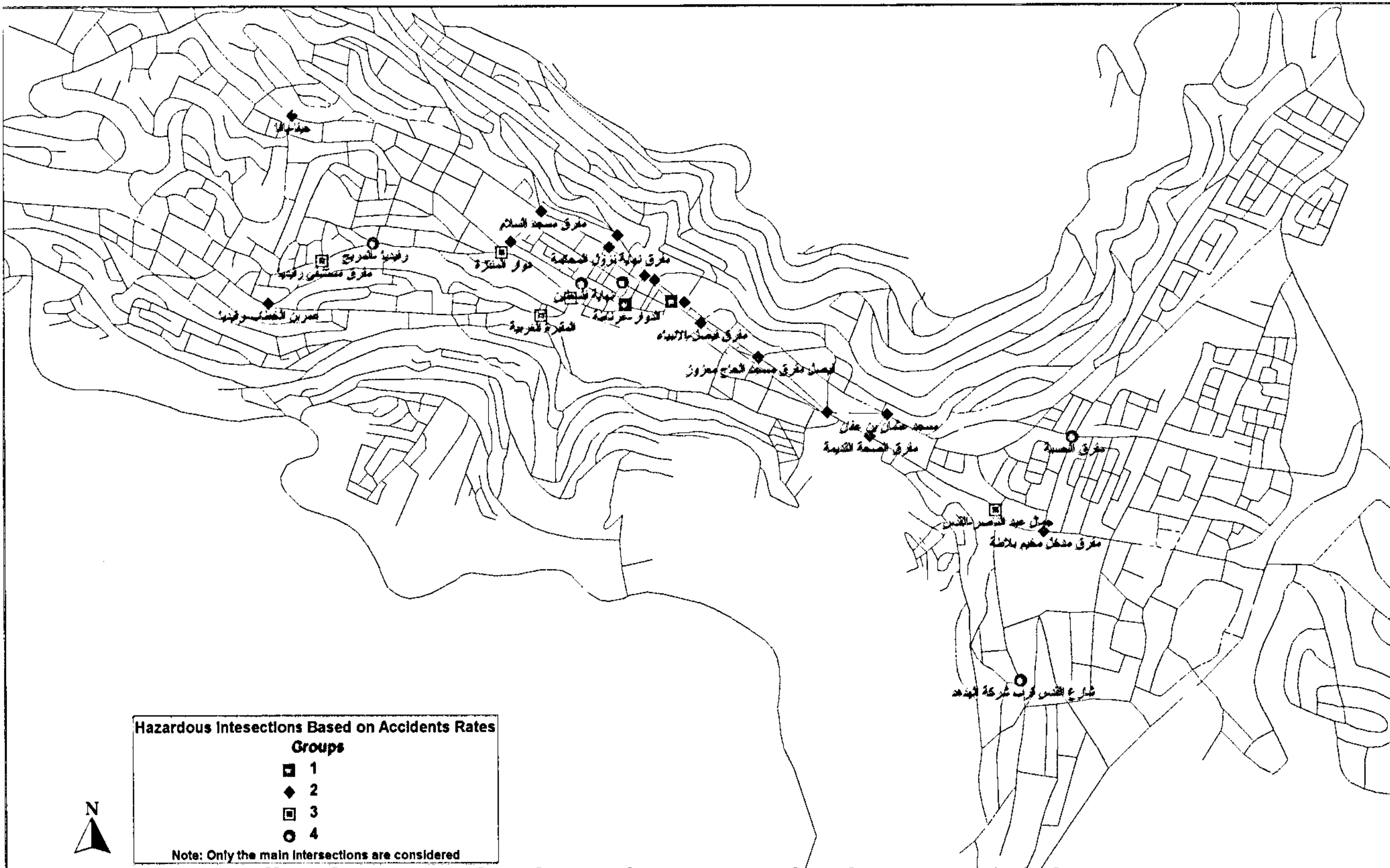


Figure 5.13: Plot of Hazardous Intersections Based on Accidents Rates, 1997-1998



identify hazardous intersections based on the frequencies and rates methods. For more details see Appendix E, which is a report on the accident statistic for all accidents ranked in descending order of frequencies and rates, respectively.

Based on the frequency method, the most hazardous intersection was Al-Hesba intersection which recorded 11 injury accidents during the study period. The second hazardous intersections were: Al-Adel; Jamal-Abed Al-Naser/Al-Quds; Al-Ashghal Circle, Palestine/Sufian, and Al-Montazh intersections. Each one of these intersections recorded 8 injury accidents during the study period. Whereas, based on the accident rate method, Al-Adel street was identified as the most hazardous intersection; while the second was Al-Hesba intersection, and the third was the intersection near Al-Hodhod Company on Al-Quds street.

It should be noticed that the main reason of grouping all intersection accidents in Table 5.33 depending on only the frequency, was the lack of traffic volume data on each intersection. Table 5.34 comprises the main intersections in Nablus City, where traffic volume data was available. This enables the comparison to be based on accidents rate and frequency, and not only on accidents frequency alone.

Table 5.35 presents accident statistics on the main streets ranked in descending order of accident rates and groups based on the standard deviation calculated from the accident rates and frequencies, respectively.

Table 5.35: Street Accident Statistics, 1997-1998

Street ID	Name	Accident Rates: Rate Acc/10^6-vehs	Accident Rates: Group	Accident Frequencies: No. of Accidents	Accident Frequencies: Group
2146	Sufian	10.24	4	11	2
5832	Prince Mohammed	3.68	4	10	2
5812	Al-Kefiar	3.22	3	50	4
5336	Askar-Balata	2.82	3	6	2
5567	Amman	2.33	3	35	4
3922	Omar In Al-Khatab	2.11	3	28	3
5798	Ghernata	1.89	3	5	2
2601	Faisal (east to west)	1.86	3	27	3
2590	Faisal (Both directions)	1.79	3	22	3
5422	Al-Quds	1.78	3	62	4
5817	Balata	1.77	3	4	2
356	Al-Zoyout	1.75	3	8	2
5317	Haifa	1.69	2	8	2
5835	Faisal (west to east)	1.68	2	27	3
5312	Jamal Abed Al-Naser	1.58	2	22	3
5164	Al-Hesba	1.48	2	18	3
5716	Haifa (Western Part)	1.41	2	31	4
4249	Tunis	1.19	2	5	2
5804	Askar	1.15	2	25	3
2932	Ein Defna	0.87	2	2	2
29	Ahmaad Al-Shaka'h	0.81	2	2	2
5821	Governorate Street	0.81	2	3	2
5833	Rafidia	0.70	2	11	2
5747	Palestine	0.44	2	1	2
5819	Amman (After Othman Mosque)	0.35	2	2	2
5570	Soliman Al Nablusi	0.00	1	0	1
5557	Al-Motanabi	0.00	1	0	1
5387	Sufian (After Palestine Intersection)	0.00	1	0	1
2522	Al-Shwitreh	0.00	1	0	1

*Accident Rates

Mean accident rate (χ) = 1.70 Acc./10^6-veh

Standard Deviation (σ) = 1.89 Acc./10^6-veh

Group 1: 0.0 < accident rate $\leq \chi - \sigma$

Group 2: $\chi - \sigma <$ accident rate $\leq \chi$

Group 3: χ < accident rate $\leq \chi + \sigma$

Group 4: accident rate $\geq \chi + \sigma$

**Accident Frequencies

Mean Frequency (χ) = 14.65 accidents

Standard Deviation (σ) = 15.87 accidents

Group 1: 0.0 < Frequency $\leq \chi - \sigma$

Group 2: $\chi - \sigma <$ Frequency $\leq \chi$

Group 3: χ < Frequency $\leq \chi + \sigma$

Group 4: Frequency $\geq \chi + \sigma$

The results in Table 5.35 and Figures 5.14 and 5.15 show that, based on the accident rate method, Sufian Street was the most hazardous street, next was Prince Mohammed Street, and the third was Al-Kefiar Street. Whereas, based on the frequency method, Al-Quds Street was the most hazardous street, the second was Al-Kefiar, and the third was Amman Street.

The results mentioned above highlight the different results obtained using various methods.

Figure 5.16 shows a plot of identified hazardous locations for pedestrian accidents only. These locations correspond to those links with more than 60 percent of accidents occurring there being pedestrian accidents and recording more than three accidents and with more than 30 percent of accidents occurring on intersections and recording more than four accidents at each intersection. The above criteria were suggested based on the study performed in Haifa *(Peld and Hakkert, 1993).*

Shown in Figure 5.17 is a plot of identified hazardous locations for nighttime accidents only. These accidents included all accidents occurring at night depending on monthly average night defined as the average time between sunrise and sunset. The selection criteria here was based on locations having more than 30 percent of accidents recorded there occurring at night and registering more than three accidents for links and more than four accidents for intersections *(Peled and Hakkert, 1993).*

Figure 5.14: Plot of Hazardous Streets Based on Accidents Frequencies, 1997-1998

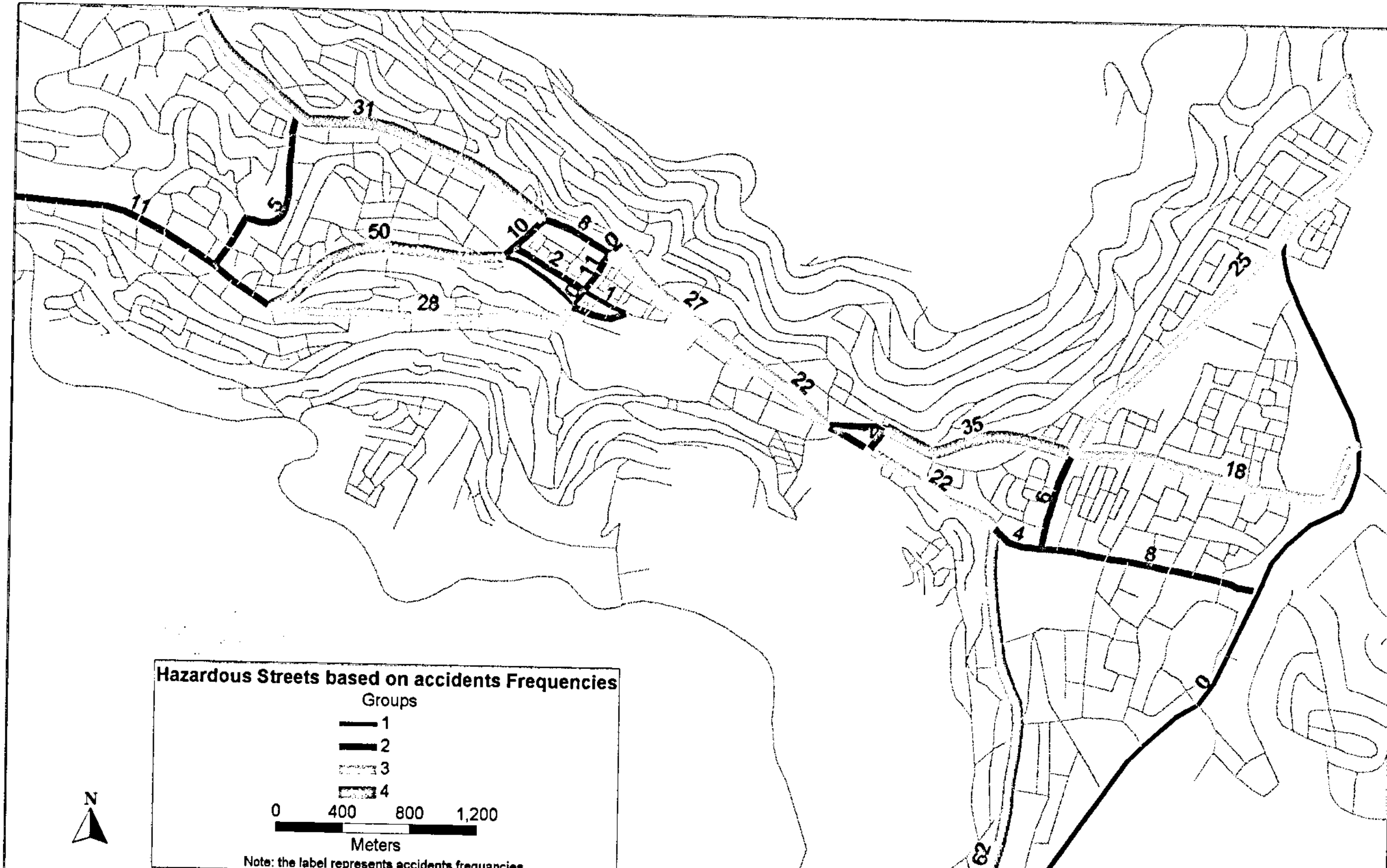


Figure 5.15: Plot of Hazardous Streets Based on Accidents Rates, 1997-1998

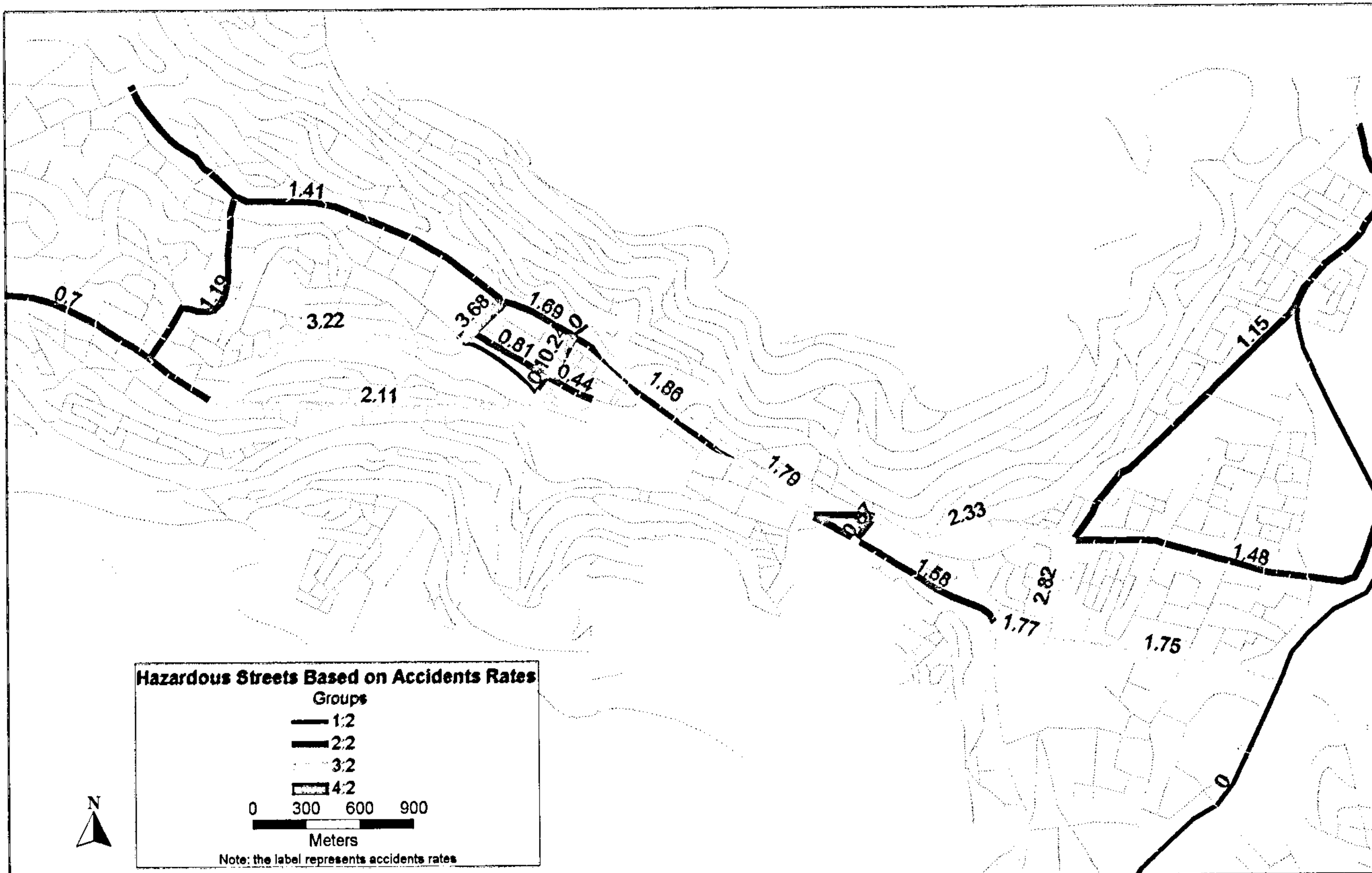
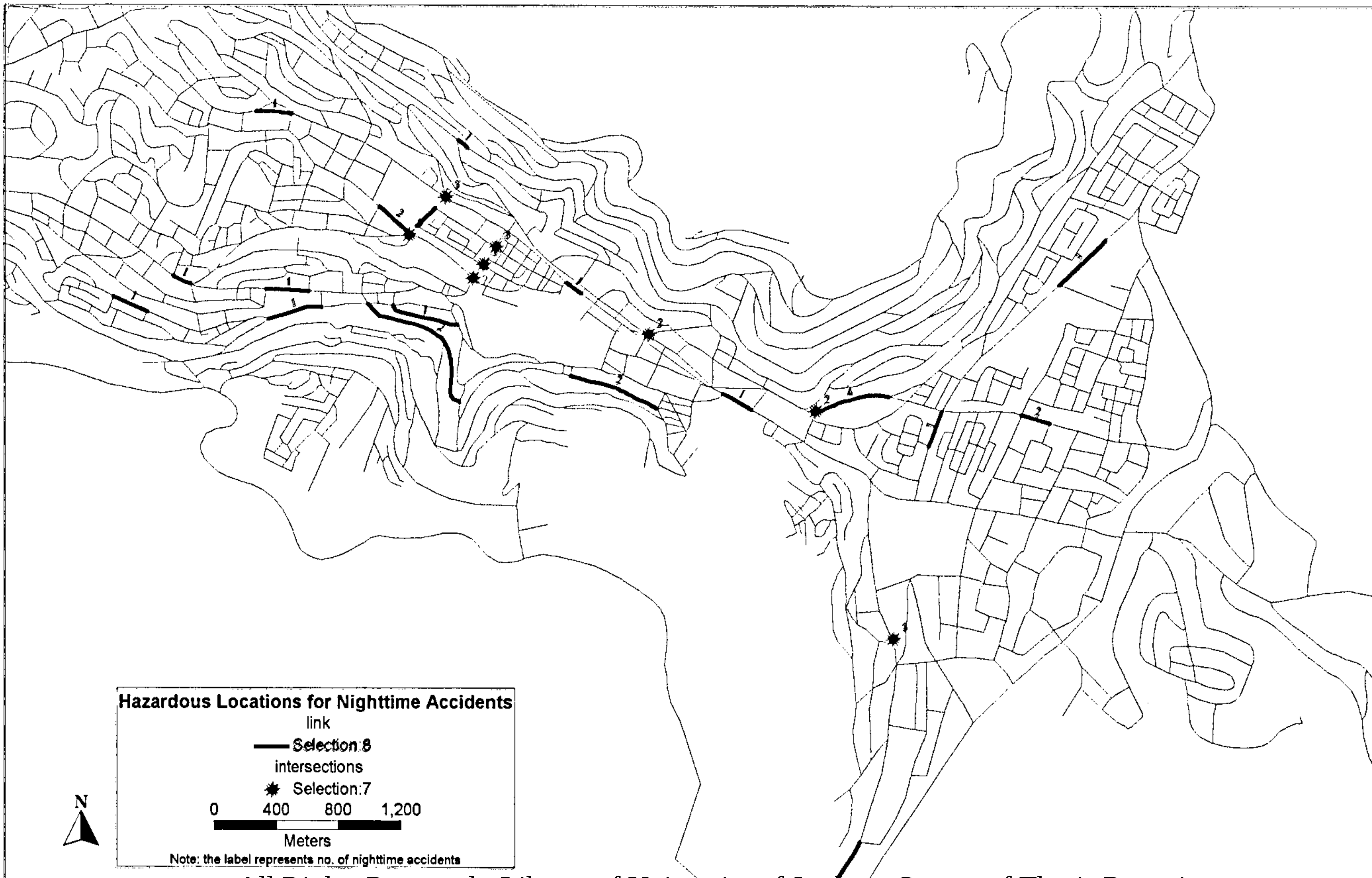


Figure 5.17: Plot of Hazardous Nighttime Accident Locations, 1997-1998



5.3.3 Analysis

After a particular location has been identified as hazardous, a detailed study was performed to identify the safety problem. Once the safety problem was identified, suitable safety-related countermeasures can be developed.

The first task in this sub-process is an in-depth study of the accident data obtained at the hazardous sites. These investigations involve detailed locational analysis by selected accident variables of all accidents at the site, a field survey to inspect the existing problems and the preparation of collision diagrams. Because road accidents occurred due to several factors, it is sometimes difficult to locate specific faults, which could be the cause of the accident. The above investigations will. however, provide a review of the range of engineering problems from which possible improvements can be formulated. Presented below in Tables 5.36 through 5.38 are the results of the locational analyses of the most three hazardous intersections (as presented in section 5.3.1).

Investigations of the results for Al-Hesba Intersection indicated that most of the accidents occurred when the weather was bright. This indicated that weather was not a contributing factor to the occurrence of accidents at this location, with the exception of the third and forth accidents where they occurred when it was raining. The results indicated further that failure to give right-of-way on stop sign accidents was predominate.

Table 6.36: Locational Analysis of Al-Hesba Intersection

Year	Day	Month	Time	Day/ Night	Weather	Surface Condition	Reason	Type	No. of Injuries
1997	Sunday	7	17.30	Day	Bright	Dry	Bicycle rider error	Bicycle-related	1
1997	Monday	11	16.00	Day	Bright	Dry	Failure to give right of way on stop sign	Right angle	2
1997	Saturday	12	21.30	Night	Raining	Wet	Failure to give right of way on stop sign	Right angle	3
1997	Wednesday	12	14.00	Day	Raining	Wet	Failure to give right of way on stop sign	Left-turn	1
1998	Saturday	2	17.00	Day	Bright	Dry	Failure to give right of way on stop sign	Left-turn	1
1998	Thursday	5	21.00	Night	Bright	Dry	Failure to give right of way on stop sign	Right angle	6
1998	Wednesday	6	9.00	Day	NA[1]	NA	Following too closely	Rear-end	1
1998	Thursday	6	17.00	Day	Bright	Dry	Illegal behavior and driving	Left-turn	1
1998	Monday	10	16.00	Day	Bright	Dry	Failure to give right of way on stop sign	Right angle	2
1998	Tuesday	10	NA	NA	Bright	NA	Failure to give right of way on stop sign	NA	1
1998	Wednesday	10	20.30	Night	Bright	Dry	Following too closely	Rear-end	1

[1] Not Available

Table 6.37: Locational Analysis of Palestine/Sufian Intersection

Year	Day	Month	Time	Day/ Night	Weather	Surface Condition	Reason	Type	No. of Injuries
1997	Tuesday	2	22.00	Day	Bright	Dry	Failure to give right of way on stop sign	Right angle	6
1997	Friday	2	13.00	Day	Bright	Dry	Failure to give right of way to pedestrian	Pedestrian-related	1
1997	Wednesday	6	9.30	Night	Bright	Dry	Illegal behavior and driving	Right angle	1
1997	Thursday	9	18.45	Day	Bright	Dry	Failure to give right of way to pedestrian	Pedestrian-related	1
1997	Friday	10	19.30	Day	Bright	Dry	Failure to give right of way on stop sign	Right angle	3
1997	Wednesday	12	6.55	Night	Raining	Wet	Failure to give right of way on stop sign	Right angle	3
1998	Saturday	1	16.30	Day	NA	NA	Failure to give right of way on stop sign	Pedestrian-related	1
1998	Tuesday	1	14.00	Day	Raining	Dry	Failure to give right of way on stop sign	Right angle	1

Table 6.38: Locational Analysis of Al-Adel Intersection

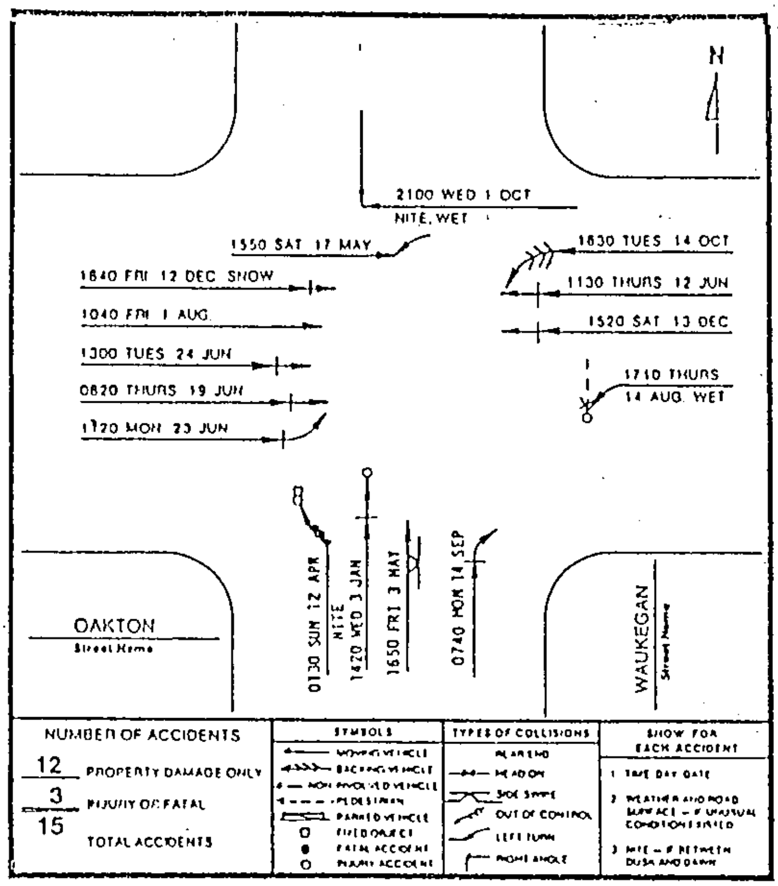
Year	Day	Month	Time	Day/ Night	Weather	Surface Condition.	Reason	Type	No. of Injuries
1997	Saturday	1	6.30	Day	Bright	Dry	Failure to give right of way on stop sign	Right angle	1
1997	Thursday	3	17.30	Day	Bright	Dry	Failure to give right of way on stop sign	Right angle	1
1997	Sunday	5	14.30	Day	Bright	Dry	Failure to give right of way on stop sign	Right angle	1
1997	Friday	6	12.30	Day	Bright	Dry	Failure to give right of way on stop sign	Right angle	1
1997	Wednesday	7	18.00	Day	NA	NA	Failure to give right of way to pedestrian	Pedestrian-related	1
1997	Thursday	12	19.30	Night	NA	NA	Failure to give right of way on stop sign	NA	1
1998	Tuesday	1	14.00	Day	NA	NA	Failure to give right of way to pedestrian	Pedestrian-related	1
1998	Sunday	5	9.30	Day	NA	NA	Failure to give right of way to pedestrian	Pedestrian-related	1

More details about the pattern of the accidents at these sites can be obtained by using collision diagrams. This is a diagram of each location showing the direction of movements of vehicles and people involved in each accident prior to and immediately after the collision. It deals with the reconstruction of each accident at the candidate locations. Shown in Figure 5.18 is an example of a collision diagram taken from *(Garber and Hoel, 1996)*. Close scrutiny of these diagrams supplemented by information from the field survey and the locational analysis will bring out any noticeable accident pattern and causal factors from which a known remedy can be formulated. The plotting of collision diagrams was not undertaken in the study due to lack of directional details of vehicles and people involved in some of accidents in the database. The usefulness of collision diagrams in accident studies should not be under-estimated. This database system is open and flexible, lending itself to the addition of more layers and variable items to any of the layers. It is suggested that information on the directional movements of vehicles and people involved in the accidents be obtained. Then, a way of incorporating it into the system can be sought to enable it to be used in plotting collision diagrams.

5.4 Data Integration

GIS makes it possible to link, or integrate information that is difficult to associate through any other means. Thus, GIS can use combinations of mapped variables to build and analyze new variables.

Figure 5.18: Accident Collision Diagram



Source: (Garber and Hoel, 1996)

By integrating road physical data, or data on the locations of some activity centers with the accident database, accidents of a particular type can be displayed, analyzed, and viewed in relation to the location of an activity center, or in relation to any selected road physical feature. The following examples illustrate some of the study capabilities in the field of data integration.

5.4.1 Injury Accidents by Road Classification

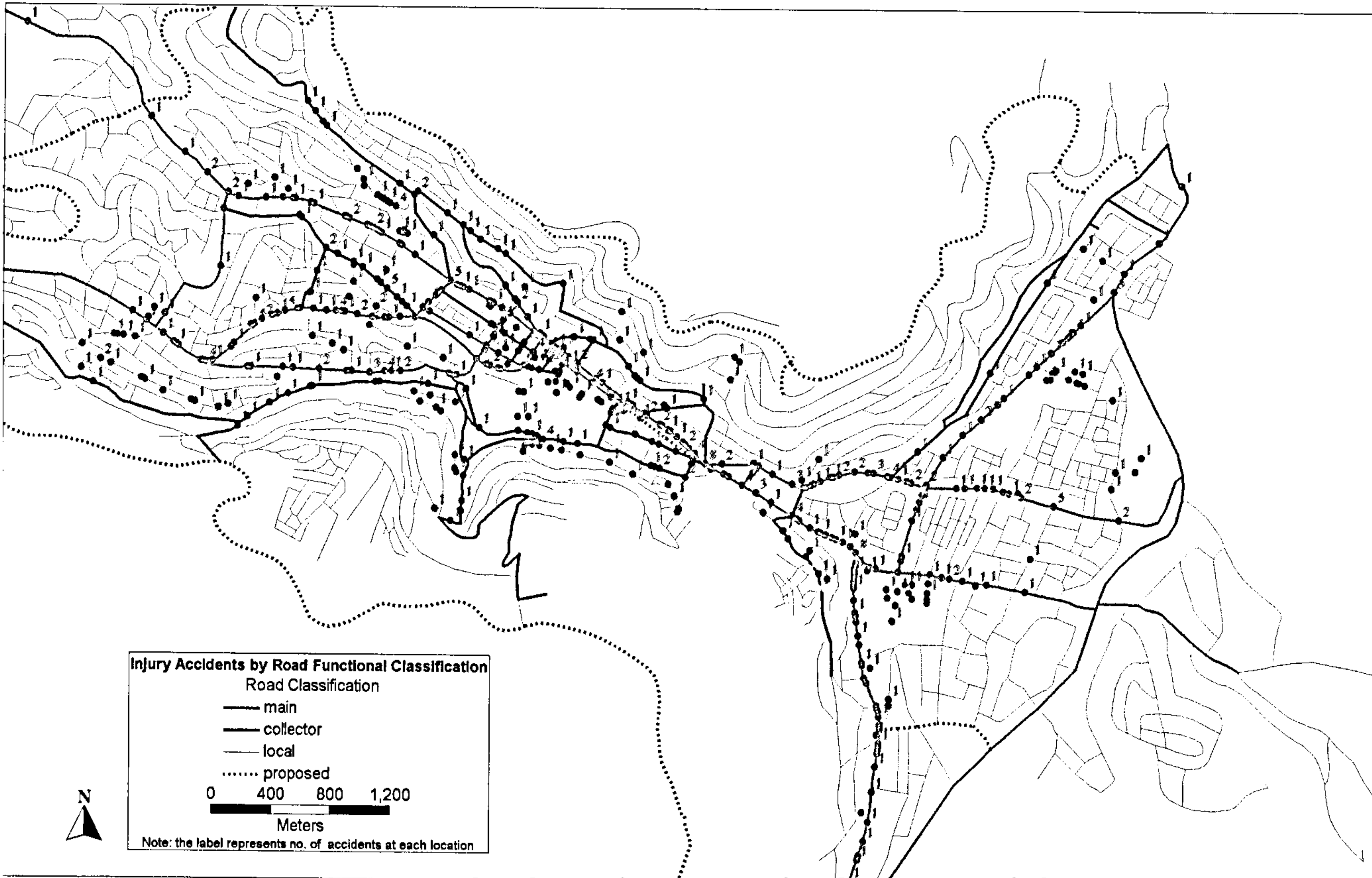
The results showed that 61.22% of all injury accidents during the study period in Nablus City occurred on main roads, which form 12.85% of total roadway length, as illustrated in Table 5.39 and Figure 4.19. This comes as no surprise because the main function of these roads is to move large volumes of traffic with limited access. The second percentage of injury accidents occurred on local streets with 20.87 percent. A local street's primary function is to provide local access. This percentage may be attributable to the large number of local streets which form 77.49 percent of the total roadway length. However, more motorists may be using these streets to circumnavigate congested areas on main streets. Collector roads, which form 9.66% of the total roadway length recorded the least percentage of accidents (17.91%).

The rate of injuries per kilometer on the main roads was 22.5 injury/km, while this rate decreases to 6.5 injury/km on collector roads. On the other hand, this rate was only 1 injury/km on local roads during the study period.

Table 5.39: Injury Accidents by Road Functional Classification, 1997-1998

Type of Road	Length (km)	Percentage of length	Total of accidents	Percentage of accidents	Number of casualties	Percentage of casualties
Main	37.8	12.85	499	61.22	850	67.30
Collector	28.4	9.66	146	17.91	186	14.73
Local	227.8	77.49	170	20.87	227	17.97
Total	**294**	**100.00**	**815**	**100.00**	**1263**	**100.00**

Figure 5.19: Plot of Injury Accidents by Road Functional Classification, 1997-1998



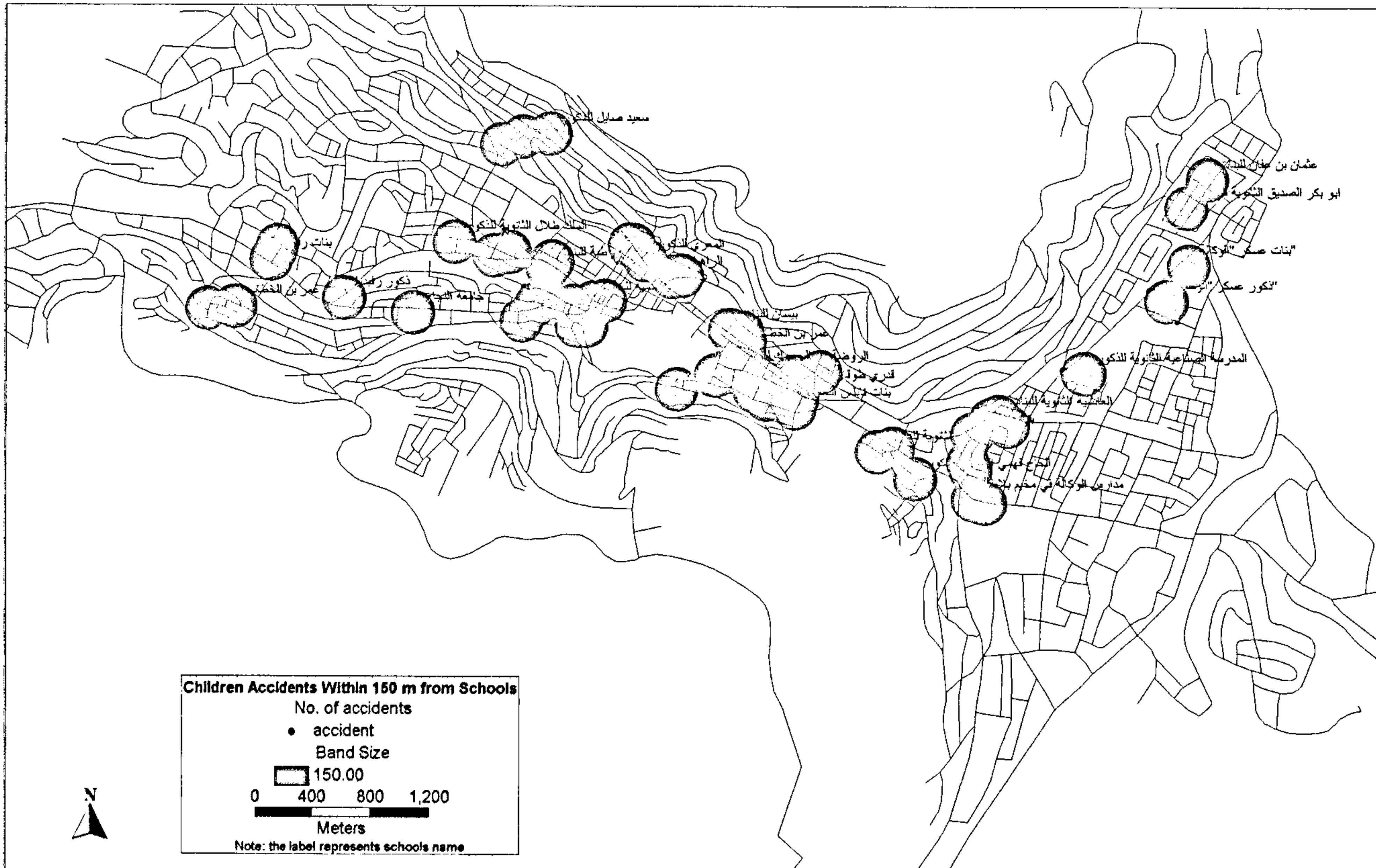
5.4.2 Children Accidents and Location of Schools

The children accidents were analyzed to see if they were influenced by the location of schools in the area. That is, to see if any relationship between children accidents and the location of schools can be established. First the location of schools were selected and displayed on a special layer. Then all children accidents for the time was between 7:00 AM and 2:00 PM were also selected from the accident layer. By creating a band of uniform width from the schools, all accidents falling inside this band were selected using the command selection by location, and choosing the location inside the band, then all children accidents falling inside the band were highlighted by combining the two selections. Figure 5.20 is a display of children accidents that fall inside a 150-meter band. Almost one fifth of all children accidents occurred between 7:00 AM and 2:00 PM and within 150 meters from schools. This means that there is a noticeable relation between children accidents and the location of schools.

5.4.3 Pedestrian Accidents in CBD

The pedestrian accidents in the Central Business District (CBD) of Nablus City were analyzed to see if there is any influence of the location in this case, and if any relationship between pedestrian accidents and the location can be established. First, the boundary of the CBD was selected and displayed on a special layer "area layer". Next, all pedestrian accidents were also selected from the accident layer. By using the command "select by location" and choosing the option inside the area

Figure 5.20: Plot of Children Accidents Within 150 m From Schools, 1997-1998



of the CBD to select all accidents that lie within the boundaries of the CBD, and then combine the two selections using the option (both), all the pedestrian related accidents inside the CBD were highlighted. Figure 5.21 is a display of pedestrian accidents that lie inside the CBD area.

The results showed that, there were 189 accidents within the CBD boundaries of Nablus City during the study period forming 23.19 percent of the total accidents. The percentage of pedestrian related accidents was 53.4 percent of all accidents that lie inside the CBD.

Hourly distribution of these accidents, as illustrated in Figure 5.22, showed that the 10:00-11:00 AM period had the highest percentage of accidents (12.9%). This may be attributed to the fact that this is the peak hour for shopping.

Distribution of injuries by gender showed that 71.3 percent of all pedestrian injuries inside the CBD were male compared to 28.7 percent of injuries were female.

Distribution of injury by age showed that the relationship between pedestrian injuries in the CBD and age was inversely related. Figure 5.23 shows the age group (1-18) recorded the highest percentage of pedestrian injuries in the CBD, while the age group (65 or greater) recorded the least percentage.

Figure 5.21: Plot of Pedestrian Accidents in the CBD, 1997-1998

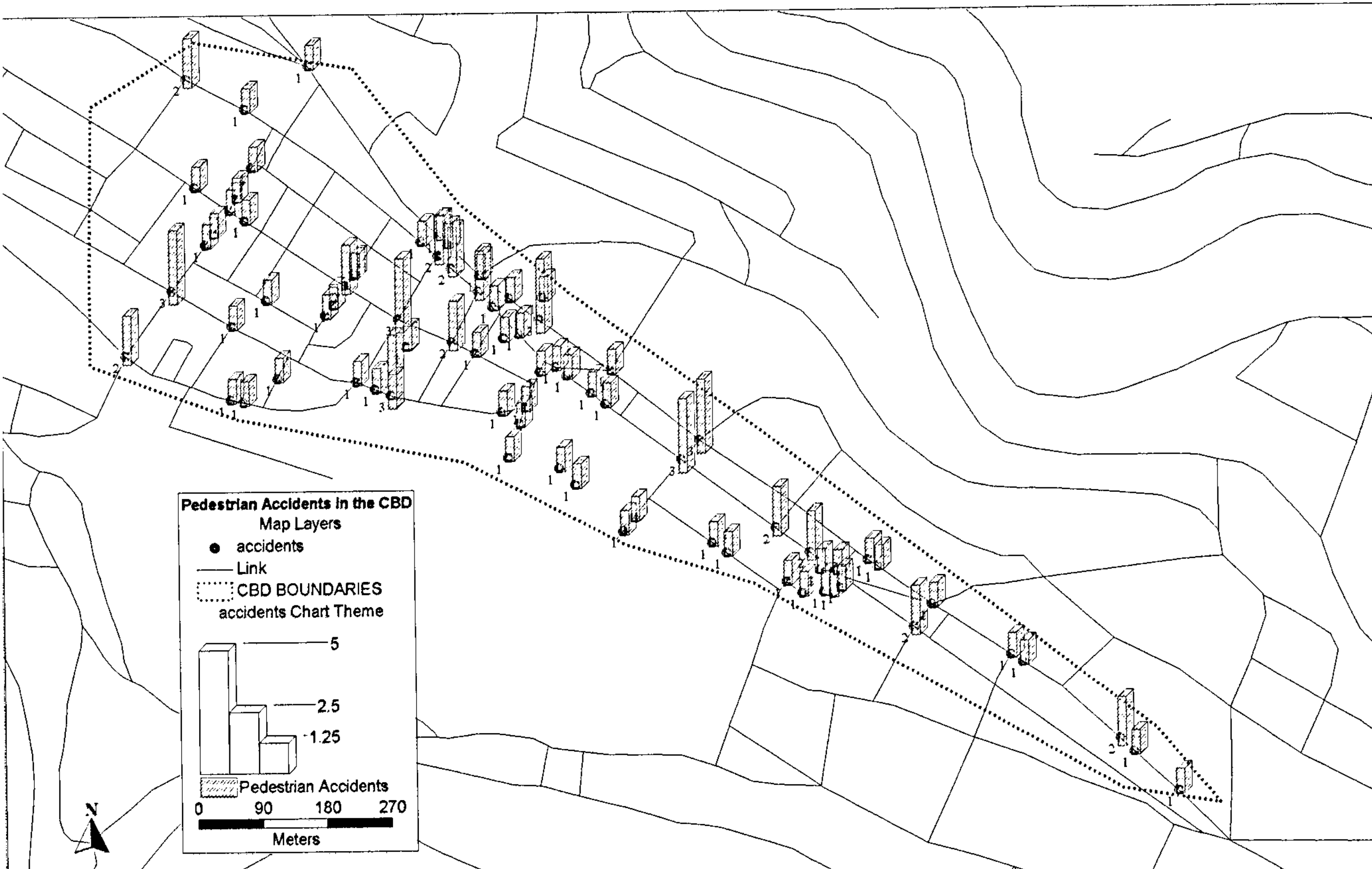


Figure 5.22: Hourly distribution of pedestrian accidents in the CBD

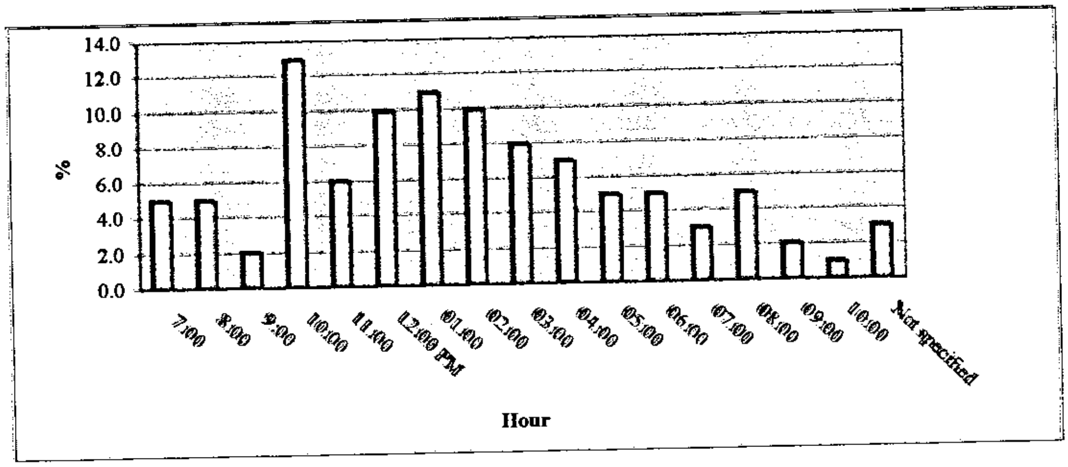
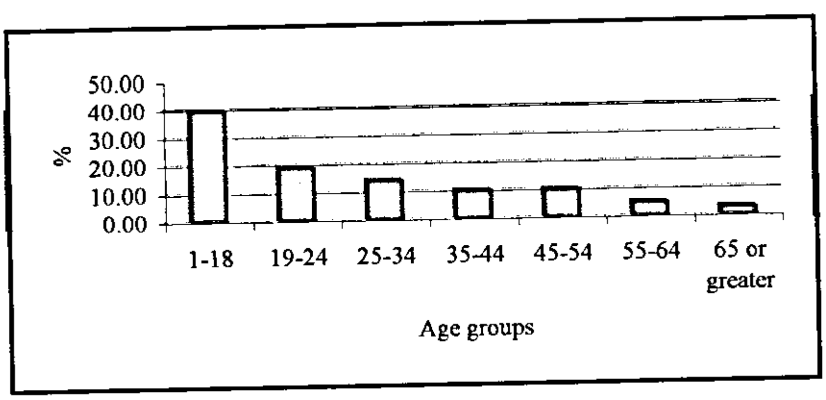


Figure 5.23: Percentage of pedestrian injuries in the CBD by age group



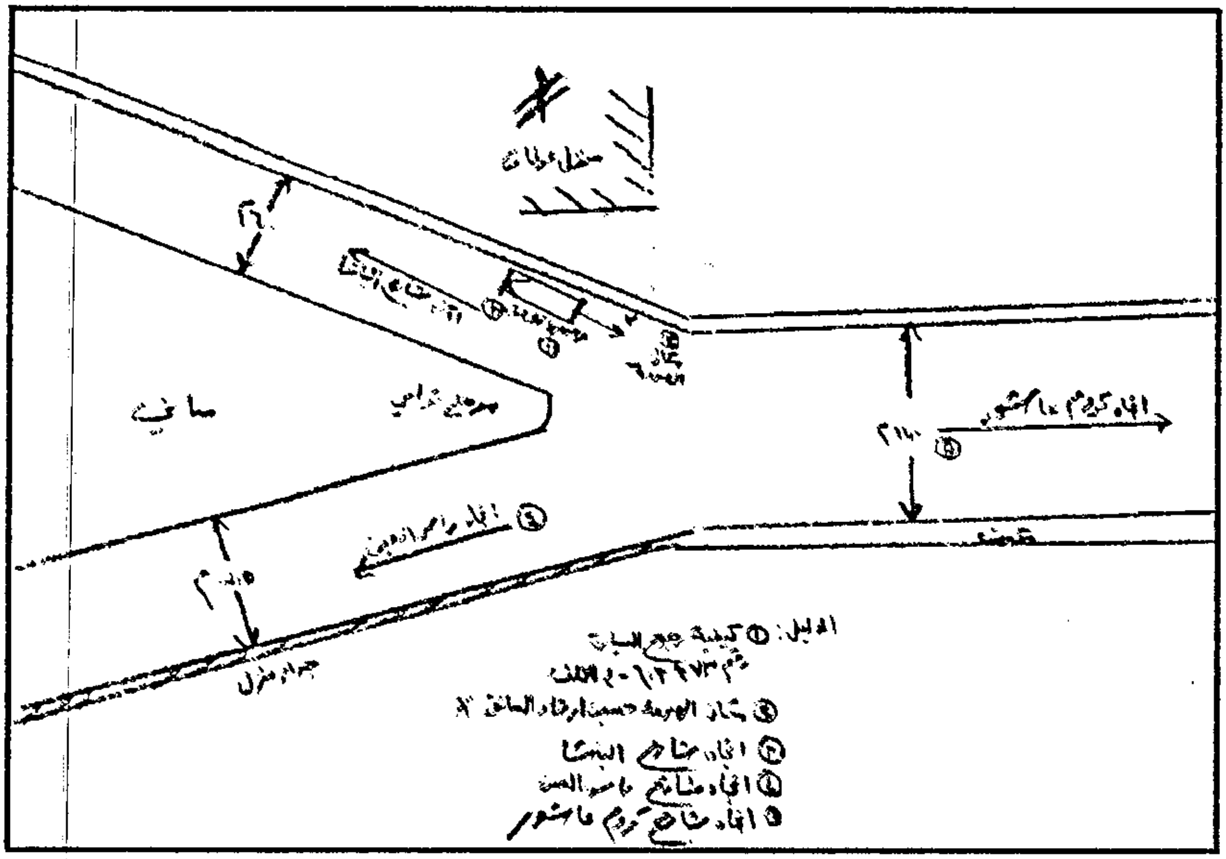
5.5 Pictures and Images

Pictures and images of links, intersections, and accident conditions enhance the map and expand the types of information used in the work. They can improve the appearance of the road network, add to the depth of information of the road physical features and its surrounding environment without going to the site, and provide a basis for editing and updating the road network file *(Caliper Corporation, 1996).*

However, this function would only be worthwhile if the images and photographs of the sites could be updated as changes to the road infrastructure occur. In this way the results obtained from this method will almost be the same as would be obtained from a site survey.

In this study, 178 accident condition diagrams were added to the database as a slide show to enable the user to see the accident condition by only clicking on the location of the related accident. An example of these condition diagrams is illustrated in Figure 5.24

Figure 5.24: An Example of a Condition Diagram



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APPENDICES

Appendix A

Two proposed traffic accident report forms
prepared by *(Dornier SystemConsult, 2000)*

PALESTINIAN CENTRAL ROADS ADMINISRATION
POLICE ACCIDENT REPORT

DO NOT WRITE IN THIS SPACE

TIME

DATE OF ACCIDENT 200 Day of week Hour A.M. P.M.

LOCATION

PLACE WHERE ACCIDENT OCCURRED City/Village Street

If accident was outside city limits indcate distance from nearest town Kilometers North S E W at City or Town

ROAD ON WHICH ACCIDENT OCCURRED Give name of street or highway number

AT ITS INTERSECTION WITH Name of street or highway number

IF NOT AT INTERSECTION Meter North S E W at Show nearest intersection, street or highway, house number, Kilometer post, etc

POLICE ACTIVITY:
Time notified of accident Date Hour A.M. P.M. What was the source of accident information? (Officer at scene, 1 driver contacted station, both drivers contacted station,............etc)

Name Charge

Name Charge

Other action taken

VEHICLE NO.1

VEHICLE Year Make Type (sedan, truck, taxi, bus ...etc) License Plate Year Number

Parts of vehicle damaged Vehicle removed to By

Owner Name Address

Driver Name Address

Driver's license Number Date of birth

OCCUPANTS
Passenger 1 Name Address

Passenger 2 Name Address

Passenger 3 Name Address

Passenger 4 Name Address

AGE	SEX	INJURY

VEHICLE NO.2 or PEDESTRIAN

VEHICLE Year Make Type (sedan, truck, taxi, bus ...etc) License Plate Year Number

Parts of vehicle damaged Vehicle removed to By

Owner Name Address

Driver Name Address

Driver's license Number Date of burth

OCCUPANTS
Passenger 1 Name Address

Passenger 2 Name Address

Passenger 3 Name Address

Passenger 4 Name Address

AGE	SEX	INJURY

WITNESSES

Name Address

Name Address

AGE	SEX

FIRST AID GIVEN BY: .... Injured Taken to ....

DAMAGE TO PROPERTY OTHER THAN VEHICLES

Name and address of owner of object struck

Name object and state nature of damage

CODE FOR INJURY

(Use only the most serious one in each injury)

K- Dead before report made.

A- Visible signs of injury, as bleeding, wound or distressed members; or had to be carried from scene

S- Other visible injury, browses, obresims, swelling, limping.............etc.

C- No visible injury but complaint of pain or momentary unconsciousness.

O- No indication of injury.

ENVIRONMENTAL CONDITIONS

WEATHER (Check one)	ROAD SURFACE (Check one)	TRAFFIC CONTROL (Check one)	LIGHT (Check one)	ROADWAY	No of lanes	ALIGNMENT (Check one)	
☐ Clear	☐ Dry	☐ Stop sign	☐ Dawn	☐ Divided	....	☐ Straight	☐ Overpass
☐ Cloudy	☐ Wet	☐ Yield sign	☐ Daylight	☐ Undivided	..	☐ Curve	☐ Underpass
☐ Raining	☐ Icy	☐ Traffic Signal	☐ Dusk	☐ Asphalt	....	☐ Bridge	☐ Level
☐ Snowing	☐ Snowy	☐ Flagman	☐ Darkness	☐ Concrete	....	☐ Intersection	☐ Uphill
☐ Foggy	☐ Other	☐ No traffic controle	☐ Other	☐ Gravel		☐ Ramp	☐ Downhill
☐ Other		☐ Other		☐ Other		☐ Railroad	

WHAT DRIVERS WERE GOING TO DO BEFORE ACCIDENT

Driver No. 1 was headed ☐ ☐ ☐ ☐ .... (Street or highway)

North S E W

Driver No. 2 was headed ☐ ☐ ☐ ☐ .... (Street or highway)

Driver 1 2 (Check one for each driver)	Driver 1 2	Driver 1 2	Driver 1 2
☐ ☐ Go straight ahead	☐ ☐ Make left turn	☐ ☐ Start in traffic lane	☐ ☐ Remain stopped in traffic lane
☐ ☐ Overtake	☐ ☐ Make U turn	☐ ☐ Start from parked position	
☐ ☐ Make right turn	☐ ☐ Slow or stop	☐ ☐ Back	☐ ☐ Remain parked

WHAT PEDESTRIAN WAS DOING

Pedestrian was going ☐ ☐ ☐ ☐ (Chek one) North S E W

☐ Along

☐ Across .... From .... To ....

☐ Crossing at intersection	☐ Walking in roadway with traffic	☐ Working on vehicle	☐ Other in roadway
☐ Crossing out of intersection	☐ Walking on roadway against traffic	☐ Working in roadway	☐ Not in roadway
☐ Getting on or off vehicle	☐ Standing in roadway	☐ Playing in roadway	

CONTRIBUTING CIRCUMSTANCES

Driver 1 2 (Check one for each driver)	Driver 1 2	Driver 1 2
☐ ☐ Speed too fast	☐ ☐ Passed stop sign	☐ ☐ Other improper driving
☐ ☐ Failed to yield right of way	☐ ☐ Disregarded traffic signal	☐ ☐ Inadequate brakes
☐ ☐ Drove left of center	☐ ☐ Followed too closely	☐ ☐ Improper lights
☐ ☐ Improper overcoming	☐ ☐ Made improper turn	☐ ☐ Had been drinking

FIRST/SUBSEQUENT HARMFUL EVENT

☐ Collision With MV (Rear-end)	☐ Collision With Pedestrian	☐ MV Hit Tree/ Shrubbery
☐ Collision With MV (Head-on)	☐ Collision With Bicycle	☐ Collision With Fixed Object Above Road
☐ Collision With MV (Angle)	☐ MV Hit Sign/Sign Post	
☐ Collision With MV (Left Turn)	☐ MV Hit Light Pole/Utility Pole	☐ MV Ran Into Ditch/Channal
☐ Collision With MV (Right Turn)	☐ MV Hit Guardrail	☐ Ran Off Road Into Water
☐ Collision With MV (Sideswipe)	☐ MV Hit Fence	☐ Overturned
☐ Collision With MV (Backed into)	☐ MV Hit Concrete Barrier Wall	☐ Occupant Fell From Vehicle
☐ Collision With Parked Car	☐ MV Hit Bridge/Rail	☐ All Other (Explain)
☐ Collision With MV on Other Roadway	☐ Collision With Traffic Gate	

PALESTINIAN CENTRAL ROADS ADMINISRATION

POLICE ACCIDENT REPORT

TIME AND LOCATION

ACCIDENT DATE (Day | Mon | Year) | DAY OF WEEK | TIME (AM PM) | GOVERNORATE OF ACCIDENT | KILOMETER OR POST NUMBER

CITY OR TOWN ☐ ☐ OR | LANDMARKS AND SCENE | NUMBER OF VEHICLES | OFFICIAL USE ONLY

ROUTE NO. OR STREET NAME AT SCENE

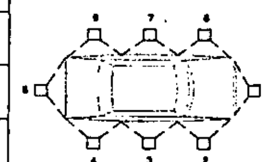
☐ AT INTERSECTION WITH OR ☐ KLM ☐ METTER ☐ N ☐ S ☐ E ☐ W | ROUTE NO OR STREET NAME OF

☐ VEHICLE ☐ PEDESTRIANS

DRIVER'S NAME (FIRST MIDDLE LAST) | DATE OF BIRTH (Day | Mon | Year) | SEX | DRIVING LICENSE NUMBER | INSURANCE CO. NAME & POLICY NO.

ADDRESS (STREET NO.) | CITY

VEHICLE NO 1 DAMAGE (CHECK POINT OF IMPACT)



VEHICLE OWNER'S NAME (FIRST MIDDLE LAST) | CITY

MAKE & TYPE OF VEHICLE (Motorcycle motor vehicle, ambulunce, etc.) | YEAR | LICENSE PLATE NUMBER | REPAIR COST

ACCIDENT TO PROPERTY OTHER THAN VEHICLES | OBJECT STRUCK (TREE, FENCE, ETC) | OWNER'S NAME (FIRST MIDDLE LAST)

ADDRESS

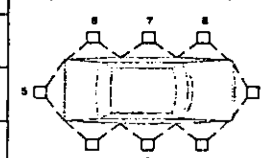
VEHICLE DAMAGES ☐ UNKNOWN ☐ NO DAMAGE ☐ OVERTURNED ☐ MOTOR ☐ UNDERCARRIAGE ☐ TOTALED ☐ BY FIRE ☐ OTHER | No. OF INJURIES | SPEED: BEFORE ACCIDENT | LIMIT

☐ VEHICLE ☐ PEDESTRIANS

DRIVER'S NAME (FIRST MIDDLE LAST) | DATE OF BIRTH (Day | Mon | Year) | SEX | DRIVING LICENSE NUMBER | INSURANCE CO. NAME & POLICY NO.

ADDRESS (STREET NO.) | CITY

VEHICLE NO 1 DAMAGE (CHECK POINT OF IMPACT)



VEHICLE OWNER'S NAME (FIRST MIDDLE LAST) | CITY

MAKE & TYPE OF VEHICLE (Motorcycle motor vehicle, ambulunce, etc.) | YEAR | LICENSE PLATE NUMBER | REPAIR COST

ACCIDENT TO PROPERTY OTHER THAN VEHICLES | OBJECT STRUCK (TREE, FENCE, ETC) | OWNER'S NAME (FIRST MIDDLE LAST)

ADDRESS

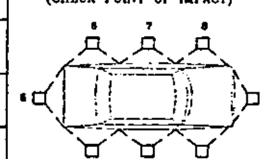
VEHICLE DAMAGES ☐ UNKNOWN ☐ NO DAMAGE ☐ OVERTURNED ☐ MOTOR ☐ UNDERCARRIAGE ☐ TOTALED ☐ BY FIRE ☐ OTHER | No. OF INJURIES | SPEED: BEFORE ACCIDENT | LIMIT

☐ VEHICLE ☐ PEDESTRIANS

DRIVER'S NAME (FIRST MIDDLE LAST) | DATE OF BIRTH (Day | Mon | Year) | SEX | DRIVING LICENSE NUMBER | INSURANCE CO. NAME & POLICY NO.

ADDRESS (STREET NO.) | CITY

VEHICLE NO 1 DAMAGE (CHECK POINT OF IMPACT)



VEHICLE OWNER'S NAME (FIRST MIDDLE LAST) | CITY

MAKE & TYPE OF VEHICLE (Motorcycle motor vehicle, ambulunce, etc.) | YEAR | LICENSE PLATE NUMBER | REPAIR COST

ACCIDENT TO PROPERTY OTHER THAN VEHICLES | OBJECT STRUCK (TREE, FENCE, ETC) | OWNER'S NAME (FIRST MIDDLE LAST)

ADDRESS

VEHICLE DAMAGES ☐ UNKNOWN ☐ NO DAMAGE ☐ OVERTURNED ☐ MOTOR ☐ UNDERCARRIAGE ☐ TOTALED ☐ BY FIRE ☐ OTHER | No. OF INJURIES | SPEED: BEFORE ACCIDENT | LIMIT

VEHICLE TYPE

01 Automobile
02 Passenger Van
03 Light Truck (2 rear axles)
04 Medium Truck
05 Heavy Truck (2 or more rear axles)
06 Truck Tractor (cap)
07 Motor Home (RV)
08 Bus
09 Bicycle
10 Motorcycle
11 Train
77 Other

1 2 3

VEHICLE USE

01 Private Transportation
02 Commercial Passengers
03 Commercial Cargo
04 Puplic Transportation
05 Puplic School bus
06 private School Bus
07 Ambulance
08 Law Enforcement
09 Fire Rescue
10 Military
11 Other Government
77 Other

1 2 3

PHYSICAL DEFECTS

1 No Defects Known
2 Eyesight Defect
3 Fatigue / Asleep
4 Heating Defect
5 Illness
6 Seizure Blackout
5 Other Physical Defects

1 2 3

CONTRIBUTING CAUSES DRIVER

01 No Improper Driving/Action
02 Careless Driving
03 Failed to Yield Right of Way
04 Improper Backing
05 Improper Lane Change
06 Improper Turn
07 Alcohol Under Influence
08 Drug Under Influence
09 Alcohol & Drug Under Influence
10 Follwed edToo Closely
11 Disregarded Traffic Light
12 Disregard Traffic Sign
13 Failed to Maintain Equip/Vehicle
14 Improper Passing
15 Driving Left of Center
16 Exceeded Stated Speed Limit
17 Obstructing Traffic
18 Improper Load
19 Disregarded Other Traffic Control
20 Driving Wrong Side/way
21 Fleeing Police
77 All Other (Explain)

1 2 3

VEHICLE DEFECT

01 No Defect
02 Defective Brakes
03 Worn /Smooth Tire
04 Defective Improper Light
05 Puncher/Plowout
06 Steering Mech.
07 Wind Shield Wipers
08 Equipment/Vehicle Defect
77 All Other (Explain In Narrative)

1 2 3

VEHICE SPECIAL FUNCTION

1 2 3

1 None
2 Farm
3 Police Pursuit
4 Recreational
5 Emergency Operation
6 Construction or Maintenance

LOCATION ON ROADWAY

1 On Road
2 Not On Road
3 Shoulder
4 Median
5 Turn Lane/Safey Zone

1 2 3

LOCATION TYPE

1 Primarily Business
2 Primarily Residential
3 Open Country

VEHICLE MOVEMENT

01 Straight Ahead
02 Slowing/Stopped/ Stalled
03 Making Left Turn
04 Backing
05 Making Right Turn
06 Changing Lane
07 Entering, Leaving/ Parking Space
08 Properly Parked
09 Improperly Parked
10 Making U-Turn
11 Passing
12 Driveless, or Runaway Vehicle
77 All Other (Explain in Narrative)

1 2 3

PEDESTRIAN ACTION

01 Crossing Not at Intersection
02 Crossing at Midblock Crosswalk
03 Crossing at Intersection
04 Walking Along Road With Traffic
05 Walking Along Road Against Traffic
06 Working on Vehicle in Road
07 Other Working in Road
08 Standing/Playing in Road
09 Standind in Pedestrian Island
77 All Other

1 2 3

ROAD SYSTEM IDENTIFIER

01 Main
02 Regional
03 Local
04 Dirt
05 Local
06 All Other

FIRST/SUBSEQUENT HARMFUL EVENT

01 Collision With MV in Transport (Rear-end)
02 Collision With MV in Transport (Head-on)
03 Collision With MV in Transport (Angle)
04 Collision With MV in Transport (Left Turn)
05 Collision With MV in Transport (Right Turn)
06 Collision With MV in Transport (Sideswipe)
07 Collision With MV in Transport (Backed into)
08 Collision With Parked Car
09 Collision With MV on Other Roadway
10 Collision With Pedestrian
11 Collision With Bicycle
12 Collision With Motorcycle
13 Collision With Train
14 Collision With Animal
15 MV Hit Sign/Sign Post
16 MV Hit Light Pole/Utility Pole
17 MV Hit Guardrail
18 MV Hit Fence
19 MV Hit Concrete Barrier Wall
20 MV Hit Bridge/Rail
21 MV Hit Tree/ Shrubbery
22 Collision With Construction Barricade/Sign
23 Collision With Traffic Gate
24 Collision With Crash Attenuator
25 Collision With Fixed Object Above Road
26 MV Hit Other Fixed Object
27 Collision With Movable Object On Road
28 MV Ran Into Ditch/Channal
29 Ran Off Road Into Water
30 Overturned
31 Occupant Fell From Vehicle
32 Tractor/Trailer
33 Fire
34 Explosion
35 All Other (Explain)

F S

ROAD SURFACE TYPE

01 Slag/Gravel/Stone
02 Asphalt
03 Brick/Block
04 Concrete
05 Dirt
77 All Other (Explain)

ROAD SURFACE CONDITION

01 Dry
02 Wet
03 Slippery
04 Icy
77 All Other (Explain)

WEATHER

01 Clear
02 Cloudy
03 Rainy
04 Fog
77 All Other (Explain)

LIGHTING CONDITION

01 Daylight
02 Dusk
03 Dawn
04 Dark (Street Light)
05 Dark (No Street Ligh)
06 Unknown

TRAFFICWAY CHARACTER

01 Straight Level
02 Straight-Upgrade/Downgrade
03 Curve-Level
04 Curve-Upgrade/Downgrade

CONTRIBUTING CAUSES - ROAD

01 No Defects
02 Obstructing With/Without Warning
03 Road Under Repair
04 Loose Surface Materials
05 Shoulders Soft/Low/High
06 Holes/Ruts/Unsafe Paved Edge
07 Standing Water
08 Worn/Polished Road Surface
77 All Other (Explain)

TYPE SHOULDER

01 Paved
02 Unpaved
03 Curb

CONTRIBUTING CAUSES ENVIRONMENT

01 Vision Not Obscured
02 Inclement Weather
03 Parked/Stopped Vehicle
04 Trees/Crops/Bushes
05 Load On Vehicle
06 Building/Fixed Object
07 Signs/Billbords
08 Fog
09 Smoke
10 Glare
77 All Other Explain

TRAFFIC CONTROL

01 No Control
02 School Zone
03 Traffic Signal
04 Stop Sign
05 Yield Sign
06 Flashing Light
07 Railroad Signal
08 Officer/Guard/Flagman
09 Posted No U-Turn
10 Special Speed Zone
11 No Passing Zone
77 All Other (Explain)

SITE LOCATION

01 Not At Intersection/RR Xing/ Bridge
02 At Intersection
03 Influenced By Intersection
04 Driveway Access
05 Railroad crossing
06 Bridge
07 Entrance Ramp
08 Exit Ramp
09 Parking Lot, Public
10 Parking lot, Private
11 Private Property
77 All Other Explain

Provide a Sketch of the Accident

SHOW NORTH
BY ARROW

DESCRIBE WHAT HAPPENED:

SIGN HERE

Officer rank and name | Badge No. | Department | Date of report

Appendix B

Geographic Information Systems (GIS)

Geographic Information Systems (GIS)

INTRODUCTION

The rapid technological advances and the need for better means for the storage and analysis of geographic data and the linkage of such data with relevant information have expedited the development of geographic information systems (GIS). These systems differ from other information systems and computer programs by their analytical capabilities. They can store and establish links between both textual and spatial data and provide answers for "what if" questions which are difficult to answer using traditional means. Moreover, GIS can derive information which is not directly stored in the database. All these merits of GIS make them an ideal tool to be used by civil engineers, surveyors, geographers, planners, environmentalists, etc.

WHAT IS A GEOGRAPHIC INFORMATION SYSTEM?

The geographic information system is defined as a computer based system that is capable of managing, analyzing, and reproducing large amounts of spatial data and thematic attributes. The different elements of geographic information was itemized as hardware, software, data, and personnel. Therefore, a GIS is a computer system that can be held and used in describing places on earth's surface *(Tilmann, 1997).*

If the data being handled by the system is geographic data (i.e., it has a spatial component and the techniques being used are special data techniques), then the system concerned is referred to as a Geographic Information System (GIS).

The fundamental difference of a GIS from any other information systems is that it has the knowledge of how events and features are geographically located. How this knowledge is encapsulated within the computer depends on the design and the structure of the geographic database and the associated softwares that are designed to retrieve and manipulate the data. Vector, raster, topological, and object-oriented systems are amongst some of the more commonly understood structures used in GIS design. Each different database structure has its own merits and applications. The important criterion to note is the existence of an embedded geographic component necessary for spatial operations.

Theoretically, it will be possible to analyze limitless combination of potential interactions amongst events and whatever features that are represented in a geographical database. A typical yet simple problem would be to perform a spatial search around a feature or event and determine its proximity to another feature or event. For example:

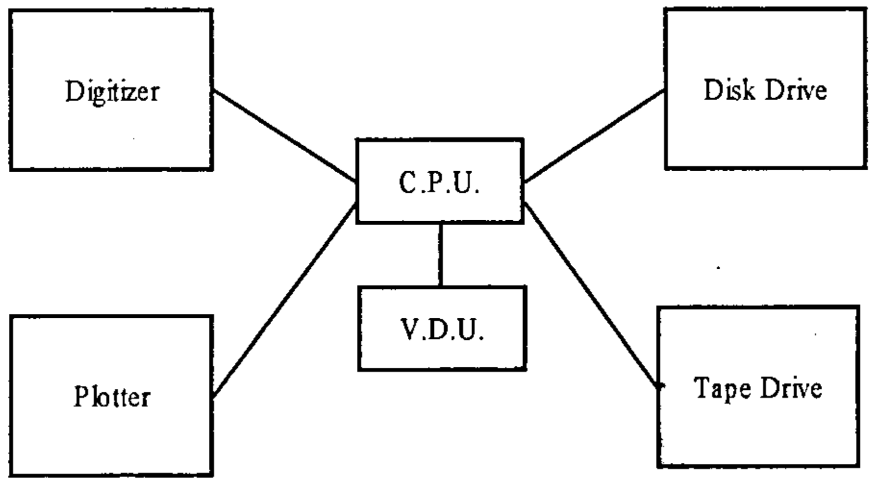
Find all accidents with school children causalities between 0600 hours and 0900 hours and within 200 meters from all schools disk drive storage unit, which provides space for storing data and programs. A digitizer or other device is used to convert data from maps and documents into digital form and send them to the computer. A plotter or another kind of display device is used to present the results of the data processing, and a drive is used for storing data or programs on compact disk, or for communicating with other systems. The user controls the computer and the peripherals (a general term for plotters, printers, digitizers, and other apparatus linked to the computer) via a visual display unit (VDU), otherwise known as monitor. The users usually incorporate special hardware to allow maps to be displayed quickly. There is a very wide range of devices that can be used to fill these general hardware requirements.

- **GIS Software Modules**

The software package for a geographical information system consists of five basic technical modules. These basic modules are sub-systems for:

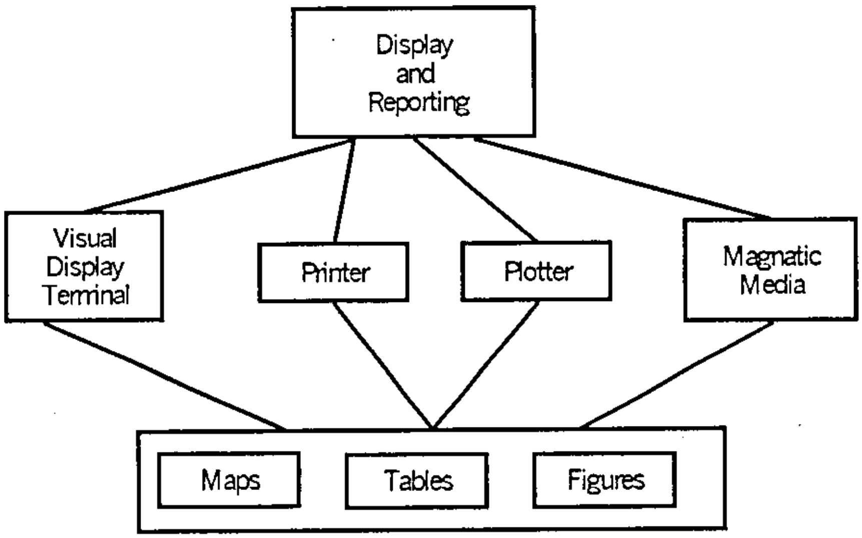
- Data input and verification
- Data storage and database management
- Data output and presentation
- Data transformation
- Interaction with the user

Figure 1: The Major Hardware Components of a Geographic Information System



Source: (Burrough, 1984)

Figure 4: Data Output



Source: (Burrough, 1984)

Data transformation (Figure 5) embraces two classes of operation, namely (a) transformations needed to remove errors from the data or to bring them up to data or to match them to other sets, and (b) the large array of analysis methods that can be applied to the data in order to achieve answers to the questions asked of the GIS. Transformations can operate on the spatial and the non-spatial aspects of the data, either separately or in combination. Logical retrieval of data and calculation of areas and perimeters, are of such a general nature that one should expect to find them in every kind of GIS in one form or another.

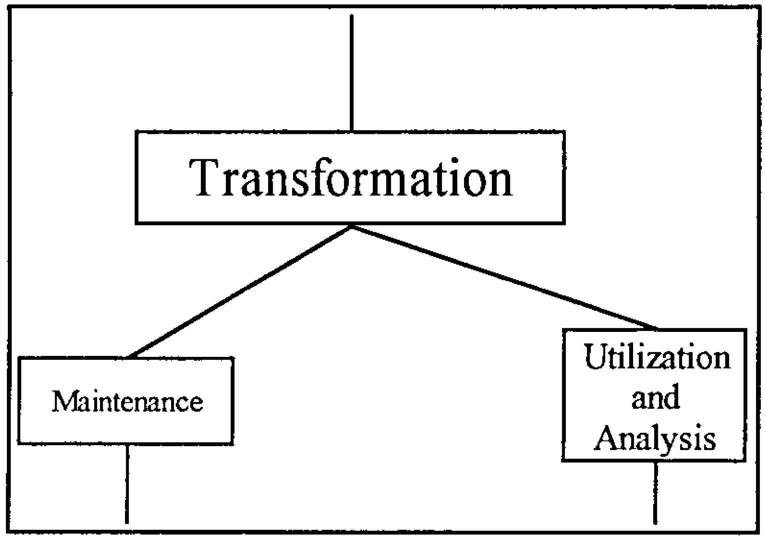
- **The Organizational Aspects of GIS**

The five technical sub-systems of GIS govern the way in which graphical information can be processed but they do not of themselves guarantee that any particular GIS will be used effectively. In order to be used effectively, the GIS need to be placed in an appropriate organizational context as presented in Figure 6.

DATA STRUCTURES FOR GEOGRAPHICAL INFORMATION SYSTEMS

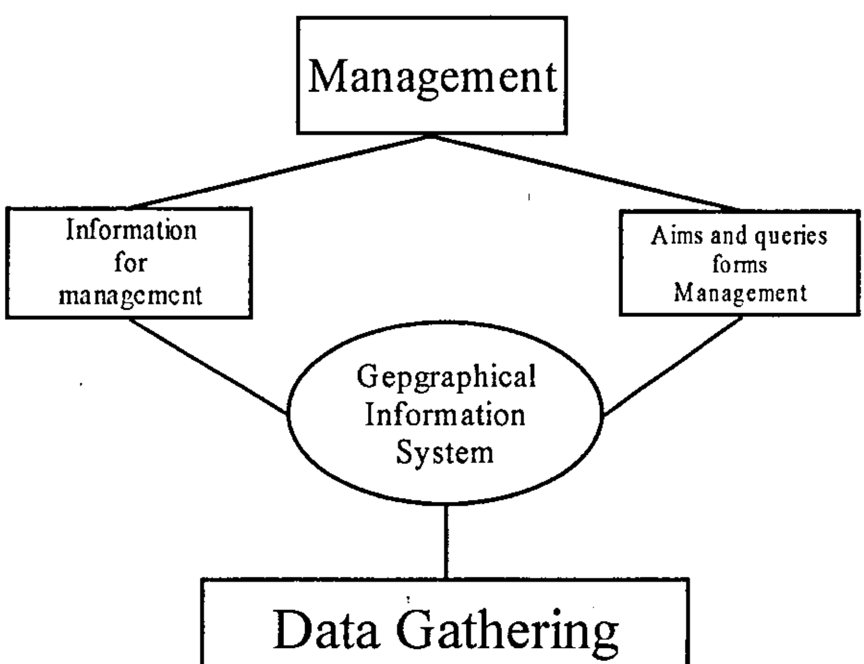
Data describing the location of spatial features can be described by topological, metric, and graphical information. Topological considerations deals with the spatial relationships among entities expressed in terms of points such as road intersections,

Figure 5: Data Transformation



Source: (Burrough, 1984)

Figure 6: Organizational Aspects of GIS



Source: (Burrough, 1984)

lines such as road segments, and areas representing land uses. The metric approach to the characterization of features is defined by the use of the above spatial coordinates to express location information, while the graphical approach utilizes cartographic principles (symbols, line weight, and colors) for characterizing spatial features and their type and magnitude. A database structure is characterized by its data content and the relationships among the data items structures or models. These are the hierarchical database structure, the network database structure, and the relational database structure *(Hakkert, Peld and Affum, 1993)*.

- **Hierarchical Database Structure**

In the hierarchical model, data are represented in a tree structure. Nodes in the tree are data items. The branches of the tree represent one-to-many relationships among the data items.

The highest level of the tree is termed the root and can be represented by any data entry. The root can have any number of dependants. This model type is asymmetric because some records or parts are treated as superior to others. Hence when the data has one-to-many relation, the hierarchical model provides quick and convenient means of data access. Hierarchical systems have the advantage that they are easy to understand, update, and expand. The asymmetric nature is its major drawback because it leads to unnecessary complications for the user. With this type of structure, with the exception of the root, no data item can be accessed without the presence of its superior in the tree.

Hierarchical models do not lend themselves readily to the structuring of the data that are not hierarchical in actually. Thus this type of structure is not flexible and can be only be used where the relationships between the data items are known beforehand. Further disadvantages of the hierarchical database structures are that large index files have to be maintained, and certain attribute values have to be repeated many times leading to data redundancy, which increase storage and access costs *(Burrough, 1986)*.

- **Network Database Structure**

The network model uses branches to indicate the relationships among data items, which are represented as nodes. It is a more general structure than the hierarchical models because any piece of data can have any number of superiors and dependants. With this type of structure, an additional entity of data called connector is introduced as link between data items. This type of structure is very efficient and usually a reason for choosing the network database model over hierarchical model or any other model type. A data item in the network model can be accessed through a number of routes whereas in the hierarchical structure there is only one path available to any datum. Network systems are very useful when the linkages or relations can be specified beforehand. They avoid data redundancy and make good use of available data. The main disadvantage of this model is its complexity *(Burrough, 1986).*

♦ Relational Database Structure

The relational approach to database structuring is based on the realization that files obey certain constraints may be considered as mathematical relations and hence that elementary relation theory may be brought to bear on various practical problems of dealing with data in such files. These are usually in the form of tables. The relational databases structure is thus based on an explicit algebra of relations that can be visualized as sets of two dimensional data files or tables each identified by a relation name. The data are stored in tables that conform to certain constraints that allow the application of elementary mathematical relation theory. The Description of an individual relation is called schema. Each column of the table representing a relation describes the characteristics of a data entry and is called an attribute. Each row of the table indicates some unique entity of the data entry and is termed as a tuple. The ordering of the columns and rows is arbitrary. The domain of an attribute refers to the set of all allowable values for that attribute. A constraint is a tool used to control the integrity of the relation. For example, one may specify non-negative values for the attribute or describe the dependency of the attribute. Hence all relations have been described, the database schema is completely defined. Each relation should posses a key, that is a set of one or more attributes that uniquely identify a particular tuple or row. The key is used to access or manipulate that particular data item. The method then ensures that the organization of the data has certain properties referred to as normalization. This structure type is simple and very easy to understand and is an effective way of determining the best possible arrangement of data in a database.

Relational databases have the great advantage that their structure is very flexible and can meet the demands of all queries that can be formulated, other advantages of this type of database structure are:

- Freeing the user from concerns about data storage and retrieval
- Facilitating ease of data manipulation
- Allowing any view of data and providing immunity to changes in storage structure or access because of its flexibility
- Reducing data inconsistencies and redundancies and promoting data integrity
- Providing centralized control of all data, coupled with generalized capability for adaptability and stability

The main disadvantage of the relational database is that many of the operations involve sequential search through the files to find the right data that satisfy the specified relation *(Hakkert, Peld, and Affum, 1993).*

GIS-T

GIS-T is the adoption and adaptation of GIS for transportation purposes. The adaptation of GIS for transportation, particularly in areas of the development of methods for data storage and provision of appropriate analytical abilities, will lead to the adoption of GIS-T by transportation agencies.

The use of GIS-T is worth considering under two main categories; first for general data maintenance (primarily inventory) and analysis, and the second, for data analysis utilized in land use /transportation system (LUTS) models *(Lewis, 1990)*.

- **The Role of Spatially Integrated Data in Transportation**

Spatial considerations are fundamental to most transportation activities. A transportation system consists of nodes, links, and entities distributed in two or three-dimensional space. Events happen within this system at a point (an accident or a signal location), along a segment (vehicle volumes or pavement deficiencies), or within a geographic area (the number of people living within two blocks of a bus stop or working in industrial park).

The collection of highway related data involves a wide variety of activities: traffic counting, sign inventories, skid-resistance measurements, accident investigation, recording of construction and maintenance projects, right-of way surveys, inventories of signs and roadside obstacles, bridge inspection, rail-highway crossing inventories, speed monitoring, pavement condition surveys, geometric design inventories, and other data-collection and maintenance activities.

An integrated highway information system, on the other hands, is a system for collection and storage of highway related data in such a way that data from different sources that apply to the same point on, or section of, a highway are correlated or linked.

Because transportation-related data always have a spatial component, the most natural way to associate elements from different data sets is through a consistent spatial referencing system. GIS technology can provide the core of a framework for an integrated highway information system *(Howard, 1989)*.

♦ Advantages of GIS-T

The GIS technology is currently gaining full-scale implementation in the transportation field due to the following advantages:

- The ease of data retrieval
- The discovery and display of information gained by observing the relationships and interactions between transportation attributes
- The processing of large amount of data for spatial evaluation

- The ability to make full scale and projection changes, remove distortions and perform coordinate rotations and translation
- The analysis of spatial relationships through the application of empirical and quantitative models

All the above advantages and more can be achieved through GIS technology applications coupled with the spatial and computing considerations which are oriented towards transportation studies (GIS-T). In this way it is possible to reduce and eliminate many problems that would be encountered during the GIS implementation process like the problem of blending of the various disciplines to shape the analysis and interpret the results *(Abkowitz, 1990).*

- **Available Software**

There are currently several commercial GIS packages and many more are expected to be published in the next few years. Although most of these systems can be used for storing geographic information, not all of them are suitable for transportation analysis purposes. The section below briefly review some currently available GIS systems that can be used for transportation planning and modeling.

- **ARC/INFO**

This system is a product of ESRI and is considered as the most widely used GIS system available for a variety of computers (mainframes, minicomputers, workstations, and PCs). It is a powerful, command-driven GIS with extensive capabilities for data storage, editing, display, and geographic analysis. It supports transportation modeling in the network module. This module contains the following procedures of interest to transportation planners:

- Routes to determine the shortest path between any pair of nodes
- Allocate to assign links in the network to the closest center
- Geocoding routines to perform address matching

ARC/INFO was designed as a general GIS system, it is therefore difficult to connect it to the already developed transportation models and algorithms. All transportation models have to be rewritten in the ARC macro language *(Prastacos, 1991)*.

- **MapInfo, Atlas**

MapInfo and Atlas GISs are menu-based, user-friendly desktop mapping and GIS systems that can store and display street networks and zone boundaries. Both of these packages have sophisticated routines for geocoding, but only limited capabilities for transportation modeling. The proprietary data structure is not topological, hence paths and routes cannot be defined. However, because of their ability to display networks and zones and their ease of use, they can be used to display graphically the results of transportation models estimated outside of these two packages *(Prastacos, 1991)*.

- **SPANS**

SPANS is a menu-driven, user-friendly GIS system with powerful spatial analysis capabilities. It is available on DOS, OS/2, and UNIX platforms. By using the quadtree method for storing information, SPANS can handle both vector and raster data. It supports a complete topological linear network and is therefore amenable to transportation planning. Networks can be analyzed to model travel distance, travel time, and rate of flow. An optimal routing procedure is included in the system, as well as procedures for gravity modeling. New transportation procedures have to be developed with the SPANS macro language because existing computer code cannot be easily integrated in the system *(Prastacos, 1991).*

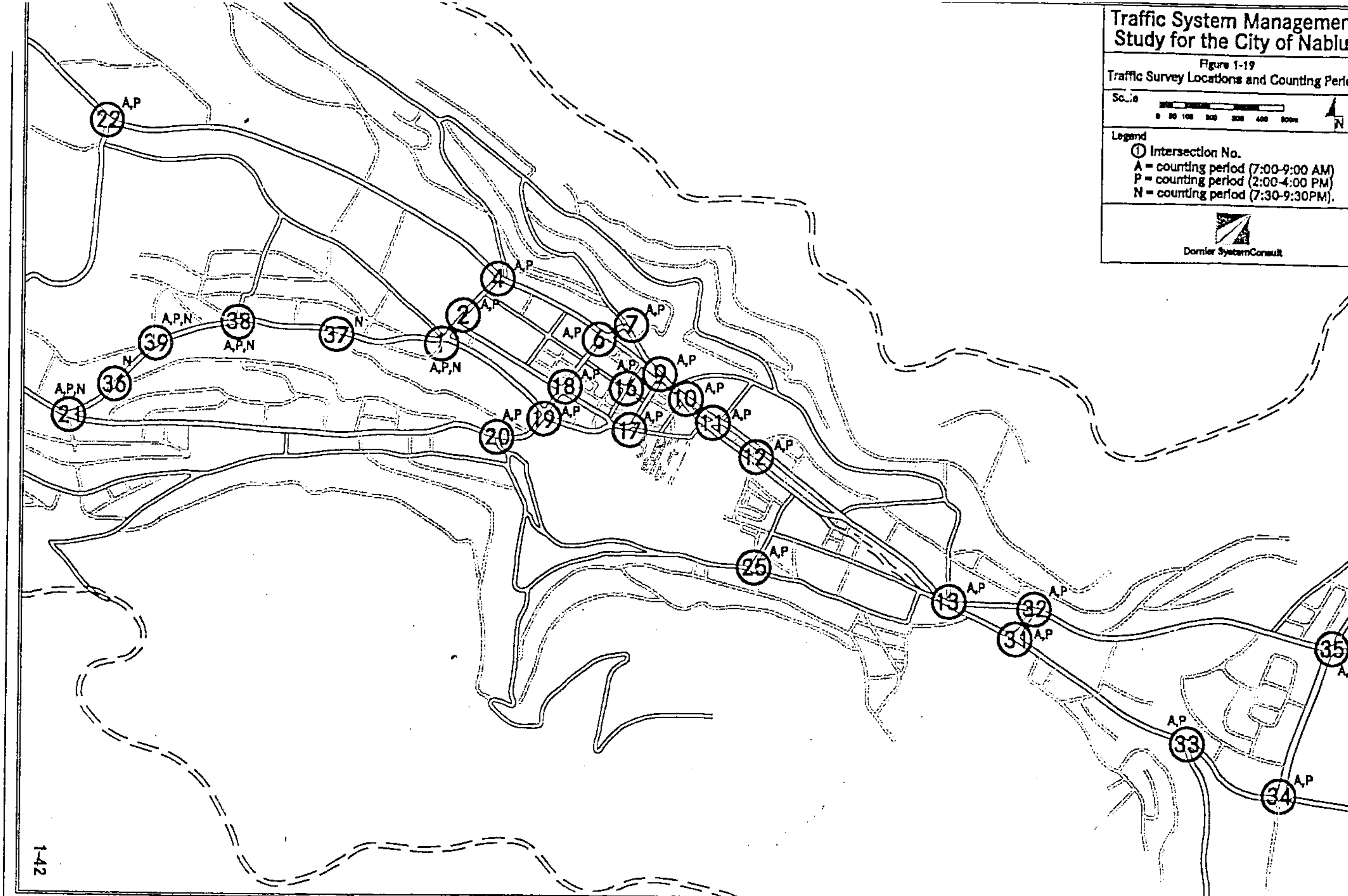
- **TransCAD**

TransCAD, which is a product of Caliper, is a powerful and easy to use GIS-based transportation package. In contrast to the other software packages mentioned that were developed as general GIS systems, TransCAD was specifically designed to serve as a platform for solving transportation, logistics, and operations research problems. The system, which is available only for PCs, consists of two parts; a GIS engine (available also as a separate product called GIS PLUS) and a toolbox of transportation models and procedures. The GIS engine is menu driven and, in addition to the standard GIS functions, can directly support transportation data structures such as nodes, links, networks, paths, and tours.

For transportation planners, a most significant component of the system is the toolbox, which consists of an expandable set of mathematical models and procedures that can be used for a variety of transportation problems. Version 3 of the software includes routines for

- Building networks from a set of links and nodes
- Estimating shortest paths between any pair of nodes (with or without transfer penalties)
- Solving the "traveling sale-man" problem (routing and scheduling)
- Performing a traffic assignment (capacity constrained, user equilibrium, incremental, stochastic);
- Spatial interaction modeling (gravity models of the entropy type)
- Assigning service stations on a network (arc/node partitioning)

TransCAD also provides a platform for users to develop their own transportation-related models. These models can be developed as standalone programs in any DOS-compatible computer language (such as FORTRAN or C) and then linked to TransCAD. This capability is significant because users can easily integrate algorithms they already have without having to recode them in a different language *(Prastacos, 1991)*.


Traffic System Management
Study for the City of Nablus
Figure 1-19
Traffic Survey Locations and Counting Periods
Scale
0 50 100 200 300 400 500m
N
Legend
① Intersection No.
A = counting period (7:00-9:00 AM)
P = counting period (2:00-4:00 PM)
N = counting period (7:30-9:30PM).
Dornier SystemConsult
22 A,P
38 A,P,N
39 A,P,N
36 N
21 A,P,N
37 N
1 A,P,N
2 A,P
4 A,P
6 A,P
7 A,P
9 A,P
16 A,P
18 A,P
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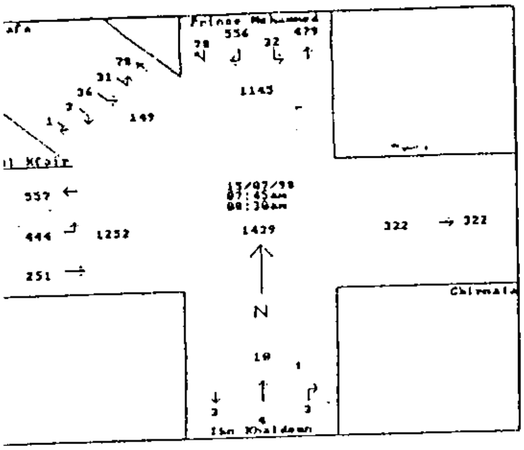
34 A,P



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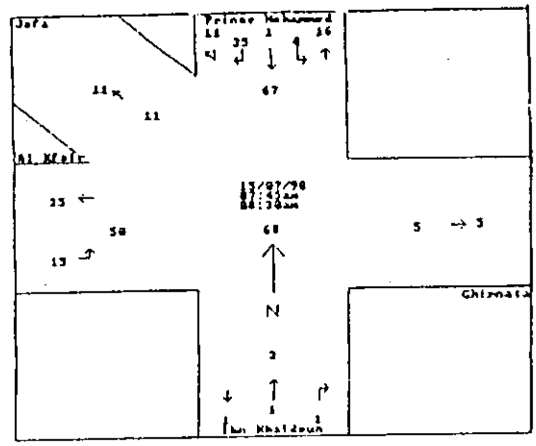

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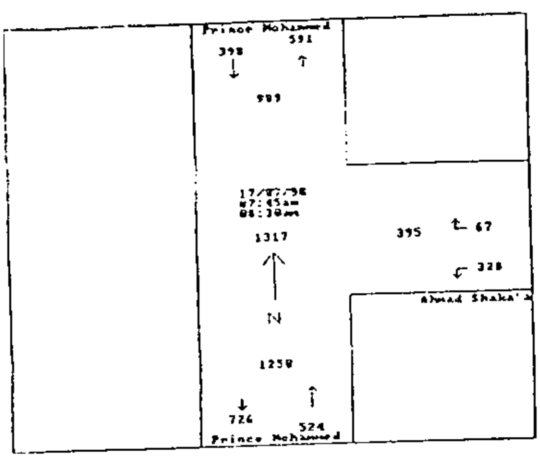

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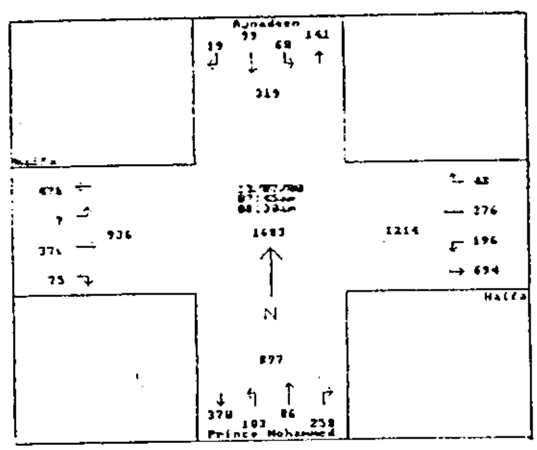

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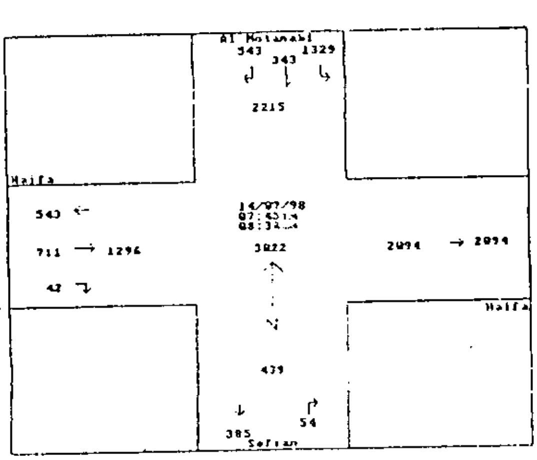

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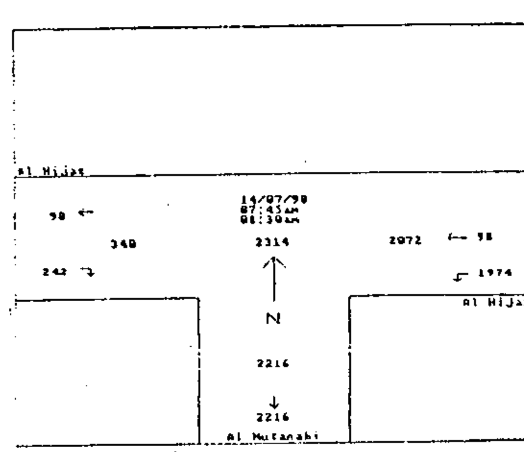

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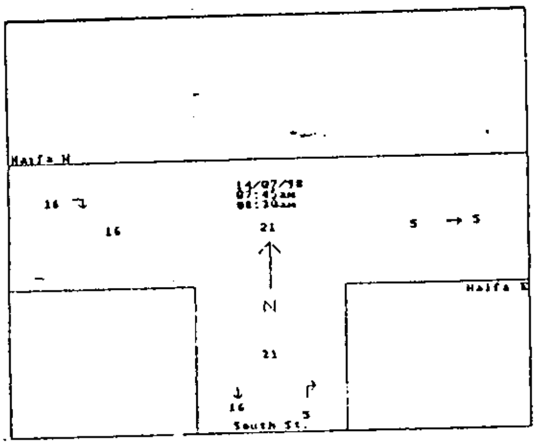

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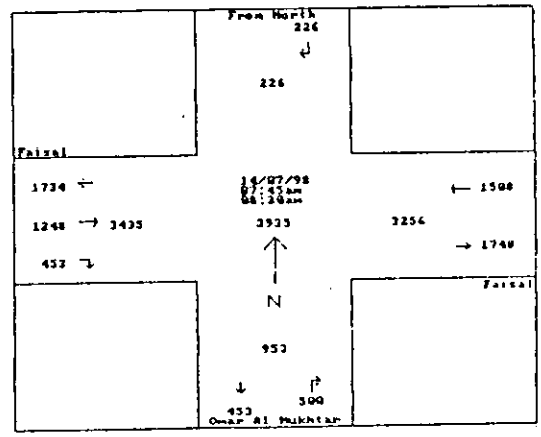

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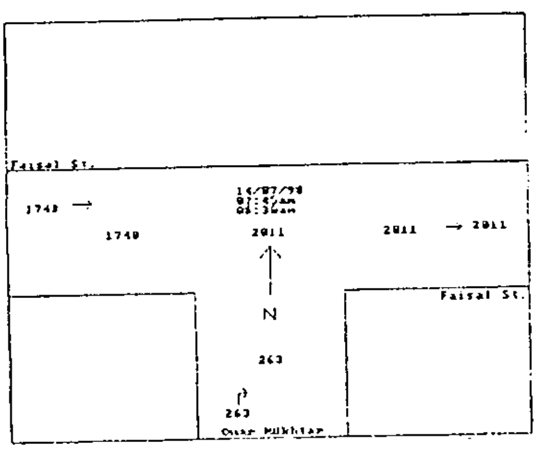

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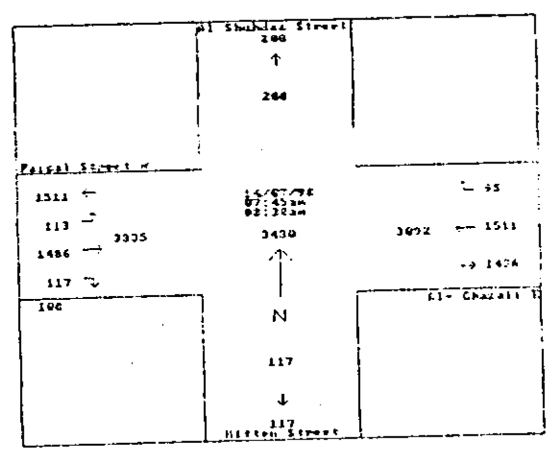

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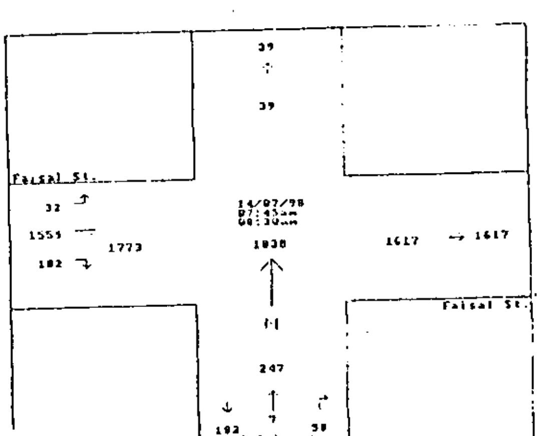

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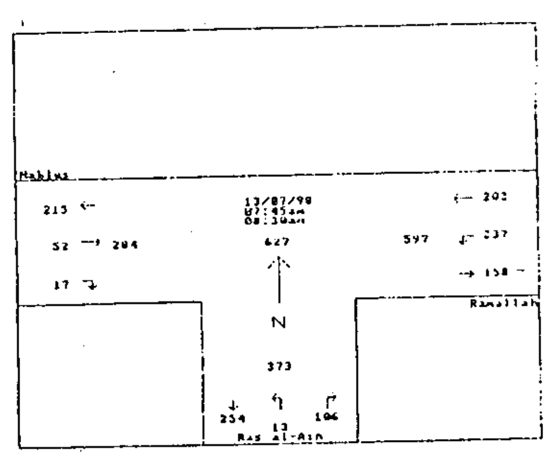

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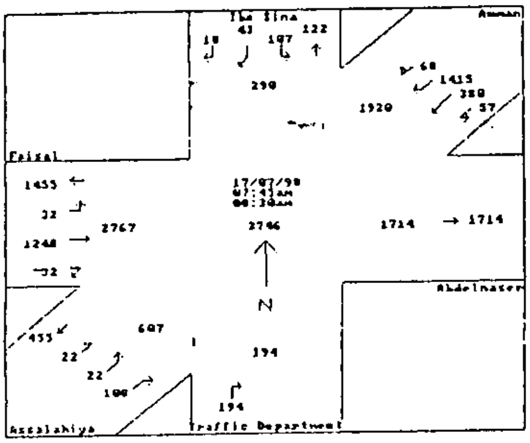

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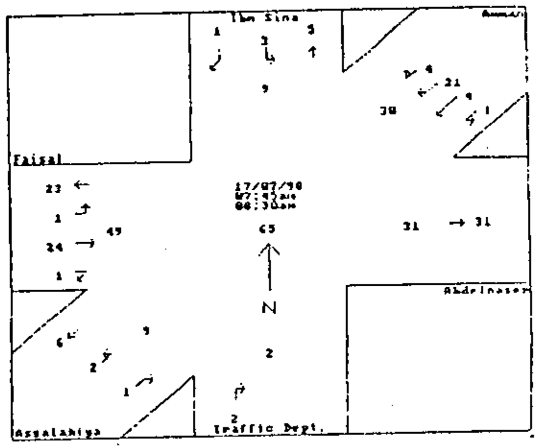

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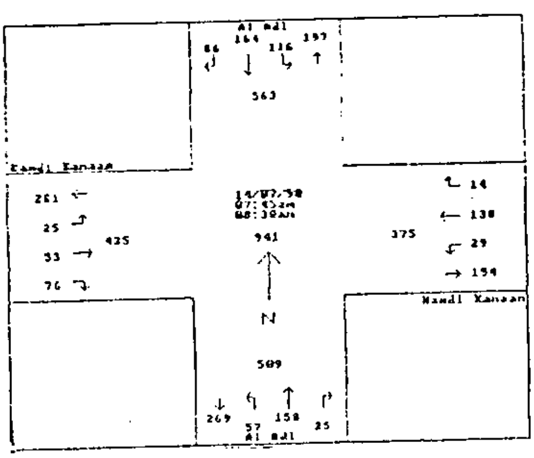

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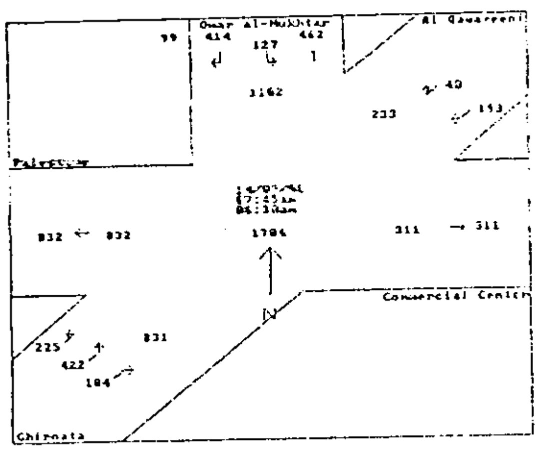

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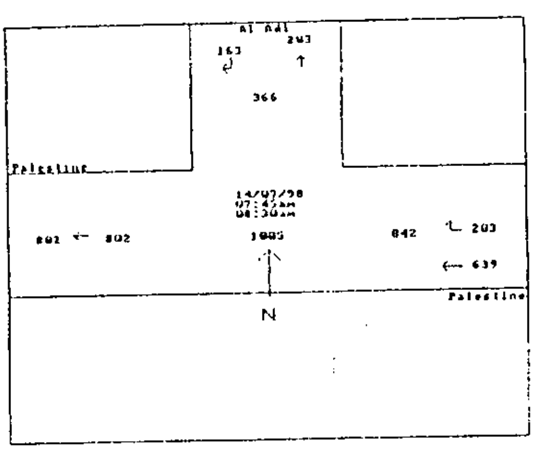

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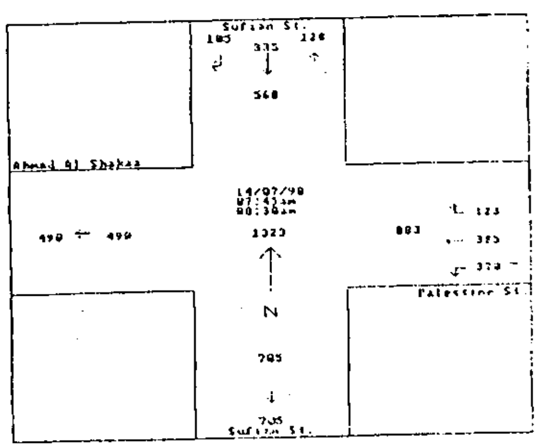

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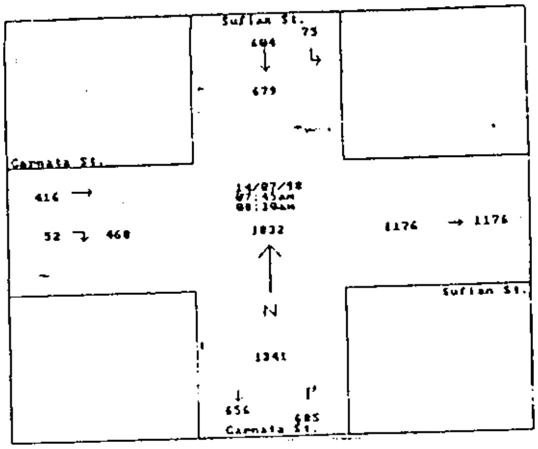

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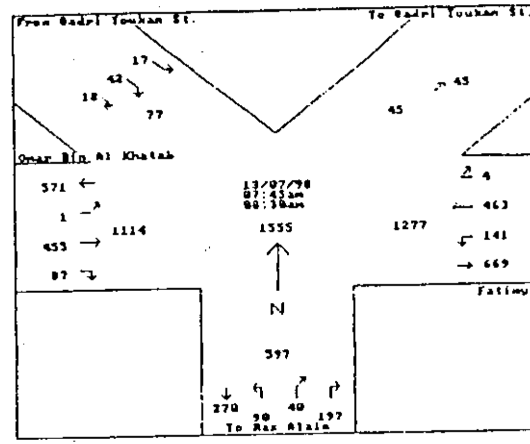

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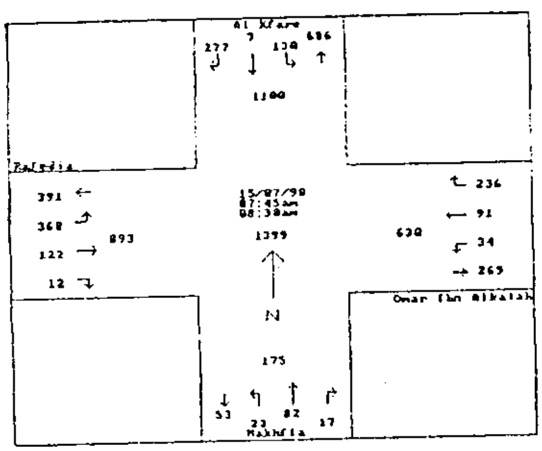

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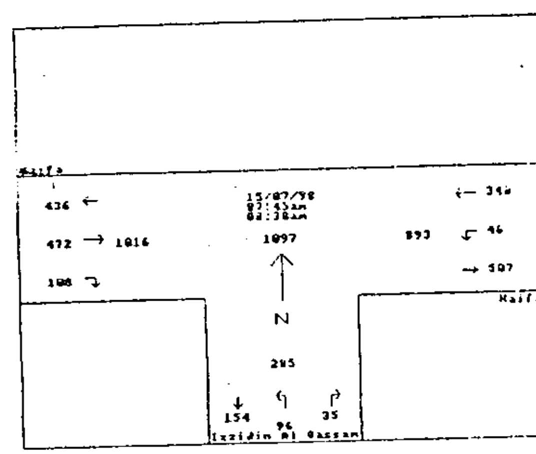

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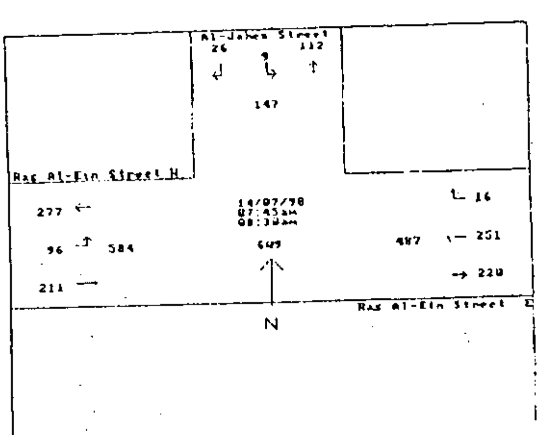

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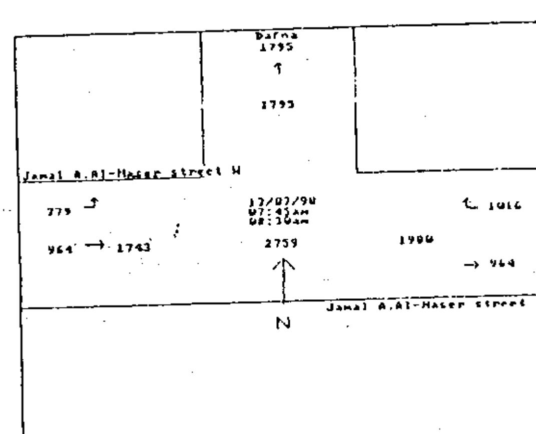

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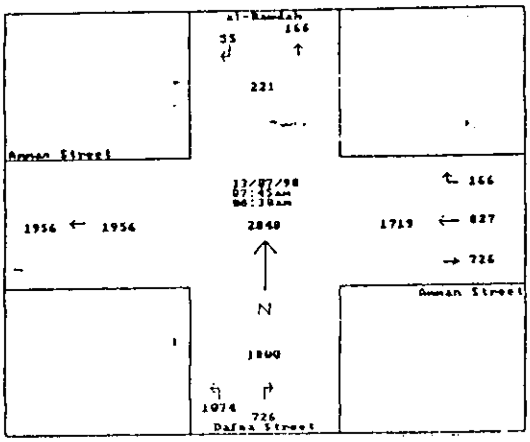

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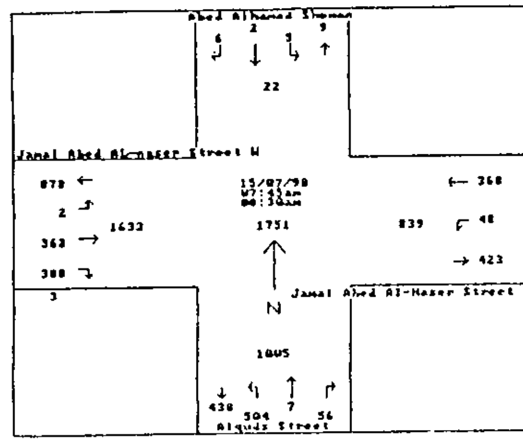

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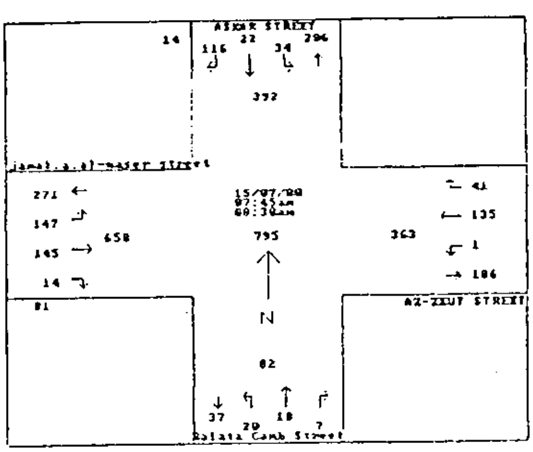

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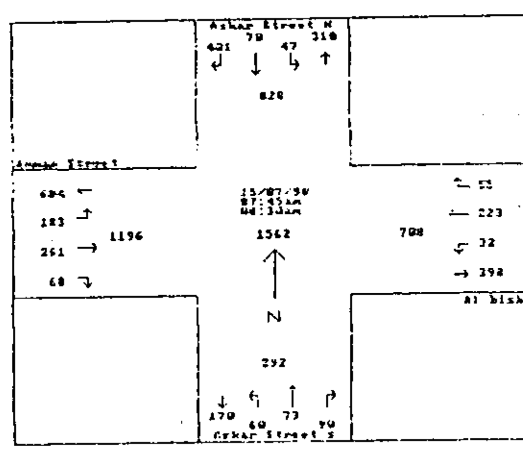

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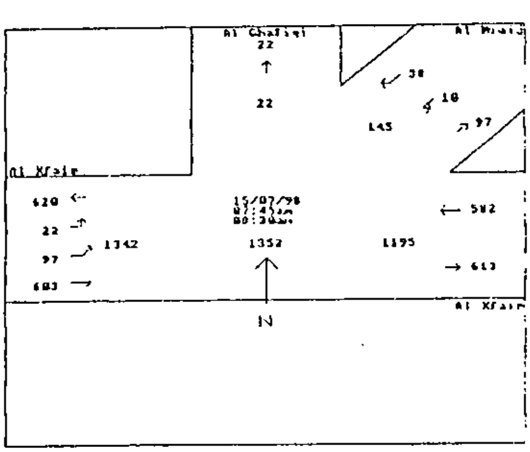

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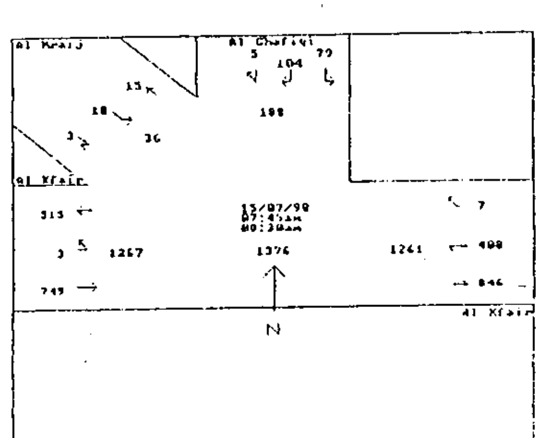

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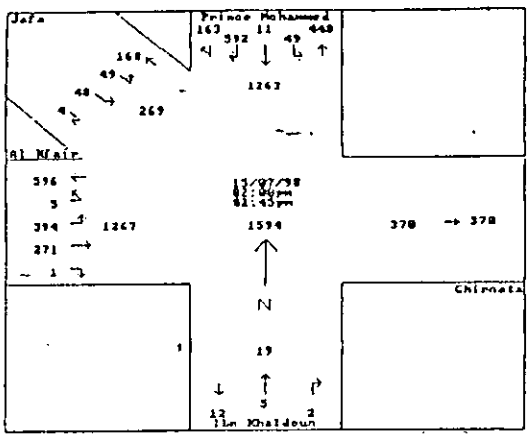

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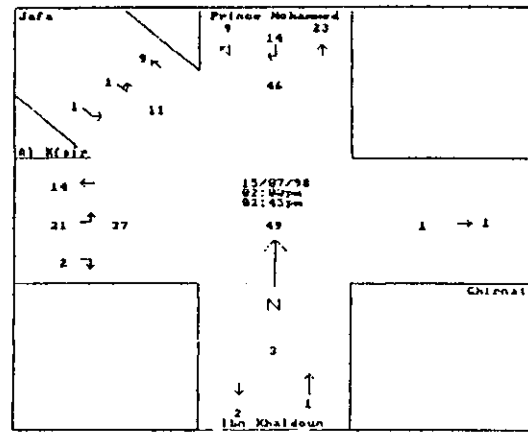

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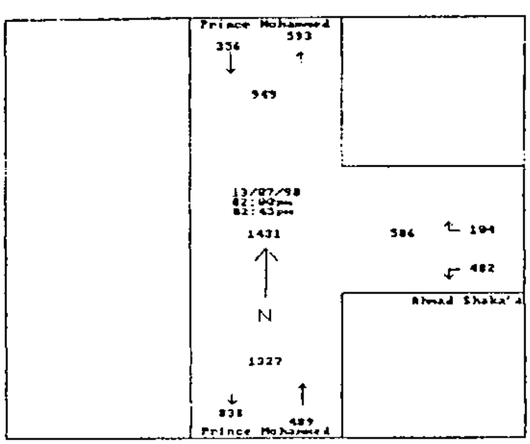

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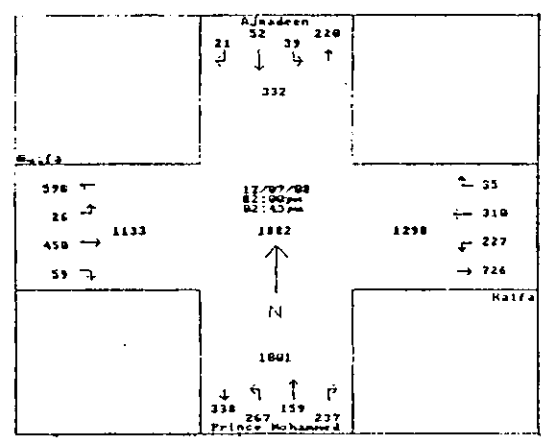

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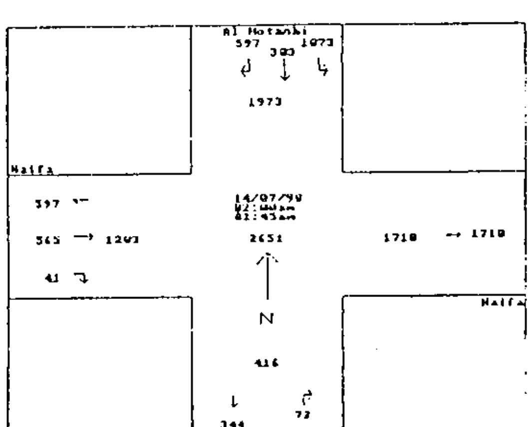

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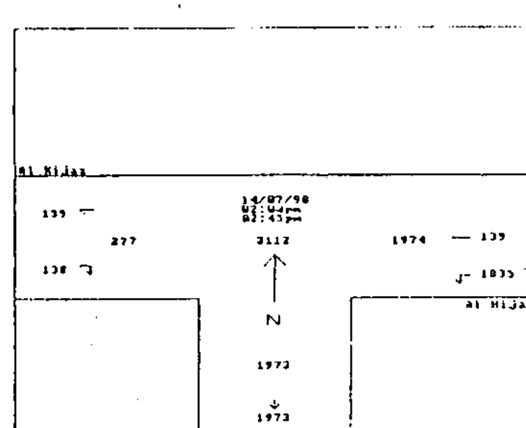

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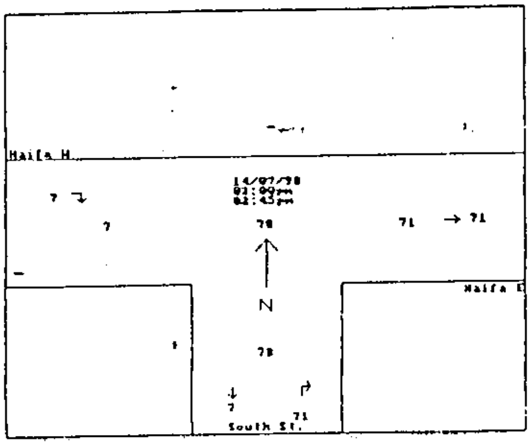

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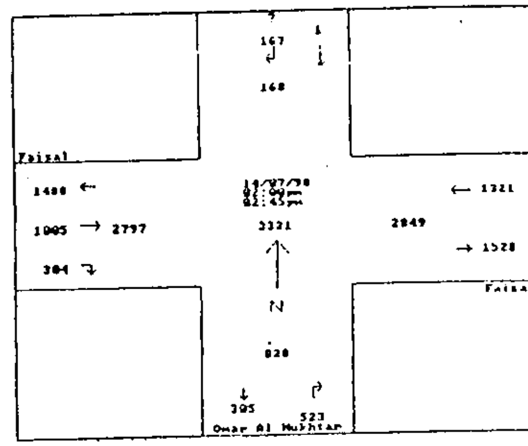

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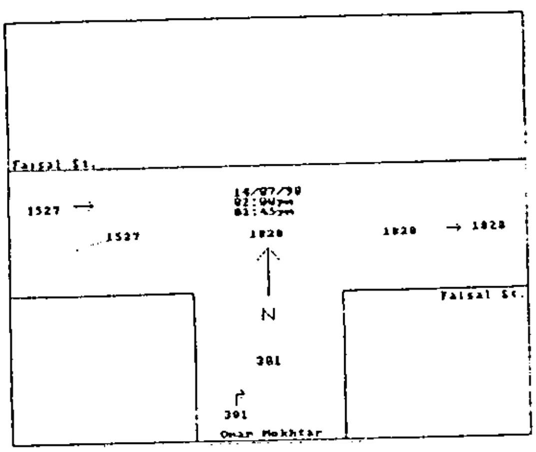

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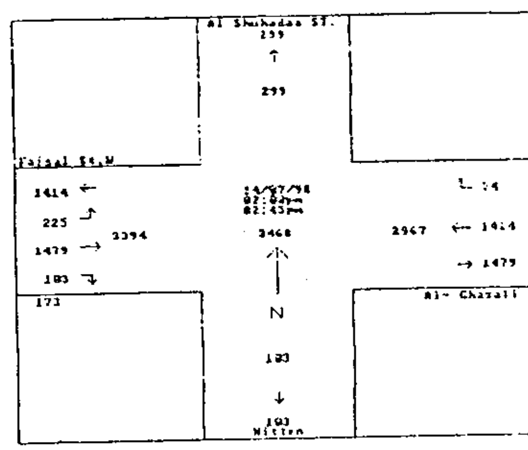

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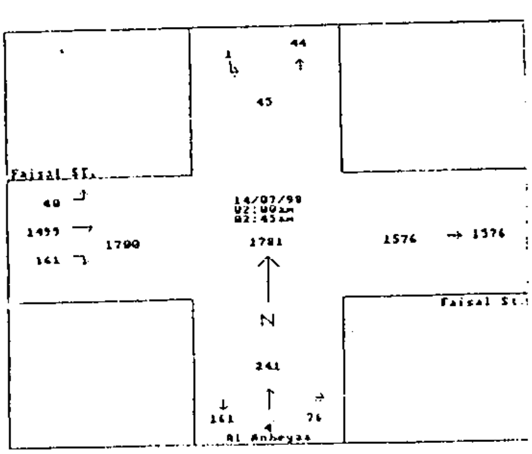

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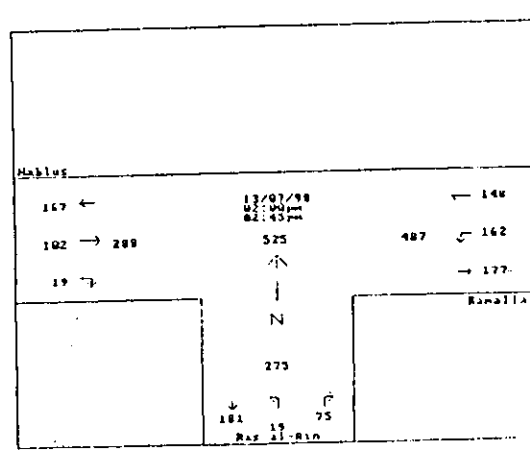

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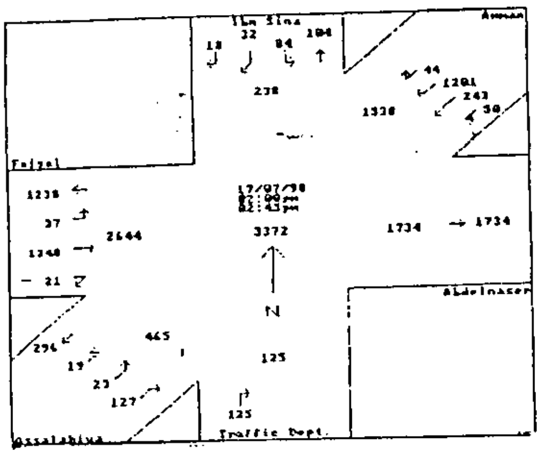

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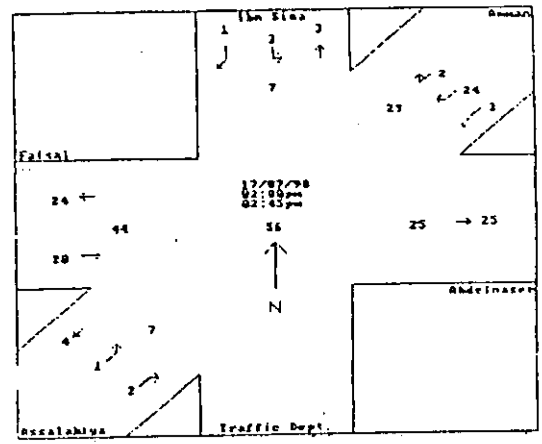

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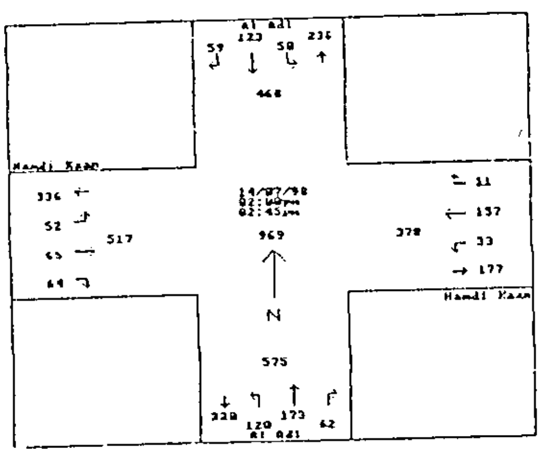

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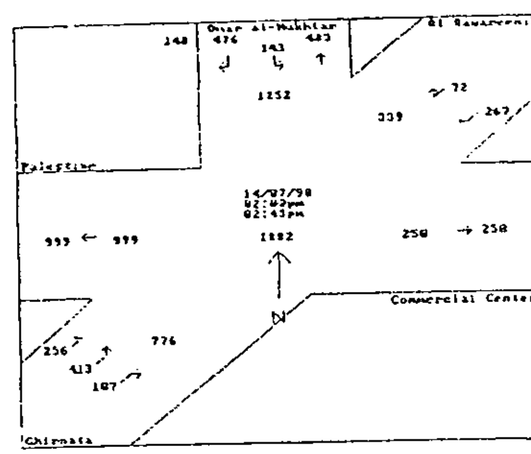

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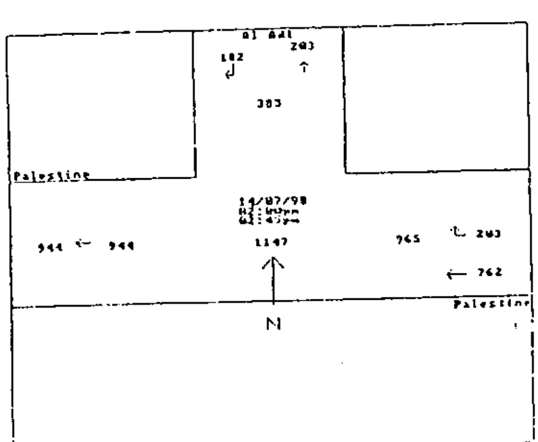
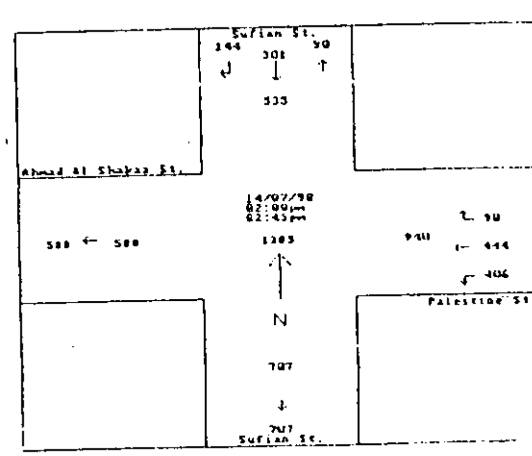
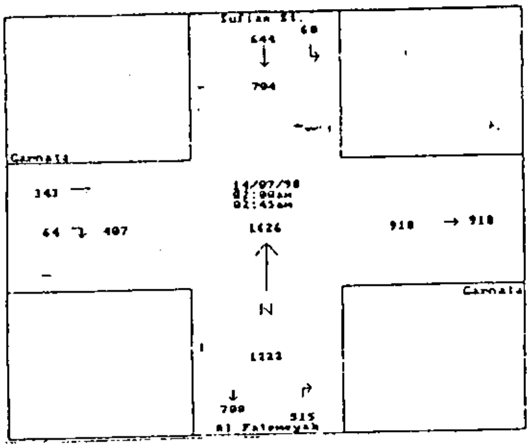


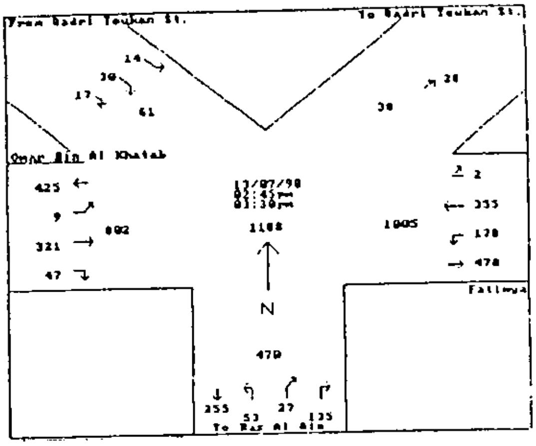
Intersection No.(171P)



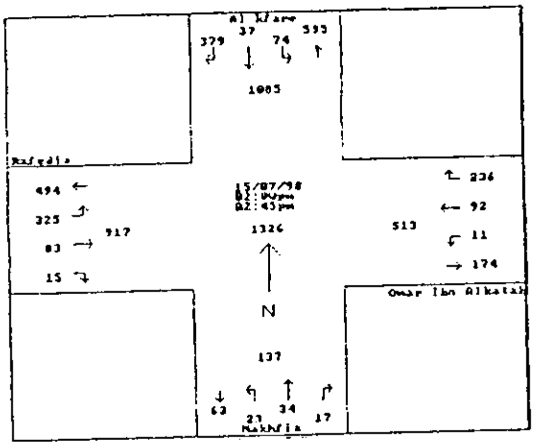
Intersection No.(18P)



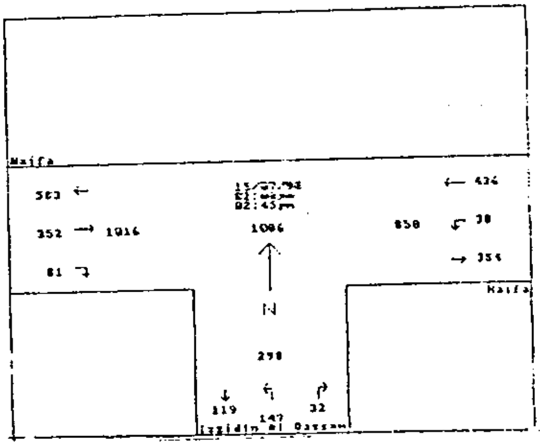
Intersection No. (19P)



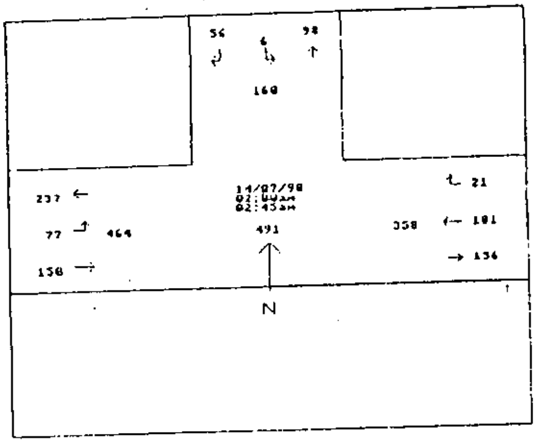
Intersection No.(20P)



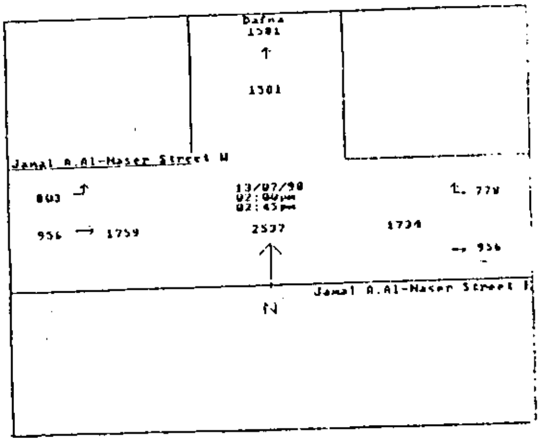
Intersection No.(21P)



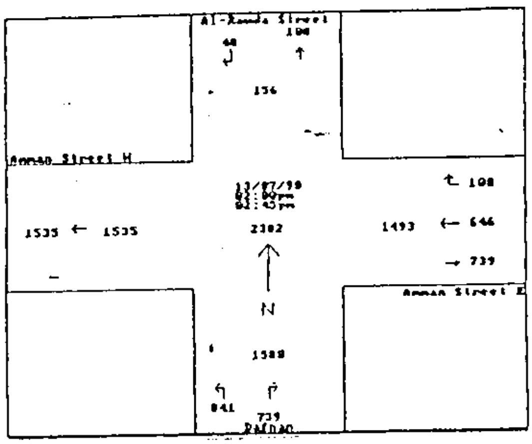
Intersection No.(22P)



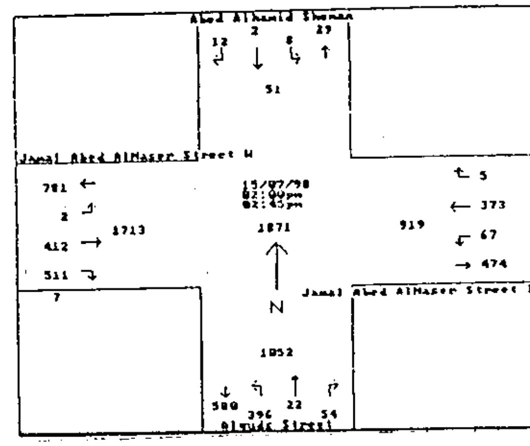
Intersection No.(25P)



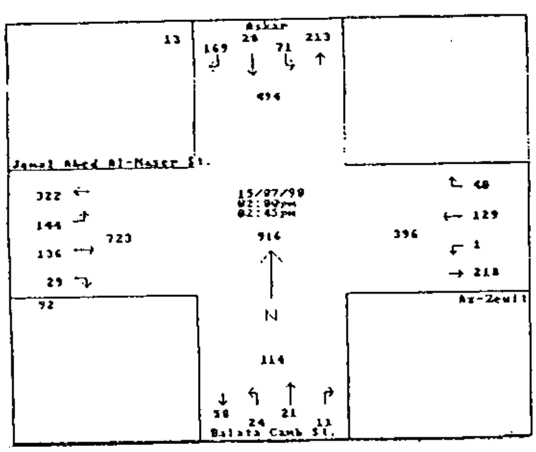
Intersection No.(31P)



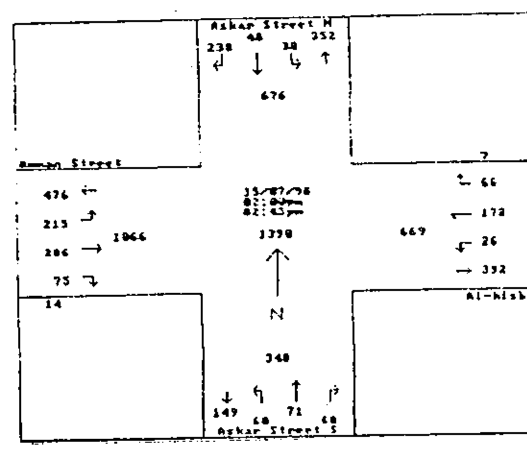
Intersection No. (32P)



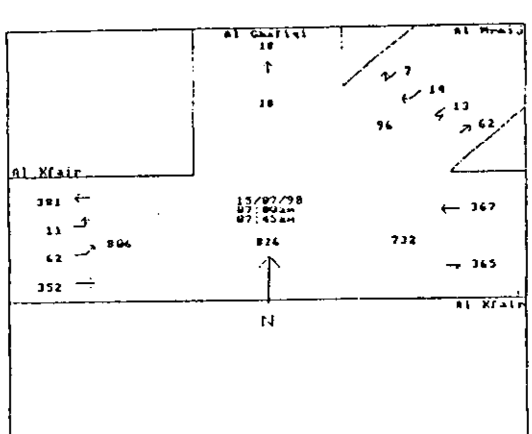
Intersection No.(33P)



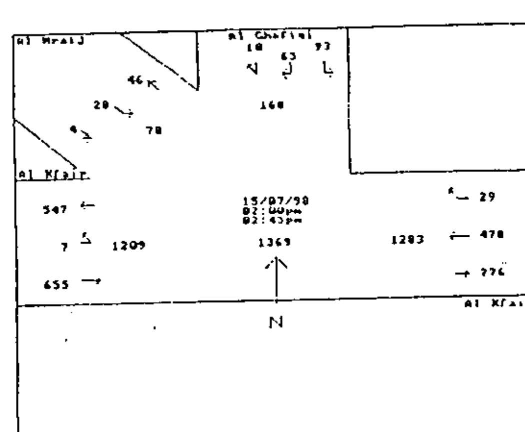
Intersection No.(34P)



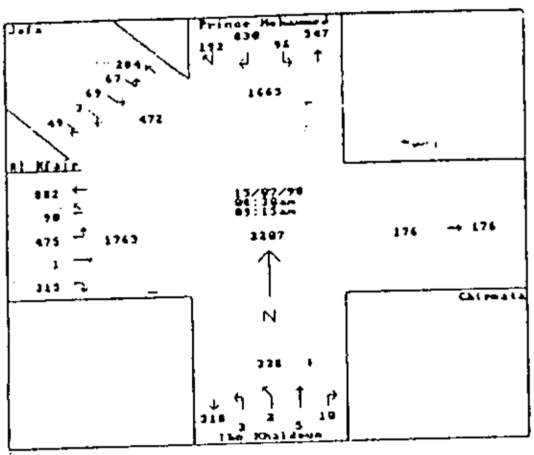
Intersection No.(35P)



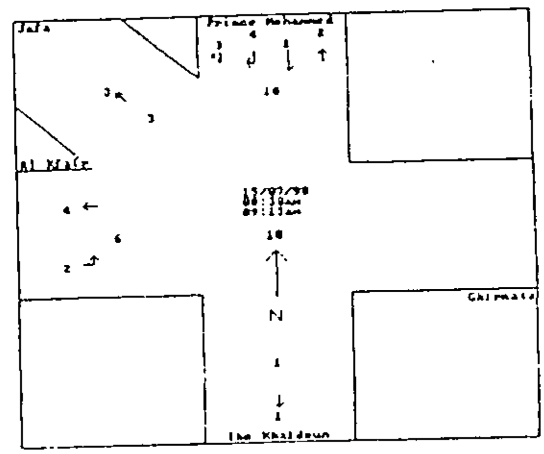
Intersection No.(38P)



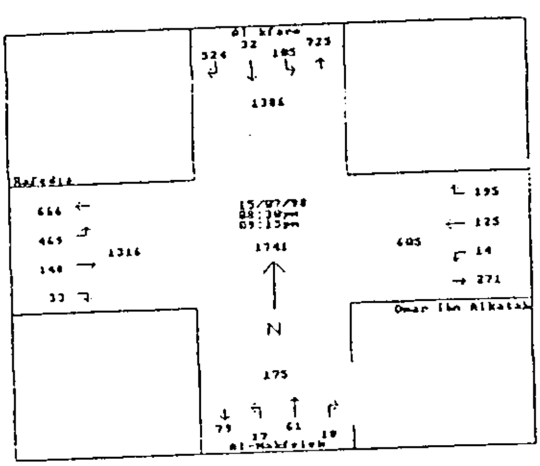
Intersection No.(39P)



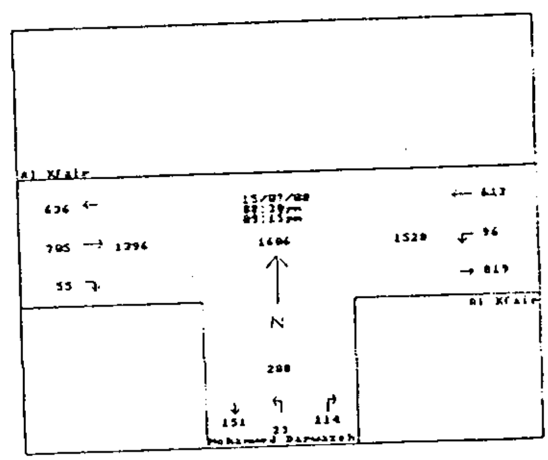
Intersection No. (1N)



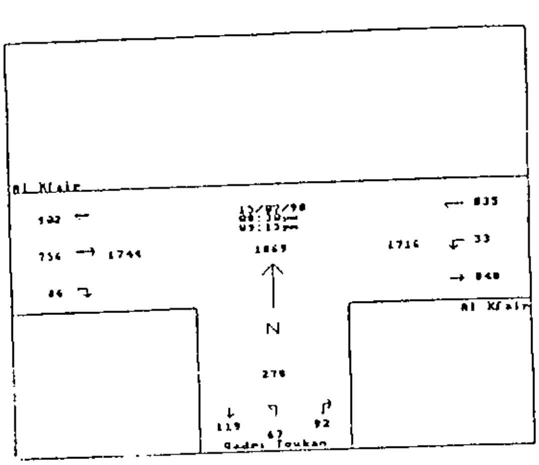
Intersection No.(1NB)



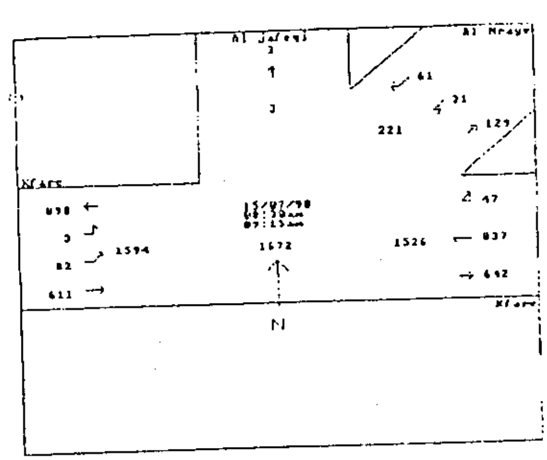
Intersection No.(21N)



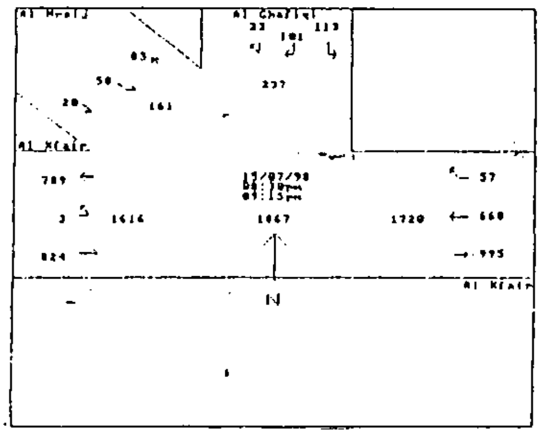
Intersection No.(36N)



Intersection No.(37N)



Intersection No.(38N)



Intersection No. (39N)

Appendix D

Accidents Database Structure

Schools Database Structure

Accidents Database Fields

The accident database structure consists of 110 fields as shown in Table 1. Each number is named, numbered and described. These fields were classified into the following groups:

1. Identification

This group forms the first ten fields as follows:

- Field 1 "ID" is the default identification number of each accident. When adding an accident on the map, it is registered directly in the database. This field is a read only one consists of a corresponding ascending order number.

- A geographic reference is provided by Fields 2-4, which can help to identify the exact location of the accident. Field 2 identifies the longitude coordinate and field 3 identifies the latitude coordinate of the accident location. These two fields were specified automatically once the location is specified on the map.

- The main road on which the accident occurred was identified by field 4, which shows the link number on which the accident occurs.

- Field 5 "CLASS" shows road classification on which the accident occurred, where roads are classified into main, collector, and local roads.
- Field 6 describes the address of the accident location as specified in the accident record of the Police Department.
- Field 7 is named ACCNUM and it records the accident number from individual accident reports. The accident number is a numeric field with a width of 8 digits. It consists of a corresponding ascending order number.
- Field 8 "POLICID" shows the accident number according to the recording system in the Police Department.
- Field 9 "POLCLAS" shows the type of record from the point of view of the Police Department. This field was added because there was an overlap in numbering system of the Police Department, so this field distinguishes between types of reports used in the police department.
- Field 10 "ISSU_NO" shows the accident number according to the court numbering system (if the accident record got to the court).
- Accident Conditions

- Field 18 "EXPERT" refers to the policeman who recorded this accident.

- Field 19 "FREQ" refers to the frequency of accidents at the same location.

- Field 20 "REASON" describes primary contributing circumstances for the accident.

- Field 21 "TYPE" describes the type of accident (rear-end, right angle, etc.).

- Field 22 "ROADTYPE" describes type of the road (intersection or a link).

- Vehicles Involved in the Accident

- Field 23 "NO_OFVEH" refers to the number of vehicles involved in the accident.

- Fields 24-27 describe vehicle no.1 type, year of production for vehicle no.1, vehicle no.1 ownership and vehicle no.1 model. Fields 28-39 describe the same information as in fields 24-27 for vehicle no. 2, vehicle no. 3, and vehicle no. 4, respectively.

- Fields 102-109 refer to the severity of injury1 up to injury8, respectively.

4. Slideshow

- Field 110 "SLIDESHO" shows the accident condition diagram. The condition diagram was scanned for the year 1998, court reports only, because they were the main reports showing condition diagrams in this year.

Table 1: Accidents Database Structure

D	Field Name	Field Description	Field Type*/Width
		1. Amjad Abed Al-hak 2. Morad Antari 3. Ryiad Eshtayih 4. Fo'ad Eshtayih 5. Wajed Halabe 6. Ebraheem Deiab 7. Saleem Abdallah 8. Feras Eshtayih	
:0	REASON	Accident reason 1. No charge 2. Extra speed 3. Extra speed regarding the location 4. Illegal maneuvering 5. Signals 6. Bright 7. No glow 8. Illegal Freight 9. Breaks are defected 10. Steering is defected 11. Other defects in the vehicle 12. Do not drive on the right side 13. Illegal turning 14. Do not give priority to pedestrian 15. Pedestrian performance 16. Do not give priority to vehicles 17. Do not stop on the stop sign 18. Do not give priority to vehicles with the existence of sign 19. Do not yield to other signs 20. Return behind 21. Illegal stopping 22. Do not keep up the distance 23. Performance of bicycle driver 24. Unavailability of reflectors 25. Drunk drivers 26. Passengers performance 27. Sleeping while driving 28. Other personal reasons 29. Road is not suitable 30. Driving on the opposite direction 31. Opening the door facing the road 32. Sudden stopping 33. Not being sure of the loading and unloading of passengers	N/8

Table 1: Accidents Database Structure

)	Field Name	Field Description	Field Type*/Width
		34.Other reasons	
		35. Unknown	
1	Type	Type of accident	N/8
		1. Rear-end	
		2. Right-angle	
		3.left-turn	
		4. Fixed object	
		5. Sideswipes	
		6. Pedestrian-related	
		7. Run-off road	
		8. Head-on	
		9. Parked vehicle	
		10. Bicycle related	
2	ROADTYPE	Road Type	N/8
		1. Inside the city (intersection)	
		2. Inside the city (Link)	
		3. Between cities (intersection)	
		4. Between cites (link)	
3	NO_OFVEH	Number of vehicles	N/8
4	VEH1TYPE	Vehicle1 Type	N/8
		1. Passenger car	
		2. Taxi	
		3. BUS	
		4. Commercial less than 4 tons	
		5. Commercial less than 15 tons	
		6. Commercial grater than 15 tons	
		7. Trailer	
		8. Agricultural tractor	
		9. Motorcycle	
		10. Bicycle	
		11. Human drawn cart	
		12. Horse drawn cart	
		13.Other	
5	VEH1YEAR	Year of production (vehicle 1)	N/8
6	VEH1OWNER	vehicle 1 ownership	N/8
		1. Security	
		2. Police	
		3. Government	
		4. Driving school	
		5. Diplomacy	
		6. Visitor vehicle	
		7. Israeli	
		8. Stolen vehicle	

Table 1: Accidents Database Structure

	Field Name	Field Description	Field Type*/Width
		9. Ambulance	
		10. Fire brigade	
7	MOD1	Vehicle 1 model	C/15
8	VEH2TYPE	Vehicle 2 Type	N/8
9	VEH2YEAR	Vehicle 2 year of production	N/8
0	VEH2OWNER	vehicle 2 ownership	N/8
1	MOD2	Vehicle 2 model	C/15
2	VEH3TYPE	Vehicle 3 type	N/8
3	VEH3YEAR	Vehicle 3 year of production	N/8
4	VEH3OWNER	vehicle 3 ownership	N/8
5	MOD3	Vehicle 4 model	C/15
6	VEH4TYPE	Vehicle 4 Type	N/8
7	VEH4YEAR	Vehicle 4 year of production	N/8
8	VEH4OWNER	vehicle 4 ownership	N/8
9	MOD4	Vehicle 4 model	C/15
0	DRI1GEND	Driver 1 gender	N/8
		1. Male	
		2. Female	
1	DRIV1AGE	Driver 1 age	N/8
2	DRI1ADD	Driver 1 address	C/15
3	LIC1YEAR	Driver 2 driving license issue year	N/8
4	LIC1TYPE	Driver 2 driving license type	N/8
		1. Tractor	
		2. Passenger, commercial less than 4 tons	
		3. Commercial up to 14.99 tons	
		4. Trailer	
		5. Taxi	
		6. Bus	
		8. Including 2, 3, 5	
		9. Including 2, 3, 4, 5	
		10. Including 2, 3, 4, 5, 6	
5	DRI2GEND	Driver 2 gender	N/8
6	DRIV2AGE	Driver 2 age	N/8
7	DRI2ADD	Driver 2 address	C/15
8	LIC2YEAR	Driver 2 driving license issue year	N/8
9	LIC2TYPE	Driver 2 driving license type	N/8
0	DRI3GEND	Driver 3 gender	N/8
1	DRIV3AGE	Driver 3 age	N/8
2	DRI3ADD	Driver 3 address	C/15
3	LIC3YEAR	Driver 3 driving license issue year	N/8
4	LIC3TYPE	Driver 3 driving license type	N/8
5	DRI4GEND	Driver 4 gender	N/8
6	DRIV4AGE	Driver 4 age	N/8

Table 1: Accidents Database Structure

D	Field Name	Field Description	Field Type*/Width
57	DRI4ADD	Driver 4 address	C/15
58	LIC4YEAR	Driver 4 driving license issue year	N/8
59	LIC4TYPE	Driver 4 driving license type	N/8
60	FAT	Number of fatalities	N/8
61	NO_INJ	Number of injuries	N/8
62	INJU1GEND	Injury 1 gender	N/8
63	INJURY1A	Injury 1 age	N/8
64	INJ1ADD	injury 1 address	C/15
65	INJ1TYPE	injury 1 type 1. Pedestrian 2. Driver 3. Passenger 4. Bicycle driver 5. Passenger with bicycle driver 6. Other 7. Motorcycle driver	N/8
66	INVETY1	Type of vehicle where injury 1 was in during the accident 1. Passenger 2. Taxi 3. Bus 4. Commercial 5. Bicycle 6. Other 7. Motorcycle	N/8
67	INJU2GEND	Injury 2 gender	N/8
68	INJURY2A	Injury 2 age	N/8
69	INJ2ADD	injury 2 address	C/15
70	INJ2TYPE	injury 2 type	N/8
71	INVETY2	Type of vehicle where injury 2 was in during the accident	N/8
72	INJU3GEND	Injury 3 gender	N/8
73	INJURY3A	Injury 3 age	N/8
74	INJ3ADD	injury 3 address	C/15
75	INJ3TYPE	injury 3 type	N/8
76	INVETY3	Type of vehicle where injury 3 was in during the accident	N/8
77	INJU4GEND	Injury 4 gender	N/8
78	INJURY4A	Injury 4 age	N/8
79	INJ4ADD	injury 4 address	C/15
80	INJ4TYPE	injury 4 type	N/8
81	INVETY4	Type of vehicle where injury 4 was in during the accident	N/8
2	INJU5GEND	Injury 5 gender	N/8
3	INJURY5A	Injury 5 age	N/8
4	INJ5ADD	injury 5 address	C/15

Table 1: Accidents Database Structure

D	Field Name	Field Description	Field Type*/Width
5	INJ5TYPE	injury 5 type	N/8
6	INVETY5	Type of vehicle where injury 5 was in during the accident	N/8
7	INJU6GEND	Injury 6 gender	N/8
8	INJURY6A	Injury 6 age	N/8
9	INJ6ADD	injury 6 address	C/15
0	INJ6TYPE	injury 6 type	N/8
1	INVETY6	Type of vehicle where injury 6 was in during the accident	N/8
2	INJU7GEND	Injury 7 gender	N/8
3	INJURY7A	Injury 7 age	N/8
4	INJ7ADD	injury 7 address	C/15
5	INJ7TYPE	injury 7 type	N/8
6	INVETY7	Type of vehicle where injury 7 was in during the accident	N/8
7	INJU8GEND	Injury 8 gender	N/8
8	INJURY8A	Injury 8 age	N/8
9	INJ8ADD	Injury 8 address	C/15
00	INJ8TYPE	Injury 8 type	N/8
01	INVETY8	Type of vehicle where injury 8 was in during the accident	N/8
02	SEVERITY1	severity of injury 1 1. Slight 2. Hard 3. Fatality	N/8
03	SEVERITY2	Severity of injury 2	N/8
04	SEVERITY3	Severity of injury 3	N/8
05	SEVERITY4	Severity of injury 4	N/8
06	SEVERITY5	Severity of injury 5	N/8
07	SEVERITY6	Severity of injury 6	N/8
08	SEVERITY7	Severity of injury 7	N/8
09	SEVERITY8	Severity of injury 8	N/8
10	SLIDESHO	Slideshow	C/40

*: N means number, and C means character

School Database Fields

School database structure consists of four fields as shown in Table 2. The following is a brief description of each field:

- Field 1 "ID" is the default identification number of each school. When adding a school on the map, it is registered directly in the database. This field is a read only consists of a corresponding ascending order number.

- A geographic reference was provided by Fields 2-3, which can help to identify the exact location of the accident. Field 2 identifies the longitude coordinate and Field 3 identifies the latitude coordinate of the school location. These two fields are specified automatically once the location is specified on the map.

- Field 4 represents the school name.

Table 2: Schools Database Structure

ID	Field Name	Field Description	Field Type*/Width
1	ID	Default identification number	N/10
2	LONGITUDE	Longitude coordinate	N/10
3	LATITUDE	Latitude coordinate	N/10
4	Name	School name	C/10

*: N means number, and C means character

Appendix E

Accident Statistics for All Intersections

Accident Statistics for All Intersections, 1997-1998

Intersection ID	Longitude	Latitude	Rank	No. of Accidents	Group*
373	33515774	30672677	6	4	3
611	33543333	30654540	6	4	3
4847	33543266	30654578	6	4	3
637	33539867	30656349	6	4	3
416	33530769	30661508	6	4	3
446	33525360	30664123	6	4	3
417	33529694	30662600	6	4	3
415	33529427	30662357	6	4	3
326	33515041	30662913	6	4	3
267	33511654	30666490	6	4	3
173	33504312	30664297	6	4	3
161	33502548	30663437	6	4	3
93	33565464	30667892	7	3	3
1049	33560173	30663434	7	3	3
375	33503748	30672468	7	3	3
1123	33543311	30656426	7	3	3
640	33540952	30657497	7	3	3
1986	33526518	30664452	7	3	3
1983	33526468	30663695	7	3	3
24	33523739	30666398	7	3	3
348	33518929	30667748	7	3	3
333	33516085	30666152	7	3	3
5014	33514155	30666133	7	3	3
288	33514008	30662857	7	3	3
989	33565861	30654388	8	2	2
343	33514199	30671407	8	2	2
92	33504060	30673419	8	2	2
4989	33502578	30674579	8	2	2
515	33534143	30659918	8	2	2
529	33534882	30659515	8	2	2
499	33535905	30656801	8	2	2
525	33534140	30657309	8	2	2
518	33533246	30660424	8	2	2
97	33531263	30661202	8	2	2
504	33530404	30659820	8	2	2
484	33528419	30663465	8	2	2
451	33525940	30664898	8	2	2
2070	33526547	30664653	8	2	2
447	33526130	30663833	8	2	2
23	33524265	30667028	8	2	2
458	33524094	30667253	8	2	2

Intersection ID	Longitude	Latitude	Rank	No. of Accidents	Group*
362	33522328	30667104	8	2	2
423	33522350	30663315	8	2	2
319	33525853	30658975	8	2	2
338	33517678	30666715	8	2	2
336	33516171	30662941	8	2	2
290	33514997	30666088	8	2	2
302	33514441	30666748	8	2	2
310	33520544	30656785	8	2	2
301	33510922	30670176	8	2	2
289	33513151	30666288	8	2	2
263	33510520	30663024	8	2	2
4835	33495233	30663551	8	2	2
1113	33566165	30668985	9	1	2
1523	33564653	30669736	9	1	2
1104	33563314	30670435	9	1	2
1059	33560873	30668401	9	1	2
1007	33555073	30659401	9	1	2
951	33559760	30652086	9	1	2
1746	33520449	30671572	9	1	2
372	33517041	30673377	9	1	2
826	33509063	30672113	9	1	2
1004	33553699	30658057	9	1	2
691	33551172	30656626	9	1	2
1178	33550135	30656868	9	1	2
1896	33539609	30663622	9	1	2
641	33540632	30657636	9	1	2
627	33552817	30651121	9	1	2
626	33551541	30654320	9	1	2
622	33550630	30651267	9	1	2
4861	33548303	30644994	9	1	2
576	33544311	30652148	9	1	2
536	33537149	30661417	9	1	2
1906	33534626	30660863	9	1	2
514	33536449	30657805	9	1	2
517	33531921	30661213	9	1	2
497	33533594	30658900	9	1	2
513	33532752	30660271	9	1	2
509	33531639	30660965	9	1	2
506	33530921	30660843	9	1	2
4733	33529480	30664840	9	1	2
4846	33527622	30663512	9	1	2
409	33527169	30663014	9	1	2
376	33524967	30666172	9	1	2
442	33524159	30665542	9	1	2

Intersection ID	Longitude	Latitude	Rank	No. of Accidents	Group*
425	33524742	30663349	9	1	2
429	33523385	30665225	9	1	2
424	33522943	30664052	9	1	2
420	33522102	30663389	9	1	2
410	33527452	30658854	9	1	2
405	33527340	30658361	9	1	2
378	33547000	30631960	9	1	2
344	33516025	30670486	9	1	2
340	33514734	30668159	9	1	2
331	33515523	30662954	9	1	2
255	33514427	30662299	9	1	2
305	33512854	30669379	9	1	2
294	33512854	30668196	9	1	2
292	33509886	30667577	9	1	2
284	33512780	30662913	9	1	2
174	33505699	30663144	9	1	2
193	33503554	30669064	9	1	2
140	33500488	30664491	9	1	2
137	33498413	30665836	9	1	2
3859	33497436	30666378	9	1	2

*Mean accident frequency (χ) = 2.55

Standard Deviation (σ) = 2.05

Group 1: 0.0 $<$ Frequency $\leq \chi - \sigma$

Group 2: $\chi - \sigma <$ Frequency $\leq \chi$

Group 3: χ $<$ Frequency $\leq \chi + \sigma$