CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT
COLLEGE OF ENGINEERING AND TECHNOLOGY
PALESTINE POLYTECHNIC UNIVERSITY

HEBRON- WEST BANK
PALESTINE
2017-2018

STREET REHABILITATION SYSTEM USING GIS AND GPS TECHNIQUE

By

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF ENGINEERING

IN

CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

SUPERVISED BY

Eng. Maher Owaiwi

CERTIFICATION

Palestine Polytechnic University

PPU

Hebron-Palestine

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Prepared By:

Walaa Ghniemat **Asmaa Adawi**

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In accordance with the recommendations of the project supervisors, and the acceptance of all examining committee members, this project has been submitted to the Department of Civil and Architectural Engineering in the College of Engineering and Technology in partial fulfillment of the requirements of Department for the degree of Bachelor of Engineering.

Project Supervisors **Department Chairman**

Name: ……………….. **Name:………………..**

May-2018

إهـداء

إلى صاحب الفردوس الأعلى وسراج الأمة المنير وشفيعنا النذير البشير محمد
(صلى الله عليه وسلم)

إلى من سهر الليالي ... ونسي الغوالي ...وظل سندي الموالي ...وحمل همي غير مبالي ... والدي الغالي

إلى... من اثقلت الجفون سهرا ... وحملت الفؤاد هما ... وجاهدت الأيام صبرا ... وشغلت البال فكرا ... ورفعت الأيادي دعاءا ... وأيقنت بالله املاً ...أغلى الغوالي وأحب الأحباب .. أمي العزيزة الغالية

إلى من علمنا أن النجاح قيمة ومعنى ... وعلمنا كيف يكون التفاني والإخلاص في العمل ... ومن معه أمنا أن لا مستحيل في سبيل الإبداع والرقي ... المهندس ماهر العويوي

إلى ورود المحبة .. وينابيع الوفاء ...إلى من رافقوني في السراء والضراء إلى اصدق الأصحاب .. إخوتي وأخواتي

إلى القلعة الحصينة التي الجأ إليها عند شدتي ... أصدقائي الأعزاء

إلى من ضحوا بحريتهم من اجل حرية غيرهم أسرانا البواسل

إلى من هم أكرم منا مكانا ... شهداء فلسطين

إلى هذا الصرح العلمي الفتي والجبار ... جامعة بوليتكنك فلسطين

إلى من احتضنتني كل هذا الكم من السنين ... فلسطين الحبيبة

فريق العمل

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Finally, we extended our thank to members in the Civil Engineering Department , especially the part of Surveying Engineering, which help us in designing our project.

Project Team

الشكر والتقدير

بسم الله الرحمن الرحيم

(قل اعملوا فسير الله عملكم ورسوله والمؤمنون)، صدق الله العظيم

الهي لا يطيب الليل الا بشكرك ولا يطيب النهار الا بطاعتك ...ولا تطيب اللحظات الا بذكرك...ولا تطيب الاخرة الا بعفوك...ولا تطيب الجنة الابرؤيتك الله جل جلاله

الى من بلغ الرسالة وادى الامانة ...ونصح الامة... الى نبي الرحمة ونور العالمين ...
سيدنا محمد صلى الله عليه وسلم

ونتقدم بجزيل الشكر والامتنان الى جامعتنا "جامعة بوليتكنك فلسطين" التي احتضننتنا طوال فترة دراستنا في كلية الهندسة.

ولا بد لنا ونحن نخطو خطواتنا الاخيرة في الحياة الجامعية من وقفة نعود الى اعوام قضيناها في الجامعة مع اساتذتنا الكرام الذين قدموا لنا الكثير باذلين بذلك جهودا كبيرة في بناء جيل الغد لتبعث الامة من جديد...فنتقدم بجزيل الشكر والتقدير لهم جميعا.

قبل ان نمضي نقدم اسمى ايات الشكر والامتنان والتقدير والمحبة الى مشرفنا المهندس ماهر عويوي ، الذي تفضل بالاشراف على هذا المشروع فجزاه الله كل خير وله منا كل التقدير والاحترام على جهوده الطيبة التي بذلها في سبيل تعليمنا.

وفي النهاية نتقدم بجزيل الشكر والعرفان...
الى كل من ساهم في انجاز هذا العمل المتواضع

فريق العمل

Abstract

Linear referencing is a method to store geographical locations on the street or land marks which have linear extension according to the linear distance along land mark.

This method depend mainly on the survey work which is monitored the street with its features by using (GPS).

This project aims to identify the location for different landmarks on Abu Ktelah street e.g. water pipes, ferries, road cracks, the painting of street, and pavements, fountains and so on. And then, calculate the quantities and cost which are required to rehabilitation it by using (GIS) Linear referencing method.

The overall rehabilitation cost of Abu Ktelah Street is 192,200 NIS.

Project Team

الملخص

المرجعية الخطية هي طريقة لتخزين المواقع الجغرافية على الشوارع او المعلم ذات الامتداد الخطي و ذلك عن طريق تحديد المواقع حسب المسافة الخطية على طول معلم خطي. وتعتمد هذه الطريقة بشكل اساسي على العمل المساحي حيث يتم رصد الشارع مع معالمه باستخدام جهاز تحديد الموقع (GPS).

و يهدف المشروع الى تحديد المواقع لمعالم مختلفة على شارع ابو كتيلا مثل أنابيب المياه و العبارات و تشققات الشارع و دهان الشارع و الأرصفة والمناهل ، واشارات المروروغيرها و من ثم حساب الكميات و الكلفة اللازمة لإعادة تأهيله باستخدام المرجعية الخطية.

وتبلغ التكلفه التقديرية لاعادة صيانة شارع ابوكتيلا حوالي 192,200 شيكل.

فريق العمل

CHAPTER ONE

INTRODUCTION

This chapter contains:

1.1 General.

1.2 Problem Definition.

1.3 Project Area.

1.4 Objectives and Advantages.

1.5 Methodology of Work.

1.6 Definitions of Terms.

1.7 Organization of the Report.

INTRODUCTION

1.1 General

Advanced transportation systems are a key characteristic of modern-day society. It affects the lifestyle of individuals, the structure of the society, and gives people convenience and freedom. However, it also poses a problem of frustrating congestion and delays, especially in most metropolitan areas, where traffic demand is steadily increasing and the transportation infrastructure, on the other hand, has been unable to expand at the same pace. These facts lead to the so-called traffic congestion problem.

Traffic congestion itself has directly cost millions of dollars of wasted fuel and millions of hours of delayed man-power, and has also resulted in increase accidents, which in turn increase congestion, and aggravate the problem of environmental pollution. This problem costs heavily and deserves serious attention.

The magnitude and seriousness of traffic congestion problems have been noticed by authorities, society, as well as different research agencies. Some assessment studies on this problem have been conducted by many transportation professionals.

The management of road transport, since it is the only used mode of transport in Palestine, plays an important factor in the country’s development. The transport sector in Palestine contributes significantly to the economic growth and poverty eradication in the country through various ways, especially, through trade and tourism.

Dimitriou and Banjo (1990) discuss transport problems of third world cities. They include traffic congestion, impacts to the environment, and high road accidents. Even today, Palestine still faces problems of traffic congestion, high road accidents, weak institutional support leading to poor definition of the problem at hand and differing technology transfer priorities in problem resolution.

Nowadays, however, the need for preventive maintenance is being appreciated in Palestine. For that, Palestinian Ministry of Public Work and Housing (MOPWH), indicated that roads maintenance needs are based on road inventory, condition and traffic data, all of which can be effectively collected and managed using Geographical Information System (GIS).

As a transportation professional, you need the most cost-effective tools to manage physical assets, human resources, and office and field operations. GIS can help you plan, monitor, and manage strategic infrastructure more effectively. Use the location power of your data to determine capacity enhancements, improve operations, and identify the most strategic investments for maintaining your transportation infrastructure. GIS can make your stand-alone systems work smarter by connecting them, allowing you to unlock the power of your information systems. Plan a smarter infrastructure today.

1.2 Problem definition

There have been many cases of poor transport services in Palestine. The road infrastructure was developed in a chaotic manner, with no plan for a coordinated and rationalized use of modes and routes. As a result, it has suffered from negligence leading to road infrastructure failure. Attempts to maintain roads have frustrated users as they (the roads) almost immediately develop pot holes after repair. Worse still, road maintenance has proven ad hoc, thus making the transport system unsatisfactory.

Also, in Palestinian cities, such as Hebron City, the decision to perform maintenance works on a road is initially based on; records of past expenditures on the road sections in question, availability of resources and traffic levels along these roads. However, most of the data required for road maintenance is spatial in nature. This makes Linear Referenced GIS Method relevant for the purpose.

1.3 Project area

Hebron City is located in the southern West Bank, 30 km south of Jerusalem, figure (1.1). It lays 930 meters above sea level. It is locally well known for its grapes, figs, limestone, pottery workshops and glassblowing factories, and is the location of the major dairy product manufacturer.

Hebron City is considered to be one of the largest municipalities in West Bank with 48 Km^2 municipal area, and 250,000 inhabitants, (Palestinian Bureau of Statistic, 2017). Its services vary from constructing new roads, maintaining old ones, supplying fresh water, managing wastewater, collecting solid waste and supplying electrical power, and many other services.

Figure (1.1): Hebron City, Location Map

Abu Ktelah Street is located at the north-western part of Hebron city, as is shown in figure(1.2); it's almost 2 km length. It's one of the main street's that serves Al Ahli Hospital and consider as a vital main street which links Al Salam Street with the north western entrance of Hebron City.

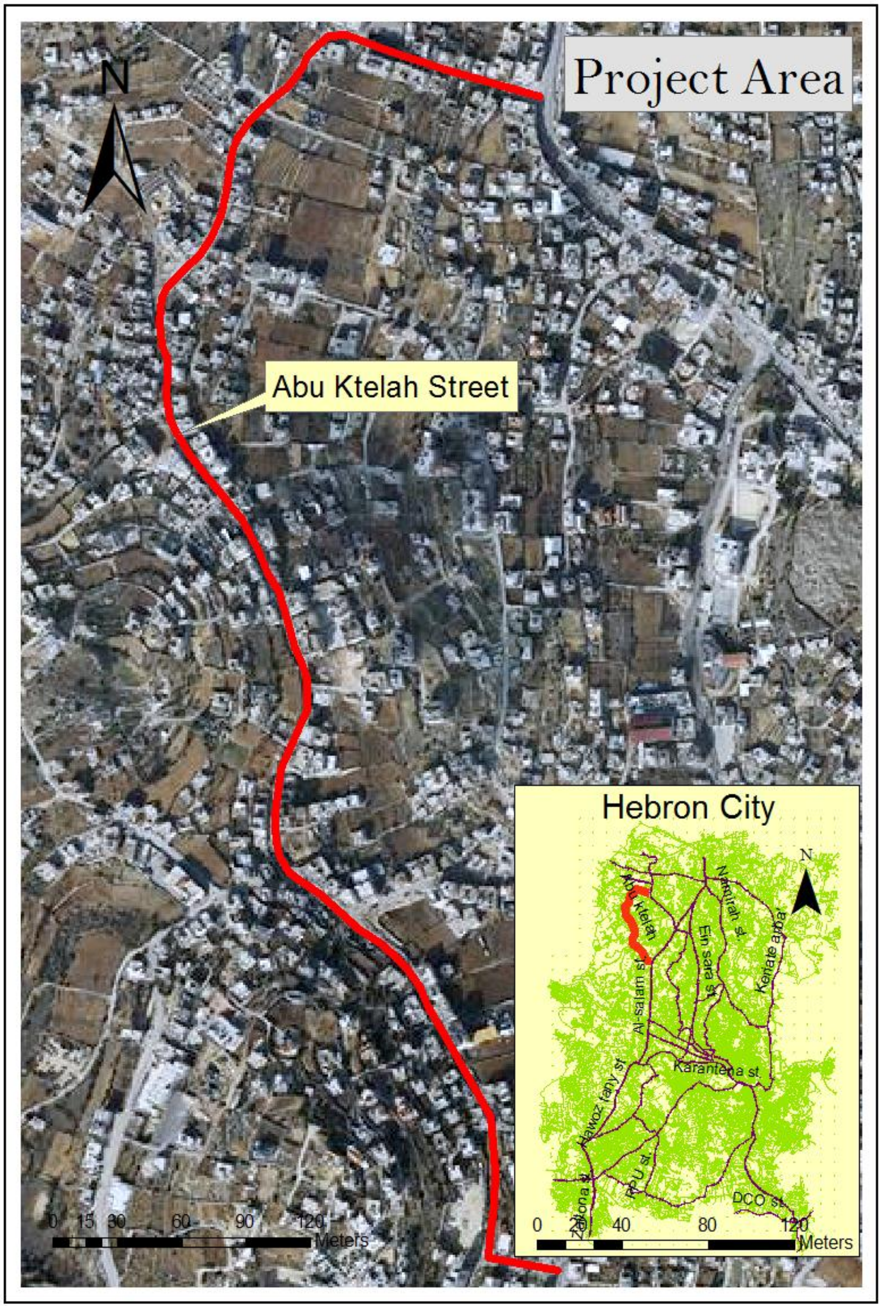


Figure (1.2): Location Map of Abu Ktelah Street

1.4 Objectives and advantages

The overall objective of this project is to serve Hebron Municipality with GIS Linear Referencing Method as a tool for street rehabilitation. More specifically the objectives of this study may be summarized as:

1. Identifying the location of different street events of Abu Ktelah, such as streets centerline trenches, street cracks, painting, and many others.
2. Using Linear referencing as a tool to associate multiple sets of attributes of Abu Ktelah Street to portions of linear features without requiring that underlying lines be segmented (split) each time that attribute values change.
3. Using Linear referencing as a tool to find the rehabilitation need's for streets.
4. calculate quantities for rehabilitation of this street by using " GIS Linear Referencing and GPS system "
5. Identifying of different surveying elements. This may include;

Culvert	Patch	Pole	Sign	Manhole
Ditch	Guardrail	Pavement	Paint	Wall
shoulder	Cat Eye	Jubbah	Along Track Crack	

Table (1.1): Different Surveying Elements

1.5 Methodology of the work

The project consists of three phases, which is designed to be completed in according with schedule in table (1.2). The description of each of the three phases of the project tasks involved are listed below:

PHASE NO.	TITLE	DURATION (2017&2018)						
		10/2017	11/2017	12/2017	1/2018	2/2018	3/2018	4/2018
One	**Data Collection And Survey.**							
Two	**Road Surveying.**							
Three	**Writing the report and Building Liner Referencing Model and Other related jobs.**							

Table (1.2): Phases of the Project with their Expected Duration

1.5.1 First phase: data collection and surveying.

During this phase, available data and information will be collected from different source. Moreover, many site visits to both project area and the related local organization will be conducted. First phase included the following tasks:

1. Collection of aerial topographical maps for the study area.
2. Using the tutorial and to get trained with the method of Linear Referencing.
3. Analyze the work.

1.5.2 Second phase: road surveying.

During second phase, the necessary survey will be conducted using the Linear Referencing Methods. This will include:

1. Surveying of Linear Referencing Events using traditional methods and or GPS.

2. Establish Entering the event data and attribute data to the GIS

3. Building Linear Referencing Model and analyses, which include:

   • Determining Route structure

   • Determining Measures

   • Create Events

   • Display Event Data, Cartographic Output

4. Construct the Roads GIS Maintenance Management Support System and prepare them to be used.

5. Preparing the final map.

1.5.3 Third phase: Writing the report and Building Liner Referencing Model and Other related jobs.

After finishing the construction of Roads GIS Maintenance Management Support System using Linear Referencing Method, the research team will prepare a dynamic map of street route and events that need to be maintained. The System will be a dynamic and the map feature will be changed automatically according to maintenance situation. A cost estimate of each modeled event as well as the overall budget will be estimated.

The project will be prepared and submitted to the Department of Civil and Architectural Engineering of Palestine University.

1.6 Definitions of Terms

This document introduces some vocabulary that is essential to understanding the linear referencing. Some definitions are related to documents with thorough descriptions, table (1.3);

Term	Description
Route	A route is any line feature, such as a street, highway, river, or pipe, that has a unique identifier and a system of measurement. Routes are stored in a route feature class.
Route feature class	A route feature class is a collection of routes with a common system of measurement stored in a single feature class (for example, a set of all highways in a county). A route feature class differs from a standard line feature class in that, along with x- and y-coordinates, it also stores an m-coordinate (x, y, h).
Measure	A value stored along a linear feature that represents a location relative to the beginning of the feature, or some point along it, rather than as an x, y coordinate. Measures are stored as m-values on route vertices. Measures can be any unit of measurement, such as miles, meters, and time.
M-value	A measure that is added to a line feature. M-values are stored in the m-coordinate of each vertex on a route feature. M-values are used to measure the distance along a line feature.
Events	An event is a linear, continuous, or point feature that occurs along a route feature. Anything that occurs on or describes a route feature can be an event. In the transportation field, examples of events might include pavement quality, accident sites, and speed limits. Events are stored in event tables.
Event tables	Event tables contain information about assets, conditions, and events that can be located along route features. Each row in the table references an event, and its location is expressed as measurements along a route feature. There are two types of route event tables: point event tables and line event tables.
Dynamic segmentation	Dynamic segmentation is the process of computing the map locations of events stored and managed in an event table along route features and displaying them on a map. The term dynamic segmentation is derived from the concept that line features need not be split (in other words, "segmented") each time an attribute value changes—you can "dynamically" locate the segment.

Table (1.3): Definitions of Terms

1.7 Organization of the project

The study report is prepared in according with the objectives, and scope of the work. The report consists of four chapters as:

Chapter one: Entitled (introduction), outline the problem, projects objective and phases of the projects.

Chapter two: Entitled (Geographic Information System (GIS) And Linear referencing) , this chapter covers how we deal with (GIS) to carry out the projects, how it works, the importance of these software and Linear Referencing Method definition, relation with GIS, and also Its importance in transportation.

Chapter three: Entitled (Data Collection and Preparation), this chapter describes the field work procedures, Linear measurement and surveying of different street events.

Chapter four: Entitled (Construction of Roads Maintenance Management Support System using Linear Referencing Method).

Chapter five: Entitled (Conclusions and Recommendations).

CHAPTER TWO

GEOGRAPHIC INFORMATION SYSTEM (GIS)

&

LINEAR REFERENCING

This chapter Contains:

GEOGRAPHIC INFORMATION SYSTEM (GIS)

&

LINEAR REFERENCING

2.1 Introducing GIS

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. The acronym GIS is sometimes used for geographical information science or geospatial information studies to refer to the academic discipline or career of working with geographic information systems and is a large domain within the broader academic discipline of Geoinformatics.

A GIS can be thought of as a system that provides spatial data entry, management, and retrieval, analysis, and visualization functions. Generally, a GIS implementation may be custom-designed for an organization. Hence, a GIS deployment developed for an application, enterprise, or purpose may not be necessarily interoperable or compatible with a GIS that has been developed for some other application, enterprise, or purpose. What goes beyond a GIS is a spatial data infrastructure, a concept that has no such restrictive boundaries.

In a general sense, the term describes any information system that integrates stores, edits, analyzes, shares, and displays geographic information for informing decision making. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations. Geographic information science is the science underlying geographic concepts, applications, and systems.

The first known use of the term "Geographic Information System" was by Roger Tomlinson in the year 1968 in his paper "A Geographic Information System for Regional Planning". Tomlinson is also acknowledged as the "father of GIS".

2.2 GIS Definition:

Geographic Information System (GIS) is a computer system build to capture, store, manipulate, analyze, manage and display all kinds of spatial or geographical data. GIS applications are tools that allow end users to perform spatial query, analysis, edit spatial data and create hard copy maps. In simple way GIS can be define as an image that is referenced to the earth or has x and y coordinate and it’s attribute values are stored in the table. These x and y coordinates are based on different projection system and there are various types of projection system. Most of the time GIS is used to create maps and to print. To perform the basic task in GIS, layers are combined, edited and designed.

GIS can be used to solve the location based question such as “What is located here” or Where to find particular features? GIS User can retrieve the value from the map, such as how much is the forest area on the land use map. This is done using the query builder tool. Next important features of the GIS is the capability to combine different layers to show new information. For example, you can combine elevation data, river data, land use data and many more to show information about the landscape of the area. From map you can tell where is high lands or where is the best place to build house, which has the river view. GIS helps to find new information, figure (2.1).

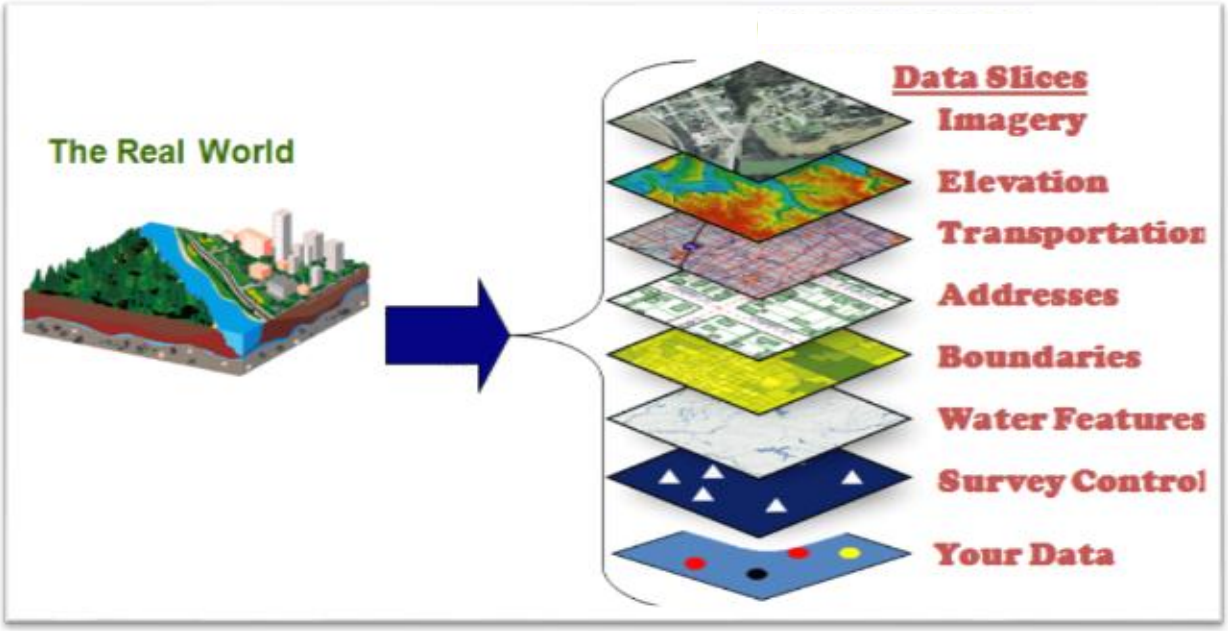


Figure (2.1): Real World Representation in GIS Model

2.2.1 How GIS Works:

- Visualizing Data: The geographic data that is stored in the databases are displayed in the GIS software.
- Combining Data: Layers are combined to form a map of desire.
- The Query: To search the value in the layer or making a geographic query.

2.2.2 Advantage of GIS:

- Better decision made by government people.
- Improve decision making with the help of layered information.
- Citizen engagement due to better system.
- Help to identify communities that are under risk or lacking infrastructure.
- Helps in identifying criminology matters.
- Better management of natural resources.

- Better communication during emergency situation.
- Cost savings due to better decision.
- Finding different kinds of trends within the community.
- Planning the demographic changes.

2.2.3 Types of GIS Data:

Raster Data: Raster data store information of features in cell based manner, figure (2.2). Satellite images, photogrammetry and scanned maps are all raster based data. Raster model are used to store data which varies continuously as in aerial photography, a satellite image or elevation values (DEM- Digital Elevation Model).

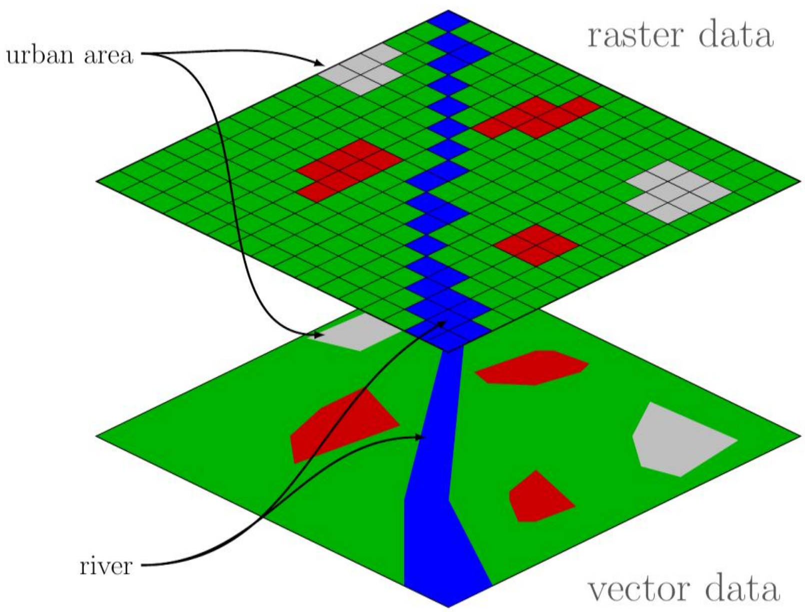


Figure (2.2): GIS Raster Data

Vector Data: There are three types of vector data, points, lines and polygons. These data are created by digitizing the base data. They store information in x, y coordinates.

Vectors models are used to store data which have discrete boundaries like country borders, land parcels and roads, figure (2.3).

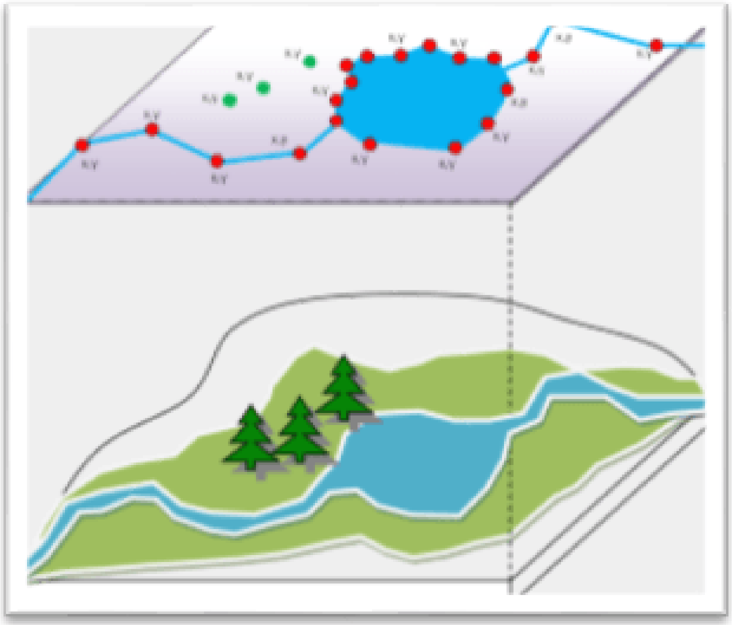


Figure (2.3): GIS Vector Data

2.3 GIS Application

2.3.1 Disaster Management

Hurricane Katrina is seen by many as the first time that GIS was used a disaster management tool. Thanks to newly available technology, the first responders on the ground shared a great deal of data about street plans - particularly which streets were and were not accessible and the extent of the flooding. Despite that FEMA and the government came in for criticism, many agree that the efforts of data transmission both prior to and during initial relief efforts were vital to relief efforts.

2.3.2 Crime Statistics

GIS is now vital to law enforcement and planning in terms of crime statistics. Though most police forces in the USA have used them for a long time, automated and digital mapping of reported crime has made the process much easier, especially when looking at different types of crime from different departments in larger cities. The ability to share maps and look for correlations between different types of crime can give police a much better idea of an overall picture of a wider region . The study cited here also permitted community leaders and the police to get a better understanding of each other, facilitating two-way dialogue.

2.3.3 Archaeology

GIS is now critical to many elements of archaeology as it takes on more elements and characteristics of an environmental science. There are many applications in the field of historical research but none has been more beneficial than the prediction of historic site location. Several US universities recently plotted an area to the south of the Caucasus to identify prehistoric sites and areas that may have potential for future on-the-ground research, most notably of the migration route out of Africa in antiquity. The project successfully identified a number of potential new sites for future investigation.

2.3.4 Civic Planning

GIS has been a superb tool for rural and urban planning for the last few decades, working out local tax rates, planning desirability and mapping social deprivation, where new roads could go or which should be prioritized for repair. It is now a vital part of our green future too. As with regular and previous methods of planning utilities, using the landscape is far more critical to planning. Cascade in Montana is a prime site for wind farms and there is a website that uses GIS data to plot wind speeds over the course of a year in order to best site the wind farms.

2.4 linear referencing definition

A linear referencing system consists of a set of line features, on which events, elements, and characteristics can be located based on a reference to the line itself rather than through absolute x,y coordinates. Events are things that happen on or to the line feature, such as crash locations and highway projects. Elements are objects that exist on or near the line feature, such as signs or guardrails. Characteristics describe the line features, like speed limits or number of lanes. In ArcGIS, the term event is used to represent events, elements, and characteristics when they are stored in tables that use a relative distance from the starting point of a line, called a route, to describe a location.

In figure (2.4), the aerial photograph is displayed with a line feature class, with streets and events rendered on it. The signs are represented as points, and pavement conditions are represented as lines. Construction projects are also rendered as a brown line along routes and overlap the pavement condition events. The locations of the construction projects could be related to the condition of the pavement to ensure projects are in place where the road conditions are poor rather than good.

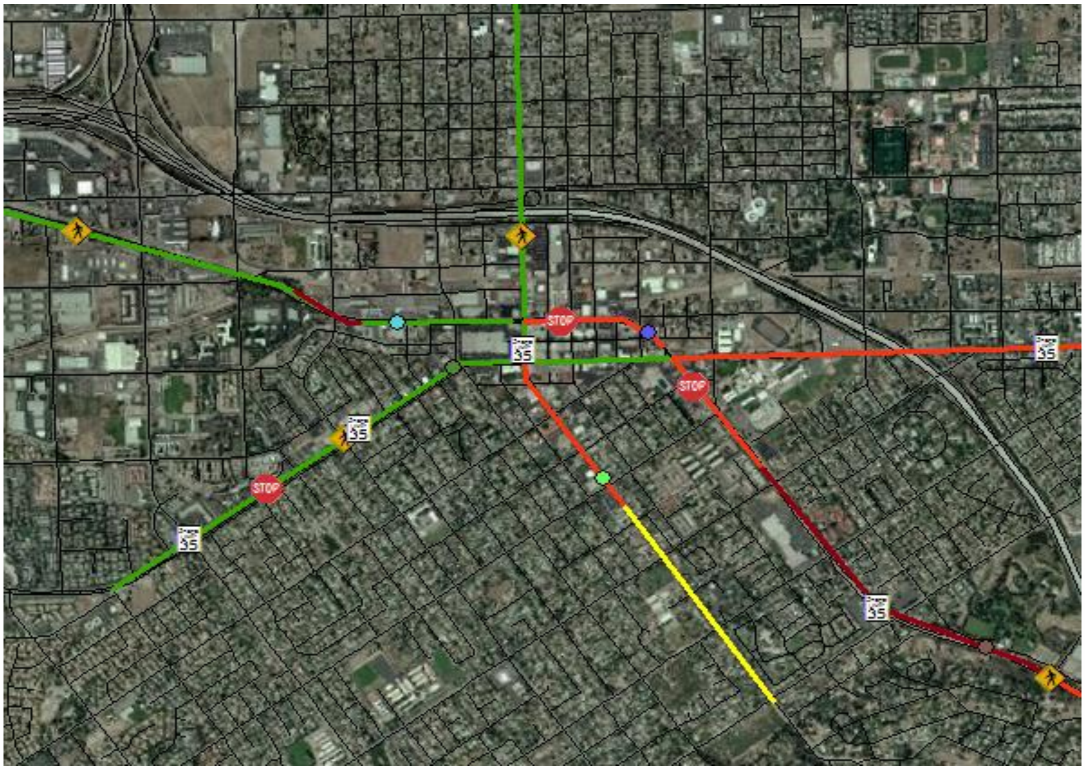


Figure (2.4): Line Feature Class

The linear referencing system tools in Production Mapping allow you to work with linearly referenced events on routes. This includes the ability to create, move, modify, and split events as appropriate for your data.

Both point and line events can be created using the event layers that are currently loaded in your map. After they are created, you can move point events along corresponding route features; line events can be extended or trimmed as needed, split at a specified location; shared line events can be adjusted based on the to- or from-point; and both types of events can be deleted.

The tools allow you to work with events visually instead of modifying table records. That is, instead of updating a value in a measure field, you can drag a point in the map to move it.

2.5 Benefits of linear referencing

The primary benefit of using linear referencing is that it allows locations to be readily recovered in the field, since these locations are generally more intuitive than locations specified with traditional coordinates. Second, linear referencing removes the requirement of a highly segmented linear network, based on differences in attribute values. More specifically, there are many network attributes that do not begin, end, or change values at the same points where the network is segmented. The implementation of linear referencing permits many different attribute events to be associated with a small set of network features. Moreover, linear referencing allows attribute data from multiple sources to be associated with the network, promotes a reduction in redundancy and error within the database, facilitates multiple cartographic representations of attribute data, and encourages interoperability among network applications.

2.6 Linear referencing applications

2.6.1 Highways and streets

Agencies that manage highways and streets use linear referencing in a variety of ways in their day-to-day operations. For example, linear referencing is useful for the following:

- Assessing pavement conditions
- Maintaining, managing, and valuing assets for example, traffic signs and signals, guard rails, toll booths, and loop detectors
- Organizing bridge management information
- Reviewing and coordinating construction projects

Linear referencing also facilitates the creation of a common database that traffic planners, traffic engineers, and public works analysts can use for cross-disciplinary decision support.

Figure (2.5) is an example displaying pavement conditions.

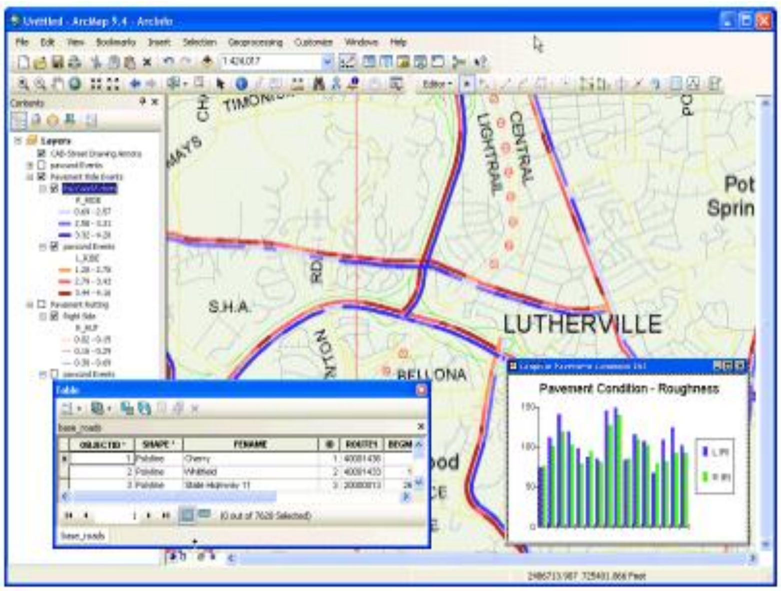


Figure (2.5): Pavement Conditions

2.6.2 Transit

Linear referencing is a key component in transit applications, and it facilitates such activities as these:

- Route planning and analysis
- Automatic vehicle location and tracking
- Bus stop and facility inventory
- Rail system facility management
- Track, power, communications, and signal maintenance

- Accident reporting and analysis
- Demographic analysis and route restructuring
- Ridership analysis and reporting
- Transportation planning and modeling

Figure (2.6) shows the results of a corridor study, displaying the number of traffic accidents along a stretch of highway.

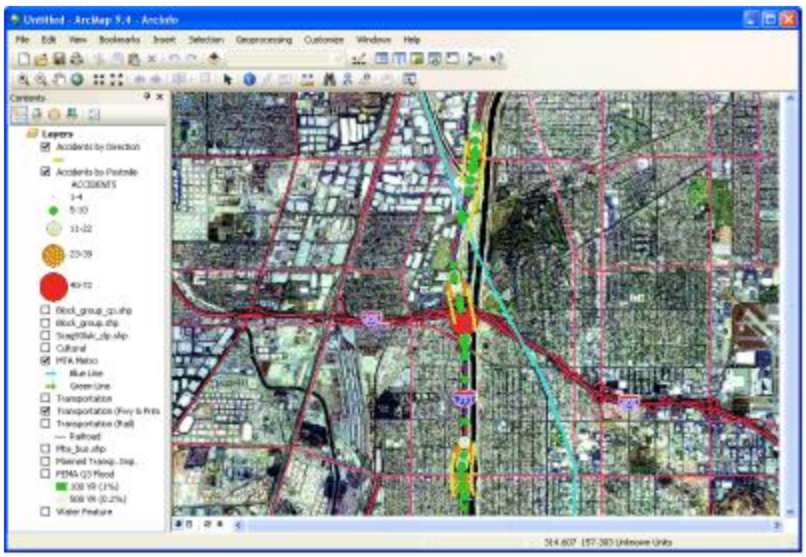


Figure (2.6): Traffic Accidents in a Corridor Study

2.6.3 Railways

Railways use linear referencing to manage key information for rail operations, maintenance, asset management, and decision support systems. Linear referencing makes it possible, for example, to select a line and track and identify milepost locations for bridges and other obstructions that would prevent various types of freight movement along the route. Furthermore, linear referencing can be used to display track characteristics or view digital images of bridges and obstructions.

Figure (2.7) is an example of analyzing rail clearances along a rail line.

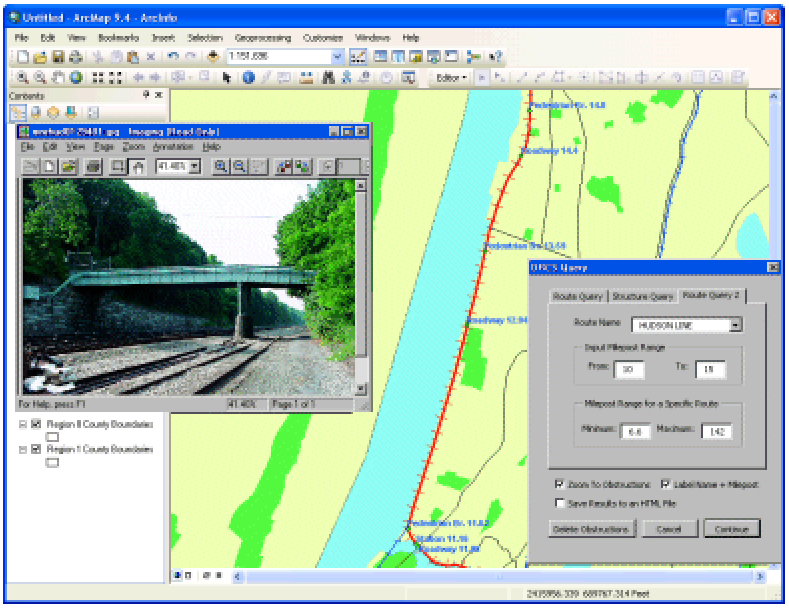


Figure (2.7): Analyzing Rail Line Clearance

2.6.4 Oil and gas exploration

The petroleum industry manages tremendous volumes of data used in geophysical exploration. Seismic surveys, or shotpoint data, are used to help understand the underlying geology in an area. The nature of seismic data is that it must be represented as both a linear object—the seismic line—and a collection of point objects (the shotpoints). Both the seismic line and the individual shotpoints have attributes, must be maintained at the same time, and are used in modeling applications. Linear referencing helps solve this problem.

Figure (2.8) shows an example of posting and labeling seismic lines and shotpoints in the Gulf of Mexico.

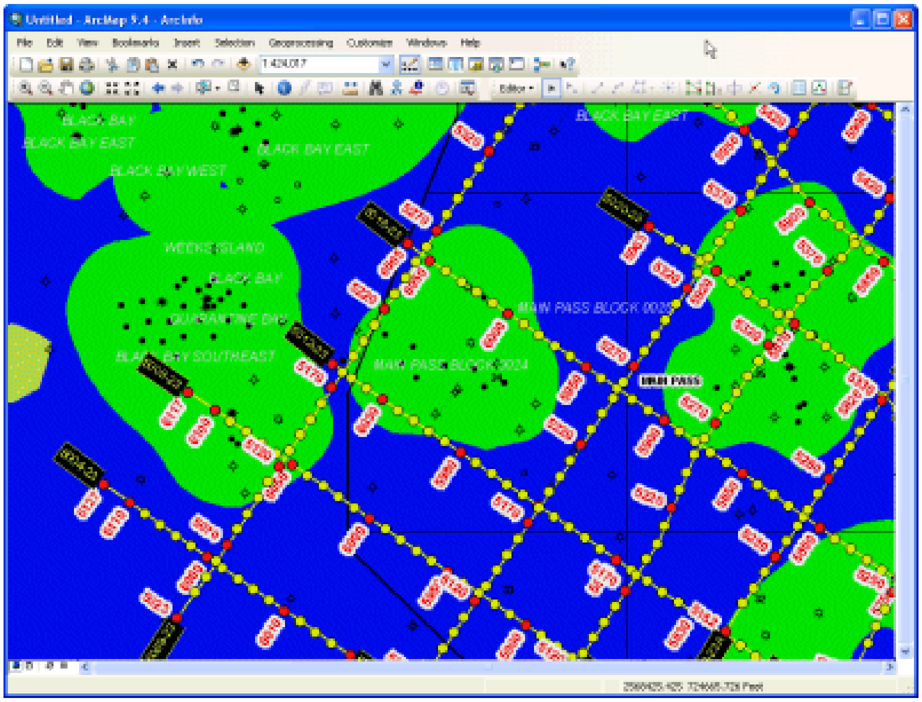


Figure (2.8): Posting and Labeling Seismic Lines and Shot points

2.6.5 Pipelines

In the pipeline industry, linear referencing is often referred to as stationing. Stationing allows any point along a pipeline to be uniquely identified. As such, stationing is useful in these applications:

- Collecting and storing information regarding pipeline facilities
- Inline and physical inspection histories
- Regulatory compliance information
- Risk assessment studies
- Work history events
- Geographic information, such as environmentally sensitive areas, political boundaries (for example, state and county), right-of-way boundaries, and various types of crossings

In figure (2.9), pipeline coating material types are being examined.

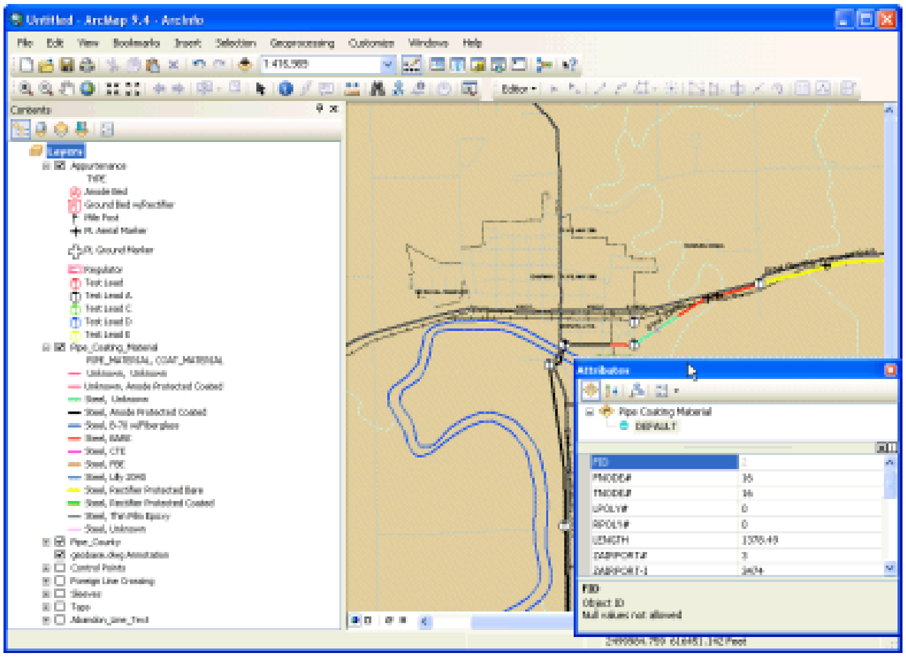


Figure (2.9): Pipeline Coating Material Types are Being Examined

2.6.6 Water resources

In hydrology applications, linear referencing is often called river addressing. River addressing allows objects such as field monitoring stations—which collect information about water quality analysis, toxic release inventories, drinking water supplies, flow, and so on—to be located along a river or stream system. Furthermore, the measurement scheme used in river addressing allows the measurement of flow distance between any two points on a flow path.

In figure (2.10) shows a monitoring stations along a hydrology network are identified.

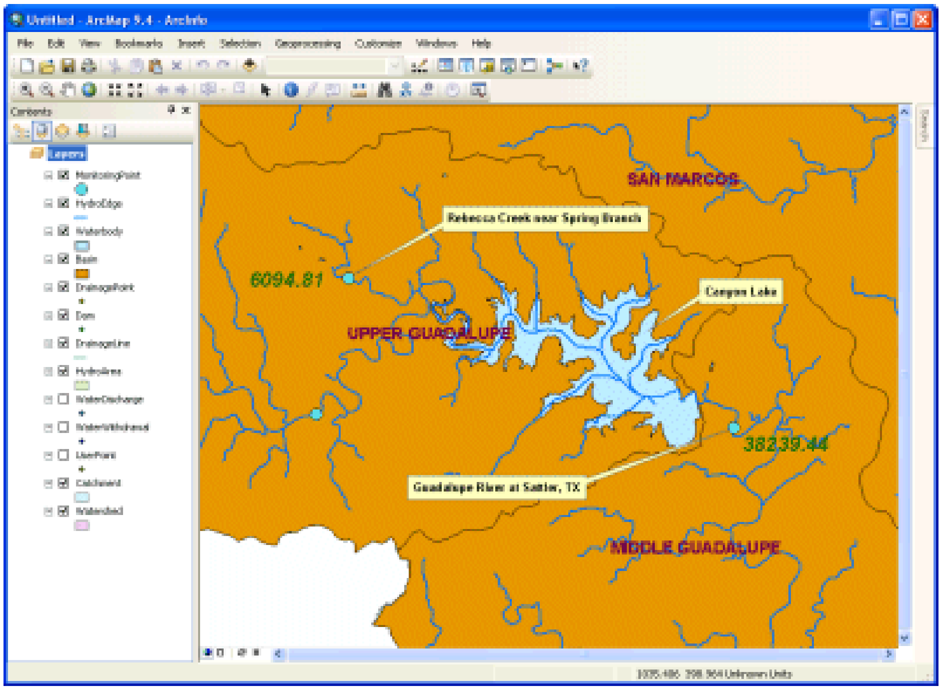


Figure (2.10): Identifying Monitoring Stations along a Hydrology Network

2.7 Linear Referencing as a Process

To implement linear referencing, several procedures must be completed. These procedures are presented as an iterative seven-step linear referencing process.

2.7.1 Determine Application, Representation, and Topology

There are fundamental differences in the structure of networks for different applications. Road and river networks, for example, do not have similar topological structures. The attributes and the analytical methods associated with different network types require different network representations. Therefore, the first step in a linear referencing process is to define which network data sets and spatial representations are to be employed for the application at hand.

2.7.2 Determining Route structure

The next step is to determine the route structure. The term route in this context is the largest individual feature that can be uniquely identified and to which events can be linearly referenced. Any linear feature can become the underlying element defining routes, but, generally speaking, a route should be longer than the events to be referenced so that event segmentation is minimized. For example, if streets are the target network for linear referencing, one may want to define the routes as single entities that represent the entire northbound and southbound directions of travel along the street, even though there are many underlying features (different blocks of the street between intersections) in the network data set. Routes may be further divided if the street name or prefix changes somewhere along the length of the route. Figure (2.11) shows the definition of four routes along an arterial road, based on direction of travel, street name, and street prefix.

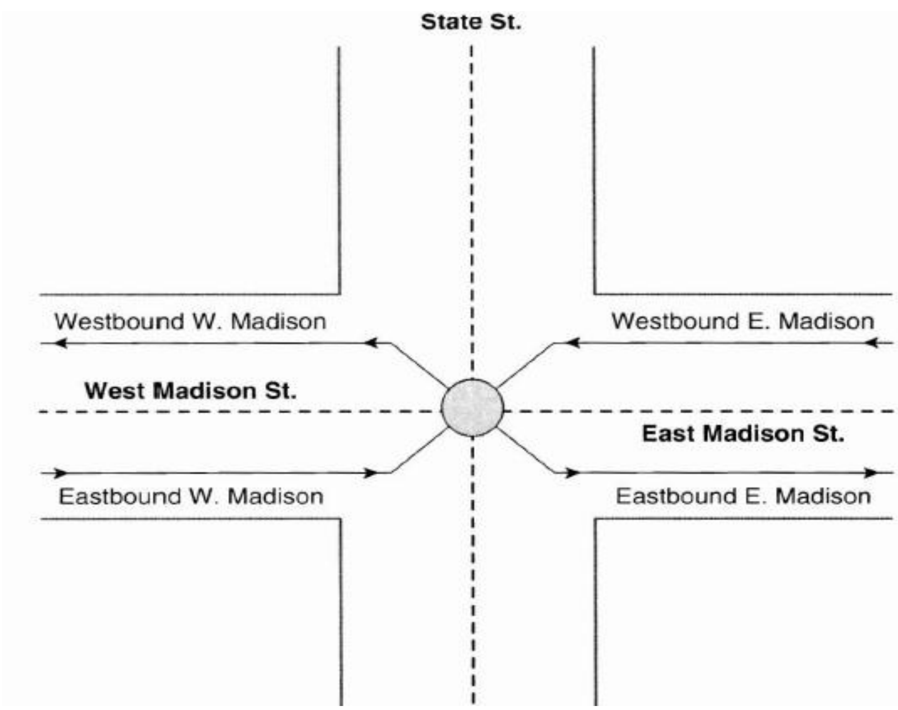


Figure (2.11): Defining Routs

2.7.3 Determining Measures

The third step is to determine measures along the routes. There are three considerations in doing so: the most appropriate unit of measure, the source for the measure values, and the direction of increasing measures. The most appropriate unit for measures along routes is a function of the application and the audience. The source of measure data has historically been of subject of intense debate. In some cases. Data collected in the field and stored in databases external to the GIS are of higher quality. Increasingly. The capture of GIS data using remote-sensing technologies has raised the accuracy of spatial databases and encouraged their use for measurements along networks. The direction of increase of measure values should be consistent with the needs of the application and should be logically consistent with the topological structure. For example, if linear referencing is to be used in the context of emergency response, the measures would best be designed to increase such that they are consistent with increasing address ranges along the streets.

2.7.4 Create Events

Given a set of routes and measure information associated with those routes, the next step is the collection of event data. Event data are occurrences along the network. Events can be point or linear in character. Point events represent objects located at specific measures along a route. Linear events have a consistent attribute along the network. There are an infinite number of possible events to locate along a network. Typical point events may be the locations of street signs or bridges along a road network. switches along a rail network, or monitoring stations along a river. Linear events could represent varying pavement conditions along the road, speed limits on a rail network, or depths associated with a river. Events can be digitized from maps. Collected in the field, or automatically generated by remote sensing technology.

2.7.5 Display Event Data, Cartographic Output

Linear referencing provides new information regarding network processes. But this can lead to poor cartography due to graphical clutter and information overload. Therefore, the next step is to carefully choose the parameters for display of the events. The display of linearly referenced events is referred to as dynamic segmentation. The decisions regarding display of event data are dependent on several factors. including the media on which the data will be displayed and the scale of the representations. One visual benefit of dynamically displaying event data is the ability to display multiple linear events along the same feature. accomplished through offsetting the events so that all events are visible in relation to the route itself and in relation to other events. A common example of this is seen on subway route maps.

2.7.6 Analysis with Linear Referencing

With routes and event data in hand, analysis can be performed through techniques such as overlays, intersections. and other spatial analysis techniques incorporated in GIS. In some cases, linear referencing allows new database queries to be made that differ from those based on the underlying network. However, while significant analytic capability is added with linear referencing, other traditional GIS analytic capabilities are lost. Most important, events do not contain topological information that is mandatory for most network analysis. For this reason, both traditional network and event representations must be maintained coincidently.

2.7.7 Data Maintenance

To keep this newly created linear referencing system functional, it is important that the route and event data be maintained properly. Geometric changes during editing, changes in measure values with the movement of real-world features, and the addition of more precise measurements all demand an ongoing process of data maintenance.

There are two primary data types that are used to implement linear referencing in ArcGIS:

1. Route feature classes
2. Event tables

Using dynamic segmentation, events from event tables are located on line features in a route feature class.

Route feature classes

A **route feature class** is a line feature class which has a defined measurement system. These measurement values can be used to locate events, assets, and conditions along its set of linear features, figure (2.12).

In ArcGIS, the term route refers to any linear feature, such as a city street, highway, river, or pipe, that has a unique identifier and a common measurement system along each linear feature.

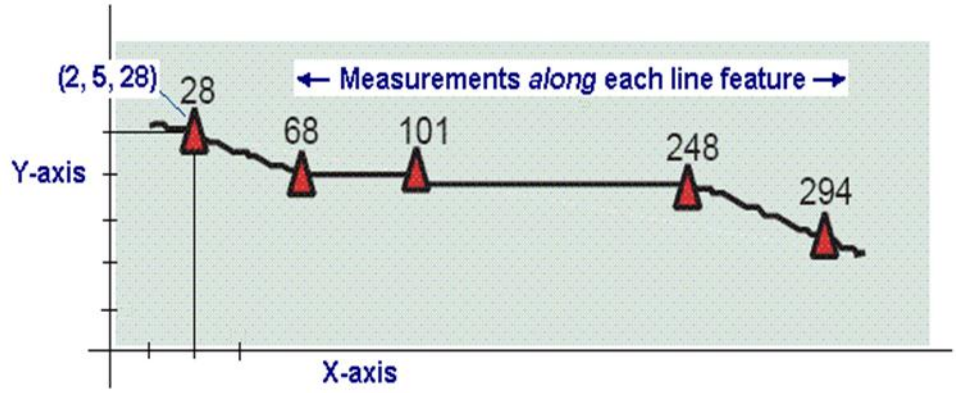


Figure (2.12): Measurement System along Each Linear Feature.

In simple terms, feature vertices in route feature classes include **m-values** (x,y,m or x,y,z,m). These measured coordinates form the building blocks for route features. In route feature classes, line features have their x,y (or x,y,z) coordinates that describe location as well as a measurement value (m) along the line.

A collection of routes with a common measurement system is a route feature class. Each route in the feature class will also have a unique identifier, figure (2.13). Line features with the same unique identifier are considered to be part of the same route:

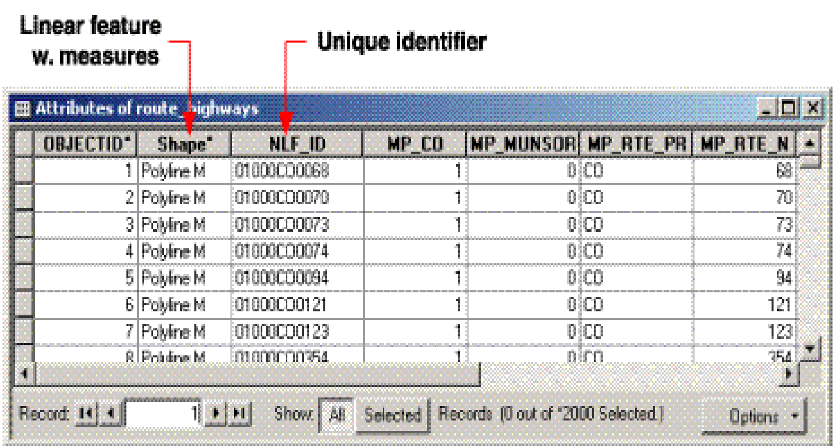


Figure (2.13): Feature Unique Identifier

Route feature classes are created and managed as line feature classes in the geodatabase. You can also use route feature classes from ArcInfo coverages and polyline shapefiles that include route identifiers and measured features.

Route feature geometry

Route features have a measurement system stored with their geometry. Each measured line's segments have x-, y-, and m- (measure) or x-,y-,z-, and m-values. When a measure value is unknown for a particular vertex, its m-value is recorded as NAN (not a number) as illustrated in figure (2.14).

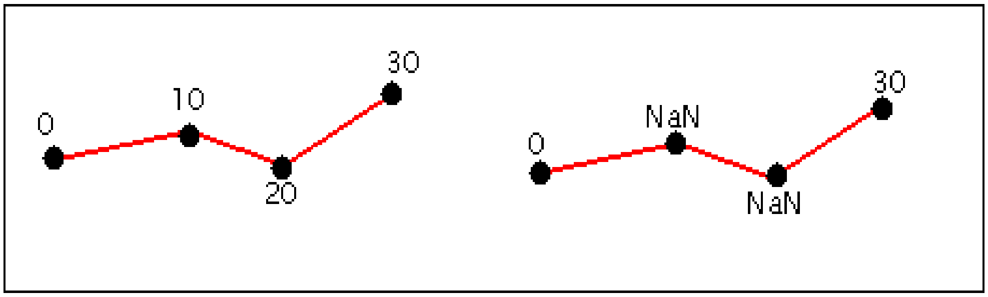


Figure (2.14): Measurement System Stored

Simple linear features are represented by lines with one path. Complex linear features are represented by lines with many paths, figure (2.15)

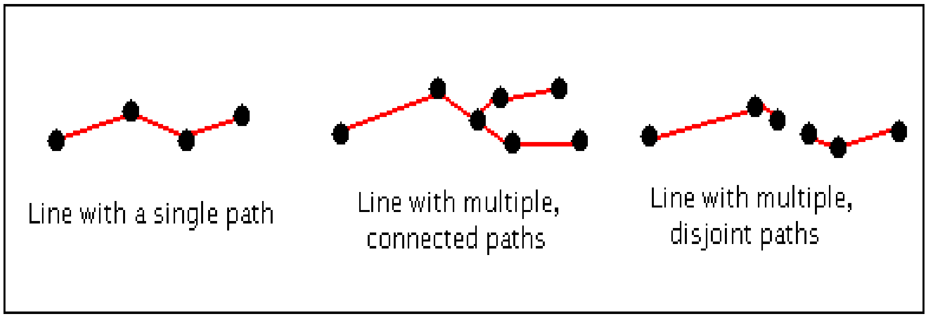


Figure (2.15): Lines with Many Paths

It is important to note that although most applications use measures to represent increasing distances along a linear feature, measure values can arbitrarily increase, remain constant, or decrease along line features.

Measure values are independent of the horizontal coordinate system of a feature class (and the vertical coordinate system, as well, if one is defined). That is, the measure values are not required to be in the same units as the feature class's x,y,z coordinates.

For example, features stored in a feature class whose coordinate system is Universal Transverse Mercator (UTM) meters might have their measure values stored in feet or miles or time.

Event tables

Event tables contain information about assets, conditions, and events that can be located along route features. Each row in the event table references an event, and its location is expressed as measurements along named (identifiable) linear features.

There are two types of events: point events and line events. A point event describes a discrete location along a route (a point), whereas a line event describes a portion of a route (a line).

1. A point event location uses only a single measure value to describe a discrete location such as "Mile 3.2 on I-91."

2. A line event uses both from- and to-measure values to describe a portion of a route, for example, "Mile 2 to mile 4 on I-91."

Because there are two types of route event, there are two types of route event tables: point event tables and line event tables. All event tables must contain a route identifier and measure location field(s) containing measure information. A point event table uses a single measure field to describe its discrete location. A line event table requires two measure fields (a from- and to- measure) to describe its location.

Route locations and their associated attributes are stored in an event table based on a common theme. For example, four event tables containing information on speed limits, year of resurfacing, present condition, and accidents could be included and used to dynamically locate events on a route feature class.

An event table can be any type of table that ArcGIS supports. This includes INFO, dBASE, geodatabase, delimited text files, and database management system (DBMS) tables accessed via an Object Linking and Embedding database (OLE DB) connection.

Event table example

Hydrologists and ecologists use linear referencing on stream networks to locate various types of events such as is illustrated in figure (2.16). The route feature class for streams provides measures along the streams using river reach mile. Point and line event tables record the route ID and location along each river reach. These event tables can be used to locate point and line events.

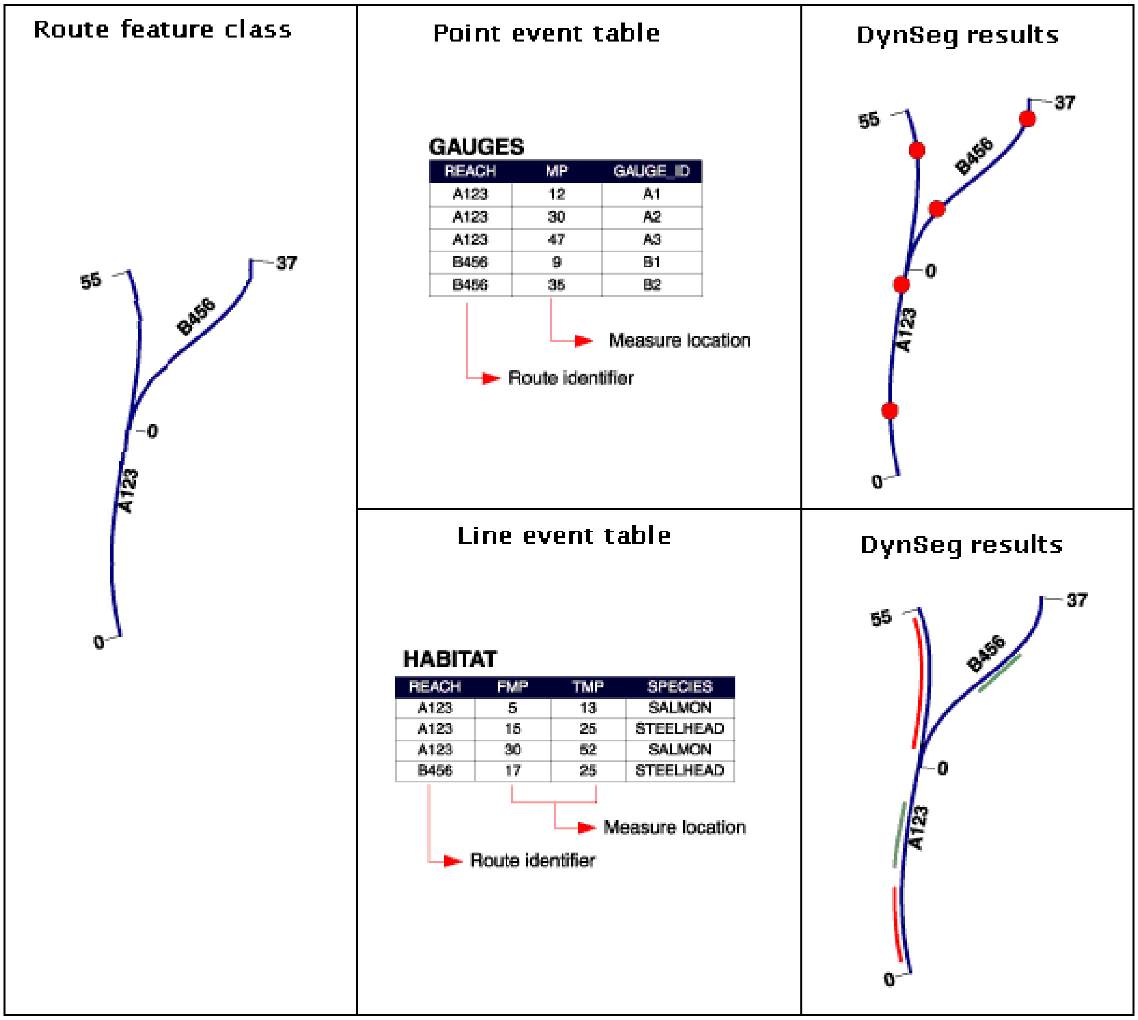


Figure (2.16): Various Types of Events

Storing features using relative locations

With linear referencing, locations along linear features are referred to in terms of their route measure, or distance from a known point, figure (2.17). For example, it often makes sense to describe the location of an accident as occurring at "12 miles from the beginning of the interstate" rather than at a GPS coordinate such as at "1,659,060.25, 1,525,238.97".

To determine a location along a linear feature, a system of measurement is required. When a measurement system is stored along with a linear feature, any location along that linear feature can be expressed in terms of the measure values.

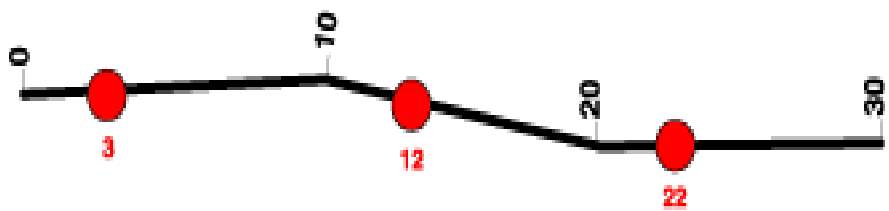


Figure (2.17): Storing Features Using Relative Locations

In addition to making data more intuitive, storing data as a relative location along a linear feature has the added benefit of ensuring that spatial phenomena you know to fall on a linear feature is located on the feature. For example, in the absence of a very accurate basemap, locating accidents using x,y coordinates may end up displaying accidents that do not fall on the road network as they should. This will not happen if the accidents are located using linear referencing.

CHAPTER THREE

DATA COLLECTION & PREPARATION

This chapter Contains:

3.1 Linear Referencing Events.

3.2 Surveying of Linear Referencing Events Using GPS.

3.3 Event Table.

3.4 Entering Data to GIS.

CHAPTER THREE

DATA COLLECTION AND PREPARATION

3.1 Linear Referencing Events

Table (3.1) shows the different types of linear events and their possible causes

TYPE OF DISTRESS	POSSIBLE CAUSE	MAINTENANCE SUGGESTIONS
Fatigue(Alligator) Cracking 	1. Excessive loading 2. Weak surface, base, or subgrade 3. Thin surface or base 4. Poor drainage 5. Any combination of 1-4	Full-depth patch
Block Cracking 	1. Old and dried out mix 2. Mix was placed too dry 3. Fine aggregate mix with low penetration asphalt & absorptive aggregates 4. Aggravated by low traffic volume	Any surface treatment or thin overlay
Edge Cracks 	1. Lack of lateral support 2. Settlement of underlying material 3. Shrinkage of drying out soil 4. Weak base or subgrade layer 5. Poor drainage 6. Frost heave 7. Heavy traffic or vegetation along edge	Improve drainage. Remove vegetation close to edge. Fill cracks with asphalt emulsion slurry or emulsified asphalt Crack seal/fill

Table (3.1): Line Events

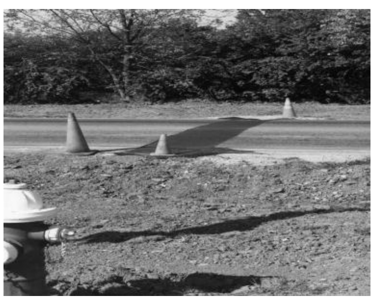
Longitudinal(Linear)& Transverse Cracking  	1. poorly constructed paving joint crack 2. Shrinkage of the asphalt layer 3. Daily temperature cycling 4. Cracks in an underlying layer that reflect up through the pavement 5. Longitudinal segregation caused by the improper operation of the paver	Improve drainage by removing the source that traps the water Seal crack or fill with asphalt emulsion slurry or light grade of asphalt mixed with fine sand. Provide side drainage ditches Crack seal/fill
Utility Cuts/Patch Failure 	1. A portion of a pavement has been removed and replaced 2. A portion of a pavement where additional material has been added 3. Poor installation techniques such as inadequate compaction, inferior or improper materials	Replace patch with deep or full-depth patch
Pot Hole 	1. Poor surface mixtures 2. Weak spots in the base or subgrade 3. Severity of the surrounding distress and traffic action accelerate potholes	Partial, full-depth or injection patching

Table (3.1): Line Events continue

3.2 Surveying Of Linear Referencing Events Using GPS

Fieldwork and field survey were basic modules in every aspect of this study, especially to confirm the data collected during the site visits, identify and mapping the existing target street characteristics.

GIS was used as a tool and multi-layers were generated. Field measurements were carried out by means of Global Positioning System (GPS) to locate the coordinates of street events. A survey meter is used to measure street events dimensions

Photo (1) shows the asphalt crack event

Photo (1): Crack Event

The survey event is entered to Event tables contain information about assets, conditions, and events that can be located along route features. Each row in the event table references an event and its location is expressed as measurements along named (identifiable) linear features.

There are two types of events: point events and line events. A point event describes a discrete location along a route (a point) whereas a line event describes a portion of a route (a line). A point event location uses only a single measure value to describe a discrete location while a line event uses both from- and to-measure values to describe a portion of a route.

Because there are two types of route event, there are two types of route event tables: point event tables and line event tables. All event tables must contain a route identifier and measure location field(s) containing measure information. A point event table uses a single measure field to describe their discrete location. A line event table requires two measure fields (a from- and to- measure) to describe their location.

Route locations and their associated attributes are stored in an event table based on a common theme. For example, four event tables containing information on speed limits, year of resurfacing, present condition and accidents could be included and used to dynamically locate events on a route feature class.

An event table can be any type of table that ArcGIS supports. This includes INFO, dBASE, geodatabase tables, delimited text files, and database management system (DBMS) tables accessed via an Object Linking and Embedding database (OLE DB) connection

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To determine a location along a linear feature, a system of measurement is required. When a measurement system is stored along with a linear feature, any location along that linear feature can be expressed in terms of the measure values.

In addition to making data more intuitive, storing data as a relative location along a linear feature has the added benefit of ensuring that spatial phenomena you know to fall on a linear feature is located on the feature. For example, in the absence of a very accurate base map, locating accidents using x,y coordinates may end up displaying accidents that do not fall on the road network as they should. This will not happen if the accidents are located using linear referencing.

The following photos illustrate some of the survied events

Photo (2): Asphalt Crack Event

Photo (3): Pavement Section Event

Photo (4): Hole Event in the Middle of Street

3.3 Event Table

Table (3.2) shows the surveyed line events

R_ID	Fmp	Tmp	ITEM	MATERIAL	CONDITION	STATUSE	LENGTH_M	WIDTH_M	NOTE
125	20	20	Crack	Asphalt	Poor	Need to fill	9.07	0	cross track
125	20.94	32.62	Trench	Asphalt	Poor	Need to repair	5.02	0.45	Null
125	32.66	39.32	Trench	Asphalt	Poor	Need to repair	6.87	1.53	Null
125	61.39	62.25	Trench	Asphalt	Poor	Need to repair	1.12	4.86	Null
125	63.12	87.36	Trench	Asphalt	Poor	Need to repair	22.63	0.9	Null
125	87.56	92.69	Trench	Asphalt	Poor	Need to repair	5.35	4.73	Null
125	90.14	102.51	Crack	Asphalt	Poor	Need to fill	12.39	0	Longitudinal crack
125	101.41	102.59	Trench	Asphalt	Poor	Need to repair	0.77	4.22	Null
125	113	113	Crack	Asphalt	Poor	Need to fill	4.6	0	cross track
125	112.18	116.02	Trench	Asphalt	Poor	Need to repair	3.99	1.14	Null
125	126.04	128.18	Crack	Asphalt	Poor	Need to fill	4.55	0	cross track

Table (3.2):Surveyed Line Events

125	143.02	143.02	Trench	Asphalt	Poor	Need to repair	0.21	5.5	Null
125	168.44	168.66	Trench	Asphalt	Poor	Need to repair	2.82	4.98	Null
125	180.52	183.33	Trench	Asphalt	Poor	Need to repair	0.49	4.72	Null
125	192.57	193.36	Trench	Asphalt	Poor	Need to repair	0.89	4.33	Null
125	210.88	211.89	Trench	Asphalt	Poor	Need to repair	0.89	5.24	Null
125	221.83	280.57	Trench	Asphalt	Poor	Need to repair	58.72	0.71	Null
125	257.33	257.33	Crack	Asphalt	Poor	Need to fill	3.75	0	cross track
125	259.53	272.54	Trench	Asphalt	Poor	Need to repair	12.8	0.46	Null
125	281.32	281.57	Trench	Asphalt	Poor	Need to repair	0.27	4.38	Null
125	284.05	332.21	Trench	Asphalt	Poor	Need to repair	47.31	0.83	Null
125	401.73	427.99	Trench	Asphalt	Poor	Need to repair	24.96	10.8	Null
125	453	455.47	Pump	Asphalt	Poor	Need to repair	2.43	7.44	Null
125	509.88	512.67	Pump	Asphalt	Poor	Need to repair	2.72	6.27	Null
125	560.18	627.49	Crack	Asphalt	Poor	Need to fill	67.02	0	Longitudinal crack
125	592.48	592.48	Crack	Asphalt	Poor	Need to fill	5.25	0	cross track
125	635.03	649.61	Guardrail	Steel	Does not exist	Need to set	13.55	0	Null
125	640.54	642.73	Pump	Asphalt	Poor	Need to repair	1.59	5.63	Null
125	661.34	709.37	Crack	Asphalt	Poor	Need to fill	46.88	0	Longitudinal crack
125	716.78	753.77	Crack	Asphalt	Poor	Need to fill	37.73	0	Longitudinal crack
125	650.52	805.05	Trench	Asphalt	Poor	need to repair	51.04	1.74	Null
125	782.18	784.19	Trench	Asphalt	Poor	need to repair	2.26	6.96	Null
125	829.08	833.6	Trench	Asphalt	Poor	need to repair	4.42	5.45	Null
125	866.99	918.63	Crack	Asphalt	Poor	Need to fill	51.39	0	Longitudinal crack
125	919.07	925.44	Trench	Asphalt	Poor	Need to repair	6.79	1.15	Null
125	925.05	935.18	Retaining wall	Concrete	Does not exist	Need to set	9.61	0	4.5 m height
125	927.66	935.9	Crack	Asphalt	Poor	Need to fill	8.15	0	Longitudinal crack
125	936.59	944.15	Trench	Asphalt	Poor	Need to repair	7.65	2.87	Null
125	942.79	964.36	Crack	Asphalt	Poor	Need tofill	21.58	0	Longitudinal crack
125	964.79	974.39	Trench	Asphalt	Poor	Need to repair	9.03	1.27	Null
125	986.41	993.29	Trench	Asphalt	Poor	Need to repair	6.85	1.5	Null
125	993.29	1003.7	Crack	Asphalt	Poor	Need to fill	10.45	0	Longitudinal crack
125	1006.83	1049.79	Trench	Asphalt	Poor	Need to repair	42.94	1.2	Null
125	1051.07	1051.87	Trench	Asphalt	Poor	Need to repair	0.8	5.83	Null
125	1052.6	1059.27	Trench	Asphalt	Poor	Need to repair	6.62	2.5	Null
125	1060.83	1074.32	Crack	Asphalt	Poor	Need to fill	13.79	0	Longitudinal crack
125	1075.84	1087.9	Crack	Asphalt	Poor	Need to fill	11.94	0	Longitudinal crack
125	1096.7	1112.44	Trench	Asphalt	Poor	Need to repair	17.38	2.85	Null
125	1025.22	1025.5	Crack	Asphalt	Poor	Need to fill	4.14	0	cross track
125	1151.34	1151.74	Trench	Asphalt	Poor	Need to repair	0.4	5.98	Null
125	1214.33	1223.95	Crack	Asphalt	Poor	Need to fill	9.7	0	Longitudinal crack

Table (3.2): Surveyed Line Events, continue

125	1226.77	1255.17	Crack	Asphalt	Poor	Need to fill	28.83	0	Longitudinal crack
125	1255.93	1259.92	Trench	Asphalt	Poor	Need to repair	3.95	1.5	Null
125	1263.95	1273.17	Trench	Asphalt	Poor	Need to repair	9.22	1.5	Null
125	1366	1367.8	Pump	Asphalt	poor	Need to repair	1.83	5.61	Null
125	1393.99	1409.27	Widening	Asphalt	Dose not exist	Need to set	15.34	2.84	Null
125	1421.21	1424.54	Pump	Asphalt	Poor	Need to repair	3.3	7.59	Null
125	1472.86	1475.92	Pump	Asphalt	poor	Need to repair	3	5.96	Null
125	1477.63	1506.14	Crack	Asphalt	Poor	Need to fill	28.97	0	Longitudinal crack
125	1508.87	1510.03	Trench	Asphalt	Poor	Need to repair	1.24	6.58	Null
125	1520.52	1525.19	Trench	Asphalt	Poor	Need to repair	4.69	1.43	Null
125	1547.91	1548	Crack	Asphalt	Poor	Need to repair	4.58	0	cross track
125	1593.3	1615.65	Crack	Asphalt	Poor	Need to fill	22.32	0	Longitudinal crack
125	1606.96	1616.62	Crack	Asphalt	Poor	Need to fill	11.55	0	Longitudinal crack
125	1621.76	1621.8	Crack	Asphalt	Poor	Need to fill	6.15	0	cross track
125	1628.85	1654.69	Crack	Asphalt	Poor	Need to fill	25.61	0	Longitudinal crack
125	1635.6	1645.44	Trench	Asphalt	Poor	Need to repair	11.3	3.44	Null
125	1648.76	1658.86	Trench	Asphalt	Poor	Need to repair	9.85	1.45	Null
125	1658.86	1658.9	Crack	Asphalt	Poor	Need to fill	5.81	0	cross track
125	1668.83	1668.9	Crack	Asphalt	Poor	Need to fill	5.74	0	cross track
125	1731.56	1734.42	Pump	Asphalt	poor	Need to repair	2.76	5.6	Null
125	1738	1752.77	Trench	Asphalt	Poor	Need to repair	14.72	0.86	Null
125	1752.86	1754.05	Pump	Asphalt	poor	Need to repair	1.36	6.39	Null
125	1754.8	1754.85	Crack	Asphalt	Poor	Need to fill	0.66	0	cross track
125	1754.44	1754.5	Crack	Asphalt	Poor	Need to fill	1.72	0	cross track
125	1754.5	1775.72	Crack	Asphalt	Poor	Need to fill	27.44	0	Longitudinal crack
125	1782.32	1782.35	Crack	Asphalt	Poor	Need to fill	4.2	0	cross track
125	1793.62	1800.66	Trench	Asphalt	Poor	Need to repair	6.95	0.82	Null
125	1802.14	1807.16	Trench	Asphalt	Poor	Need to repair	29.2	0.89	Null
125	1841.31	1867.91	Crack	Asphalt	Poor	need to fill	26.72	0	Longitudinal crack
125	189.72	192.57	Crosswalk	paint	Dose not exist	Need to set	3	5	Null
125	400	403	Crosswalk	paint	Dose not exist	Need to set	3	6	Null
125	526	529	Crosswalk	paint	Dose not exist	Need to set	3	6	Null
125	603	606	Crosswalk	paint	Dose not exist	Need to set	3	6	Null
125	806	809	Crosswalk	paint	Dose not exist	Need to set	3	6	Null
125	1009	1012	Crosswalk	paint	Dose not exist	Need to set	3	6	Null
125	1212	1215	Crosswalk	paint	Dose not exist	Need to set	3	7	Null
125	1415	1418	Crosswalk	paint	Dose not exist	Need to set	3	6	Null

Table (3.2): Surveyed Line Events, continue

Table (3.3) shows the surveyed point events

R_ID	Measurement	ITEM	MATERIAL	CONDITION	STATUS	LENGTH_M	WIDTH_M	DIAMETER_M	OFFSET_M
1	26.9494	Trench	Asphalt	Poor	Need to fill	5.0175	0.4542	0	0
1	32.8756	Trench	Asphalt	Poor	Need to fill	6.8679	1.5324	0	0
1	58.7543	Trench	Asphalt	Poor	Need to fill	4.8229	1.1227	0	0
1	78.5931	Trench	Asphalt	Poor	Need to fill	9.1389	1.0459	0	0
1	86.7221	Trench	Asphalt	Poor	Need to fill	5.3538	4.7257	0	0
1	98.8411	Trench	Asphalt	Poor	Need to fill	1.5959	4.4245	0	0
1	111.3391	Trench	Asphalt	Poor	Need to fill	3.1872	0.8602	0	0
1	170.2507	Trench	Asphalt	Poor	Need to fill	0.2055	5.5128	0	0
1	183.7943	Trench	Asphalt	Poor	Need to fill	2.8204	4.9825	0	0
1	187.8758	Trench	Asphalt	Poor	Need to fill	0.4856	4.6408	0	0
1	194.8305	Trench	Asphalt	Poor	Need to fill	0.8948	4.446	0	0
1	212.9728	Trench	Asphalt	Poor	Need to fill	0.8883	5.1675	0	0
1	241.4219	Trench	Asphalt	Poor	Need to fill	35.9515	3.7463	0	0
1	268.4218	Trench	Asphalt	Poor	Need to fill	12.7972	0.4819	0	0
1	283.4882	Trench	Asphalt	Poor	Need to fill	0.8027	4.3389	0	0
1	321.7291	Trench	Asphalt	Poor	Need to fill	23.9137	1.0992	0	0
1	356.5489	Hole	Asphalt	Poor	Need to fill	0	0	0.4	0
1	406.7499	Trench	Asphalt	Poor	Need to fill	24.9646	10.8034	0	0
1	446.8582	pump	Asphalt	Poor	Need to repair	2.4265	7.4412	0	0
1	454.6768	Hole	Asphalt	Poor	Need to fill	0	0	1	0
1	458.8364	Hole	Asphalt	Poor	Need to fill	0		1	0
1	506.8366	Trench	Asphalt	Poor	Need to fill	2.725	6.2737	0	0
1	611.7175	Hole	Asphalt	Poor	Need to fill	0	0	0.8	0
1	636.9467	Trench	Asphalt	Poor	Need to fill	2.9873	5.6324	0	0
1	770.1091	Trench	Asphalt	Poor	Need to fill	51.0371	1.7376	0	0
1	775.1624	Trench	Asphalt	Poor	Need to fill	2.2552	7.109	0	0
1	823.3059	Trench	Asphalt	Poor	Need to fill	4.4233	4.4727	0	0
1	836.8504	Hole	Asphalt	Poor	Need to fill	0	0	1	0
1	854.1364	Patch	Asphalt	Poor	Need to repair	4.2702	1.6427	0	0
1	857.5935	Patch	Asphalt	Poor	Need to repair	3.1874	3.5263	0	0
1	909.861	Hole	Asphalt	Poor	Need to fill	0	0	0.6	0
1	913.7048	Trench	Asphalt	Poor	Need to fill	6.7855	1.3556	0	0
1	931.9233	Trench	Asphalt	Poor	Need to fill	7.5664	2.8713	0	0
1	961.1174	Trench	Asphalt	Poor	Need to fill	9.0292	0.7928	0	0
1	967.4756	Patch	Asphalt	Poor	Need to repair	0	0	4	0
1	969.518	Hole	Asphalt	Poor	Need to fill	0	0	2	0
1	1047.6885	patch	Asphalt	Poor	Need to repair	6.5188	2.4956	0	0

Table (3.3): Surveyed Point Events

1	1072.9382	MH	Concrete	Good	-	0	0		0
1	1103.5364	Trench	Asphalt	Poor	Need to fill	54.7431	0.9421	0	0
1	1114.9655	Hole	Asphalt	Poor	Need to fill	0	0	1.2	0
1	1129.2758	Hole	Asphalt	Poor	Need to fill	0	0	0.6	0
1	1152.225	pump	Asphalt	Poor	Need to repair	1.5007	2.9046	0	0
1	1190.6294	Trench	Asphalt	Poor	Need to fill	9.2168	1.3733	0	0
1	1201.2478	pump	Asphalt	Poor	Need to repair	2.5623	1.8462	0	0
1	1216.457	pump	Asphalt	Poor	Need to repair	4.1895	1.5013	0	0
1	1251.0023	Hole	Asphalt	Poor	Need to fill	0	0	1	0
1	1268.107	Patch	Asphalt	Poor	Need to repair	0	0	1	0
1	1288.1091	pump	Asphalt	Poor	Need to repair	1.7947	5.3511	0	0
1	1323.418	widening	Asphalt	-	need to wide	15.9009	2.172	0	0
1	1345.4472	pump	Asphalt	Poor	Need to repair	3.9772	7.3147	0	0
1	1396.9681	pump	Asphalt	Poor	Need to repair	3.0788	5.568	0	0
1	1411.2674	Patch	Asphalt	Poor	Need to repair	0	0	1	0
1	1432.4725	Trench	Asphalt	Poor	Need to fill	1.1658	6.5804	0	0
1	1438.8927	Trench	Asphalt	Poor	Need to fill	13.7897	6.5804	0	0
1	1548.8734	Patch	Asphalt	Poor	Need to repair	13.2815	5.1861	0	0
1	1567.3335	Trench	Asphalt	Poor	Need to fill	3.6372	1.333	0	0
1	1589.4743	Hole	Asphalt	Poor	Need to fill	0	0	1	0
1	1591.2748	Hole	Asphalt	Poor	Need to fill	0	0	1	0
1	1626.7309	Patch	Asphalt	Poor	Need to repair	27.263	0.6893	0	0
1	1641.9281	Patch	Asphalt	Poor	Need to repair	2.9475	0.6893	0	0
1	1653.6667	pump	Asphalt	Poor	Need to repair	2.9936	5.6031	0	0
1	1656.9892	Trench	Asphalt	Poor	Need to fill	3.3955	0.8612	0	0
1	1666.0905	Trench	Asphalt	Poor	Need to fill	14.8326	0.8612	0	0
1	1674.4221	pump	Asphalt	Poor	Need to repair	1.0051	6.3716	0	0
1	1680.9305	Patch	Asphalt	Poor	Need to repair	10.7682	1.7168	0	0
1	1701.7929	Trench	Asphalt	Poor	Need to fill	9.0741	0.799	0	0
1	1708.1242	Patch	Asphalt	Poor	Need to repair	3.6112	0.2997	0	0
1	1715.3437	Patch	Asphalt	Poor	Need to repair	10.6891	0.2997	0	0
1	1743.0628	Trench	Asphalt	Poor	need to fill	34.4544	1.4636	0	0
1	1761.0088	Patch	Asphalt	Poor	Need to repair	4.8661	2.6233	0	0

Table (3.3): Surveyed Point Events, continue

3.4 Entering data to the GIS

In ArcGIS, features are stored in a feature class. Every feature has a geometry associated with it. This geometry is stored in a special field that is typically called ‘shape’. A feature can have one of these types of geometries: point, multipoint, polyline, or polygon. Each geometry is composed of two-dimensional (x,y) or three-dimensional (x,y,z) geographic coordinates.

In order to handle the linear referencing requirement that attribute information can be recorded in terms of a linear feature and a measurement along it, a method for defining discrete locations along a linear feature was devised. Instead of being composed of x,y coordinates, a feature's geometry in ArcGIS can be composed of x,y,m (or x,y,z,m) values. When data is linearly referenced, multiple sets of attributes can be associated with any portion of an existing linear feature, independent of its beginning and ending. These attributes can be displayed, queried, edited, and analyzed without affecting the underlying linear feature's geometry.

When linearly referenced features in ArcGIS are referred to, the terms routes, route locations, and route events are used. A route is any linear feature, such as a city street, highway, river, or pipe, that has a unique identifier and a measurement system defined (x,y,m). This measurement system defines discrete locations along the linear feature.

A collection of routes with a common system of measurement is stored in a feature class—for example, a set of all highway routes in a county. In ArcGIS, a route feature class can exist in a coverage, as a shapefile, or as a geodatabase feature class. In a geodatabase, many feature classes containing routes can be stored in a single feature dataset. For example, a state's department of transportation might maintain a feature dataset with feature classes for milepost routes, reference marker routes, and so on.

CHAPTER FOUR

CONSTRUCTION OF ROADS MAINTENANCE MANAGEMENT SUPPORT SYSTEM USING LINEAR REFERENCING METHOD

This chapter contains:

4.1 View the Data and Locate Abu Ktelah Street.

4.2 Select Abu Ktelah Route and Put it in Layer.

4.3 Create Routes.

4.4 Abu Ktelah Route.

4.5 Line and Point Event Tables.

4.6 Add Route Event to Abu Ktelah Route.

4.7 Calculate the Maintenance Total Cost.

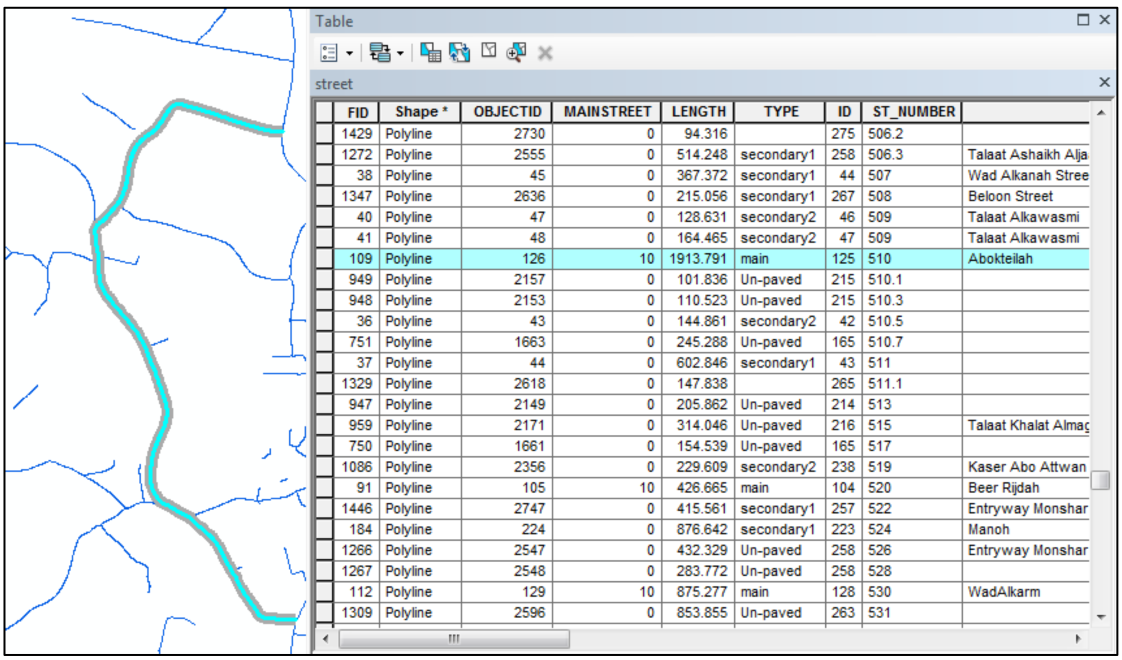
4.8 Made a Symbology.

4.9 Linear Referencing and Online ArcGIS Server (ArcGIS Web Map).

Construction of Roads Maintenance Management Support System Using Linear Referencing Method

4.1 View the Data and Locate Abu Ktelah Street

From street map database of Hebron city, Abu Ktelah Street is located and start working and processing the required data of the street, figure (4.1).



FID	Shape *	OBJECTID	MAINSTREET	LENGTH	TYPE	ID	ST_NUMBER	
1429	Polyline	2730	0	94.316		275	506.2	
1272	Polyline	2555	0	514.248	secondary1	258	506.3	Talaat Ashaikh Alja
38	Polyline	45	0	367.372	secondary1	44	507	Wad Alkanah Stree
1347	Polyline	2636	0	215.056	secondary1	267	508	Beloon Street
40	Polyline	47	0	128.631	secondary2	46	509	Talaat Alkawasmi
41	Polyline	48	0	164.465	secondary2	47	509	Talaat Alkawasmi
109	Polyline	126	10	1913.791	main	125	510	Abokteilah
949	Polyline	2157	0	101.836	Un-paved	215	510.1	
948	Polyline	2153	0	110.523	Un-paved	215	510.3	
36	Polyline	43	0	144.861	secondary2	42	510.5	
751	Polyline	1663	0	245.288	Un-paved	165	510.7	
37	Polyline	44	0	602.846	secondary1	43	511	
1329	Polyline	2618	0	147.838		265	511.1	
947	Polyline	2149	0	205.862	Un-paved	214	513	
959	Polyline	2171	0	314.046	Un-paved	216	515	Talaat Khalat Almag
750	Polyline	1661	0	154.539	Un-paved	165	517	
1086	Polyline	2356	0	229.609	secondary2	238	519	Kaser Abo Attwan
91	Polyline	105	10	426.665	main	104	520	Beer Rijdah
1446	Polyline	2747	0	415.561	secondary1	257	522	Entryway Monshar
184	Polyline	224	0	876.642	secondary1	223	524	Manoh
1266	Polyline	2547	0	432.329	Un-paved	258	526	Entryway Monshar
1267	Polyline	2548	0	283.772	Un-paved	258	528	
112	Polyline	129	10	875.277	main	128	530	WadAlkarm
1309	Polyline	2596	0	853.855	Un-paved	263	531	

Figure (4.1): Hebron City Street Database, GIS Department Hebron Municipality,2017.

4.2 Select Abu Ktelah Route and Put it in Layer

Creating a temporary layer allows you to do things, such as make selections, without affecting the original data source.

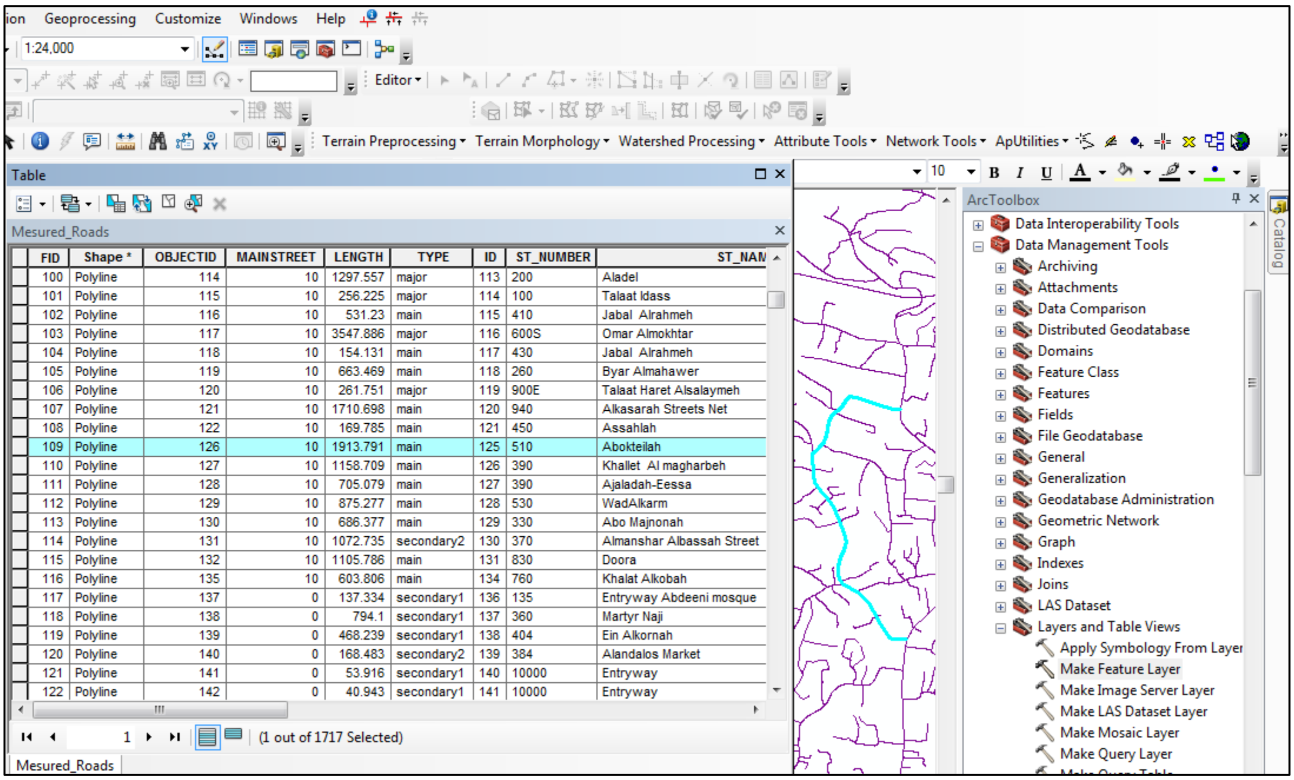


Figure (4.2): Take out the Street in the Layer

Choose the path of Abu Ktelah and put it in a layer to start applying the orders of linear referencing application on it and separate it from the rest of the Hebron city streets, figure (4.2).

4.3 Creates Routes.

A route feature class is a line feature class that has a defined measurement system. These measurement values can be used to locate events, assets, and conditions along its set of linear features.

The Create Routes tool is used to specify the input line features, the route identifier field, the method used to set the route measures, and the output feature class.

Creates routes from existing lines. The input line features that share a common identifier are merged to create a single route, figure (4.3).

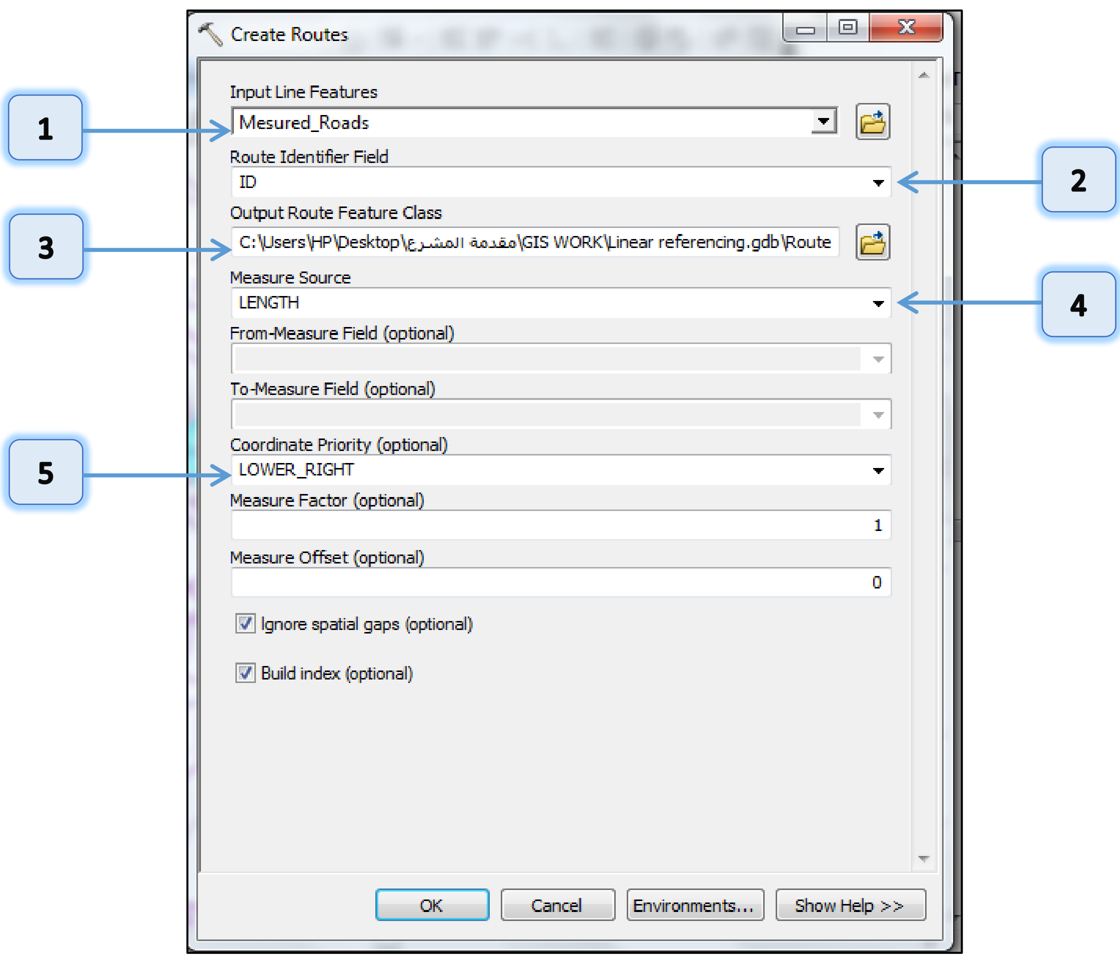


Figure (4.3): Creates Routes

As illustrated in figure (4.3), the

1. Measured_Roads layer is input line feature.
2. ID field is Abu Ktelah route identifier.
3. Street _Route the output feature class.
4. Length is measure source.
5. Lower right is coordinate priority.

4.4 Abu Ktelah Route

Figure (4.4) shows the Abu Ktelah route feature and its attribute table, which contains the ID, Shape and Shape_Length fields, which is created using create routes tool.

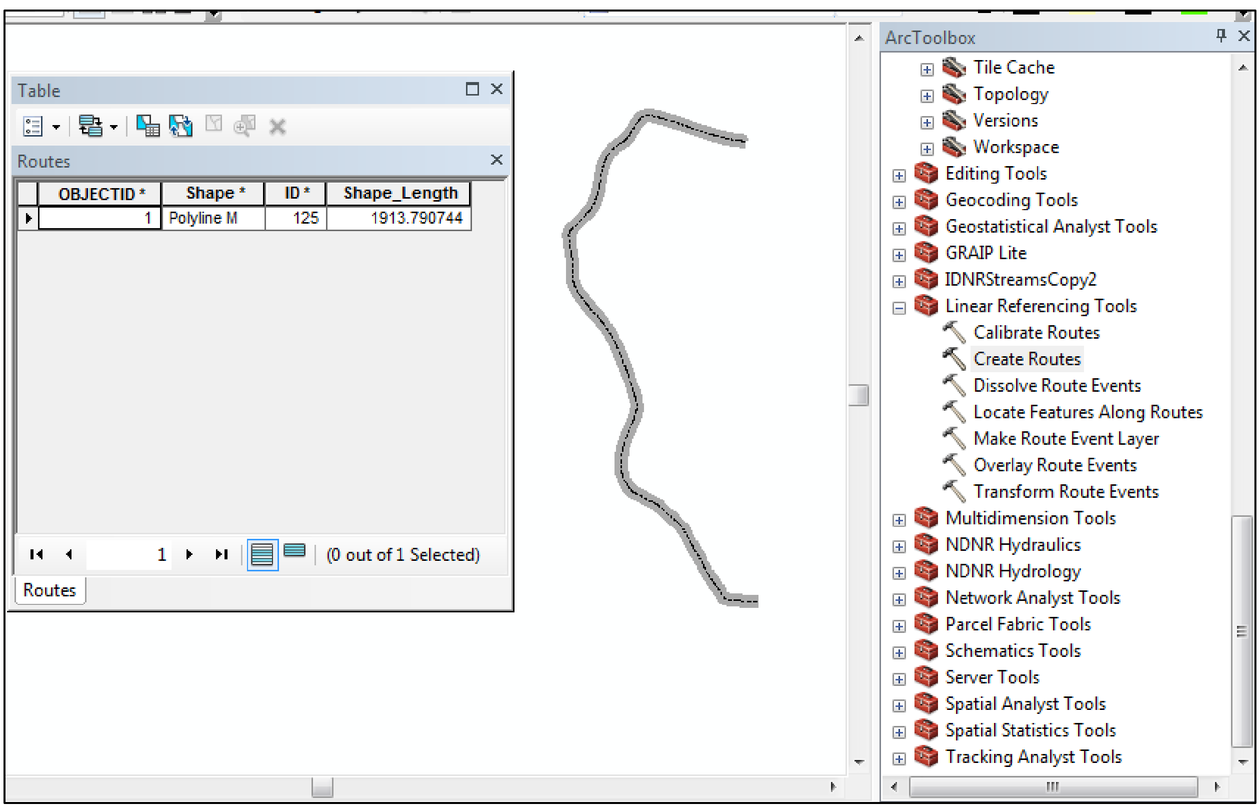


Figure (4.4): Abu Ktelah Route

4.5 Line and Point Event Tables

Event tables contain information about assets, conditions, and events that can be located along route features. Each row in the event table references an event and its location is expressed as measurements along named (identifiable) linear features.

Line event: Line events define a portion of a route. Both from- and to-measure fields must be specified. Figure (4.5) shows the surveyed line event table of Abu Ktelah street

Line Events

OBJE	OID	R_ID	Fmp	Tmp	ITEM	MATERIAL	CONDITION	status	LENGTH_	WIDTH_	OFFSET_M	NOTE
10	10	125	112.18	116.02	Trench	Asphalt	Poor	Need to repair	3.99	1.14	_	Null
79	79	125	1802.14	1807.16	Trench	Asphalt	Poor	Need to repair	29.2	0.89	_	Null
46	46	125	1060.83	1074.32	Crack	Asphalt	Poor	Need to fill	13.79	0	_	Longitudinal crack
69	69	125	1658.86	1658.9	Crack	Asphalt	Poor	Need to fill	5.81	0	_	cross track
36	36	125	925.05	935.18	Retaining wall	Concrete	Does not exist	Need to set	9.61	0	_	4.5 m height
41	41	125	986.41	993.29	Trench	Asphalt	Poor	Need to repair	6.85	1.5	_	Null
64	64	125	1606.96	1616.62	Crack	Asphalt	Poor	Need to fill	11.55	0	_	Longitudinal crack
31	31	125	650.52	805.05	Trench	Asphalt	Poor	need to repair	51.04	1.74	_	Null
17	17	125	221.83	280.57	Trench	Asphalt	Poor	Need to repair	58.72	0.71	_	Null
87	87	125	1212	1215	Crosswalk	paint	Dose not exist	Need to set	3	7	_	Null
19	19	125	259.53	272.54	Trench	Asphalt	Poor	Need to repair	12.8	0.46	_	Null
59	59	125	1477.63	1506.14	Crack	Asphalt	Poor	Need to fill	28.97	0	_	Longitudinal crack
4	4	125	61.39	62.25	Trench	Asphalt	Poor	Need to repair	1.12	4.86	_	Null
82	82	125	400	403	Crosswalk	paint	Dose not exist	Need to set	3	6	_	Null
49	49	125	1025.22	1025.5	Crack	Asphalt	Poor	Need to fill	4.14	0	_	cross track
54	54	125	1263.95	1273.17	Trench	Asphalt	Poor	Need to repair	9.22	1.5	_	Null
20	20	125	281.32	281.57	Trench	Asphalt	Poor	Need to repair	0.27	4.38	_	Null
8	8	125	101.41	102.59	Trench	Asphalt	Poor	Need to repair	0.77	4.22	_	Null
77	77	125	1782.32	1782.35	Crack	Asphalt	Poor	Need to fill	4.2	0	_	cross track
44	44	125	1051.07	1051.87	Trench	Asphalt	Poor	Need to repair	0.8	5.83	_	Null
72	72	125	1738	1752.77	Trench	Asphalt	Poor	Need to repair	14.72	0.86	_	Null
39	39	125	942.79	964.36	Crack	Asphalt	Poor	Need tofill	21.58	0	_	Longitudinal crack
62	62	125	1547.91	1548	Crack	Asphalt	Poor	Need to repair	4.58	0	_	cross track
29	29	125	661.34	709.37	Crack	Asphalt	Poor	Need to fill	46.88	0	_	Longitudinal crack
67	67	125	1635.6	1645.44	Trench	Asphalt	Poor	Need to repair	11.3	3.44	_	Null

(0 out of 83 Selected)

Line Events

Figure (4.5): Line Event Table

Point event: Point events occur at a precise location along a route. Only a from-measure field must be specified, figure (4.6).

Table

Point Events

OBJECTID *	OID	R_ID	Measurment	ITEM	MATERIAL	CONDITION	Status	LENGTH_M	WIDTH_M	DIAMETER_M
86	86	125	1350.36	TP	Wood	good	_	0	0	0.1
53	53	125	783.4	TP	Wood	good	_	0	0	0.1
148	148	125	1206.35	Patch	Asphalt	Poor	Need to repair	7.87	0.73	0
102	102	125	1528.31	TP	Wood	good	_	0	0	0.1
9	9	125	87.56	Hole	Asphalt	Poor	Need to fill	0	0	0.2
76	76	125	1214.38	Manhole	Steel	good	_	0	0	0.5
2	2	125	5	EP	Wood	good	_	0	0	0.1
43	43	125	617.64	Hole	Asphalt	Poor	Need to fill	0	0	0.4
138	138	125	1831.9	TP	Wood	good	_	0	0	0.1
125	125	125	1689.12	EP	Steel	good	_	0	0	0.1
143	143	125	1877.4	EP	Steel	good	_	0	0	0.1
130	130	125	1746.51	EP	steel	good	_	0	0	0.1
13	13	125	133.26	TP	Wood	good	_	0	0	0.1
71	71	125	976.33	Patch	Asphalt	Poor	Need to repair	0	0	3
38	38	125	489.59	TP	Wood	good	_	0	0	0.1
133	133	125	1781.61	EP	Steel	good	_	0	0	0.1
120	120	125	1669.25	Hole	Asphalt	Poor	Need to fill	0	0	0.5
94	94	125	1433.88	TP	Wood	good	_	0	0	0.1
61	61	125	886.32	EP	Steel	good	_	0	0	0.1
99	99	125	1495.96	S-MH	Steel	good	_	0	0	_
66	66	125	960.61	TP	Wood	good	_	0	0	0.1
33	33	125	451.56	EP	Steel	good	_	0	0	0.1
115	115	125	1649.41	EP	Steel	good	_	0	0	0.1
89	89	125	1367.57	EP	Steel	good	_	0	0	0.1
56	56	125	839.44	EP	Steel	good	_	0	0	0.1

0 (0 out of 157 Selected)

Figure (4.6): Point Event Table

4.6 Add Route Event to Abu Ktelah Route

Adding route events from the ArcMap Tools menu

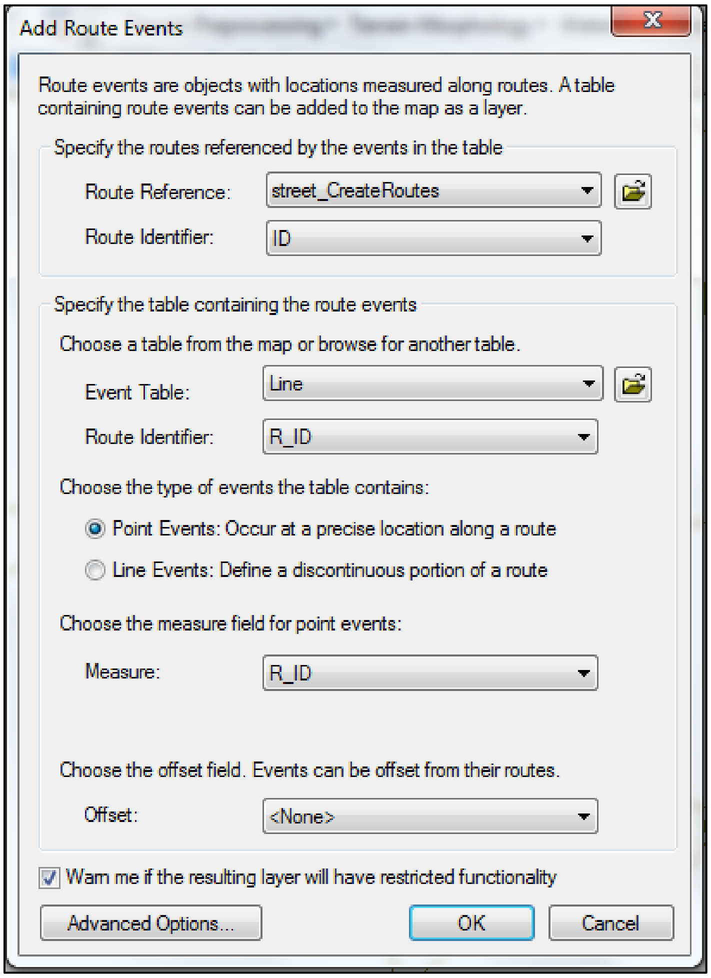
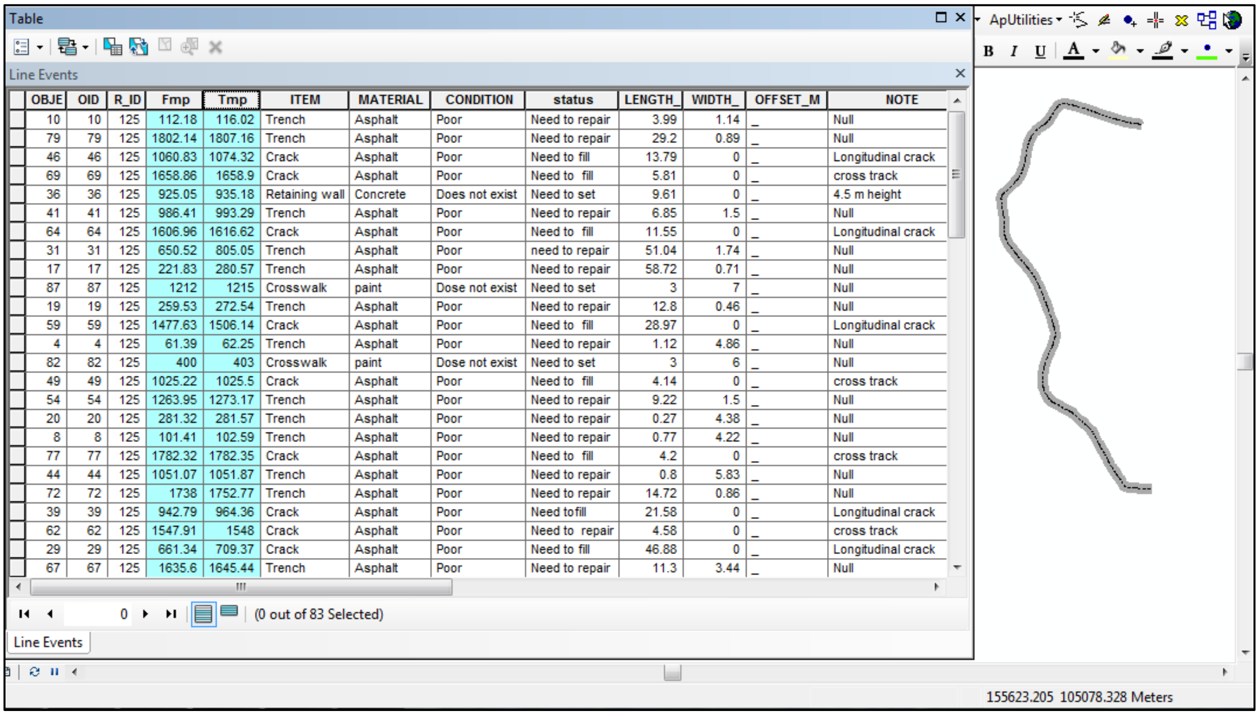


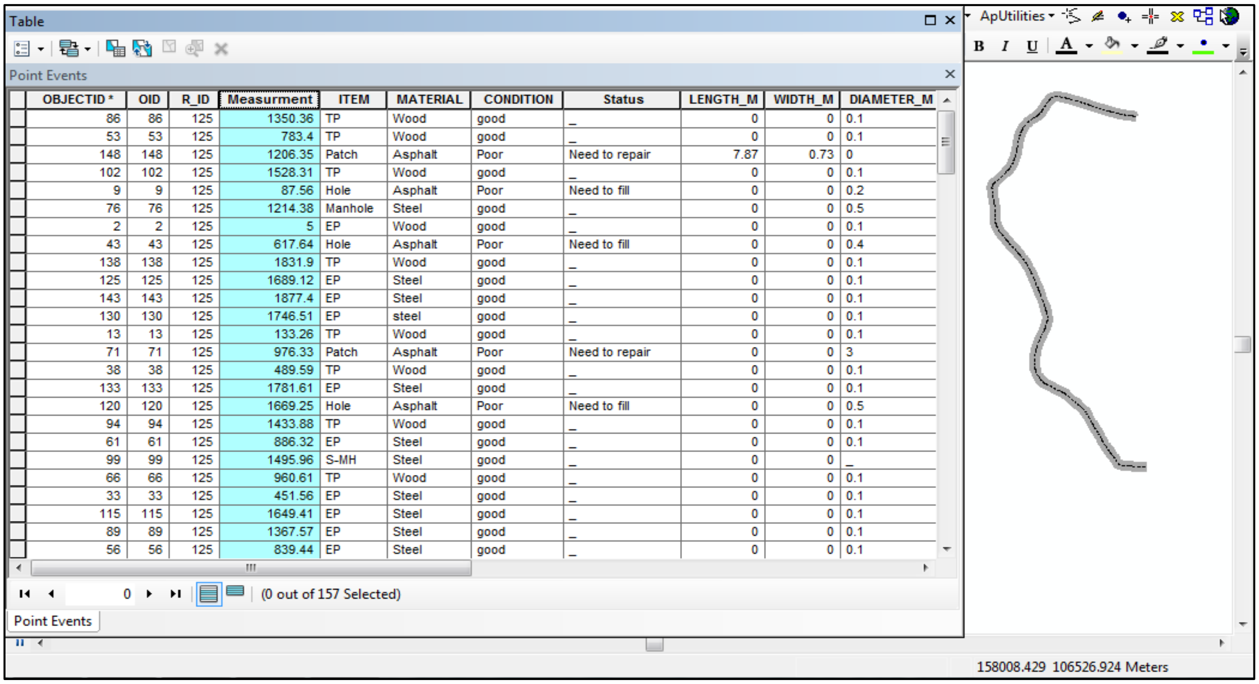
Figure (4.7): Add Route Event to Abu Ktelah Street

Add Route Events tool transforms the measures of events from one route reference to another and writes them to a new event table.Figure (4.8) and (4.9) represent the Abu Ktelah Route and its added line and point events ,respectively .



OBJE	OID	R_ID	Fmp	Tmp	ITEM	MATERIAL	CONDITION	status	LENGTH_	WIDTH_	OFFSET_M	NOTE
10	10	125	112.18	116.02	Trench	Asphalt	Poor	Need to repair	3.99	1.14	_	Null
79	79	125	1802.14	1807.16	Trench	Asphalt	Poor	Need to repair	29.2	0.89	_	Null
46	46	125	1060.83	1074.32	Crack	Asphalt	Poor	Need to fill	13.79	0	_	Longitudinal crack
69	69	125	1658.86	1658.9	Crack	Asphalt	Poor	Need to fill	5.81	0	_	cross track
36	36	125	925.05	935.18	Retaining wall	Concrete	Does not exist	Need to set	9.61	0	_	4.5 m height
41	41	125	986.41	993.29	Trench	Asphalt	Poor	Need to repair	6.85	1.5	_	Null
64	64	125	1606.96	1616.62	Crack	Asphalt	Poor	Need to fill	11.55	0	_	Longitudinal crack
31	31	125	650.52	805.05	Trench	Asphalt	Poor	need to repair	51.04	1.74	_	Null
17	17	125	221.83	280.57	Trench	Asphalt	Poor	Need to repair	58.72	0.71	_	Null
87	87	125	1212	1215	Crosswalk	paint	Dose not exist	Need to set	3	7	_	Null
19	19	125	259.53	272.54	Trench	Asphalt	Poor	Need to repair	12.8	0.46	_	Null
59	59	125	1477.63	1506.14	Crack	Asphalt	Poor	Need to fill	28.97	0	_	Longitudinal crack
4	4	125	61.39	62.25	Trench	Asphalt	Poor	Need to repair	1.12	4.86	_	Null
82	82	125	400	403	Crosswalk	paint	Dose not exist	Need to set	3	6	_	Null
49	49	125	1025.22	1025.5	Crack	Asphalt	Poor	Need to fill	4.14	0	_	cross track
54	54	125	1263.95	1273.17	Trench	Asphalt	Poor	Need to repair	9.22	1.5	_	Null
20	20	125	281.32	281.57	Trench	Asphalt	Poor	Need to repair	0.27	4.38	_	Null
8	8	125	101.41	102.59	Trench	Asphalt	Poor	Need to repair	0.77	4.22	_	Null
77	77	125	1782.32	1782.35	Crack	Asphalt	Poor	Need to fill	4.2	0	_	cross track
44	44	125	1051.07	1051.87	Trench	Asphalt	Poor	Need to repair	0.8	5.83	_	Null
72	72	125	1738	1752.77	Trench	Asphalt	Poor	Need to repair	14.72	0.86	_	Null
39	39	125	942.79	964.36	Crack	Asphalt	Poor	Need tofill	21.58	0	_	Longitudinal crack
62	62	125	1547.91	1548	Crack	Asphalt	Poor	Need to repair	4.58	0	_	cross track
29	29	125	661.34	709.37	Crack	Asphalt	Poor	Need to fill	46.88	0	_	Longitudinal crack
67	67	125	1635.6	1645.44	Trench	Asphalt	Poor	Need to repair	11.3	3.44	_	Null

Figure (4.8): Abu Ktelah Route and its Line Event Table



OBJECTID *	OID	R_ID	Measurment	ITEM	MATERIAL	CONDITION	Status	LENGTH_M	WIDTH_M	DIAMETER_M
86	86	125	1350.36	TP	Wood	good	_	0	0	0.1
53	53	125	783.4	TP	Wood	good	_	0	0	0.1
148	148	125	1206.35	Patch	Asphalt	Poor	Need to repair	7.87	0.73	0
102	102	125	1528.31	TP	Wood	good	_	0	0	0.1
9	9	125	87.56	Hole	Asphalt	Poor	Need to fill	0	0	0.2
76	76	125	1214.38	Manhole	Steel	good	_	0	0	0.5
2	2	125	5	EP	Wood	good	_	0	0	0.1
43	43	125	617.64	Hole	Asphalt	Poor	Need to fill	0	0	0.4
138	138	125	1831.9	TP	Wood	good	_	0	0	0.1
125	125	125	1689.12	EP	Steel	good	_	0	0	0.1
143	143	125	1877.4	EP	Steel	good	_	0	0	0.1
130	130	125	1746.51	EP	steel	good	_	0	0	0.1
13	13	125	133.26	TP	Wood	good	_	0	0	0.1
71	71	125	976.33	Patch	Asphalt	Poor	Need to repair	0	0	3
38	38	125	489.59	TP	Wood	good	_	0	0	0.1
133	133	125	1781.61	EP	Steel	good	_	0	0	0.1
120	120	125	1669.25	Hole	Asphalt	Poor	Need to fill	0	0	0.5
94	94	125	1433.88	TP	Wood	good	_	0	0	0.1
61	61	125	886.32	EP	Steel	good	_	0	0	0.1
99	99	125	1495.96	S-MH	Steel	good	_	0	0	_
66	66	125	960.61	TP	Wood	good	_	0	0	0.1
33	33	125	451.56	EP	Steel	good	_	0	0	0.1
115	115	125	1649.41	EP	Steel	good	_	0	0	0.1
89	89	125	1367.57	EP	Steel	good	_	0	0	0.1
56	56	125	839.44	EP	Steel	good	_	0	0	0.1

Figure (4.9): Abu Ktelah Route and its Point Event Table

4.7 Calculate the Maintenance Total Cost

Maintenance cost is calculated to give an initial idea to the concerned authorities such as municipalities, contractors or companies about the estimated cost of maintenance.

Table (4.1) shows the unit cost of maintenance for each event located on Abu Ktelah Street, Hebron Municipality.

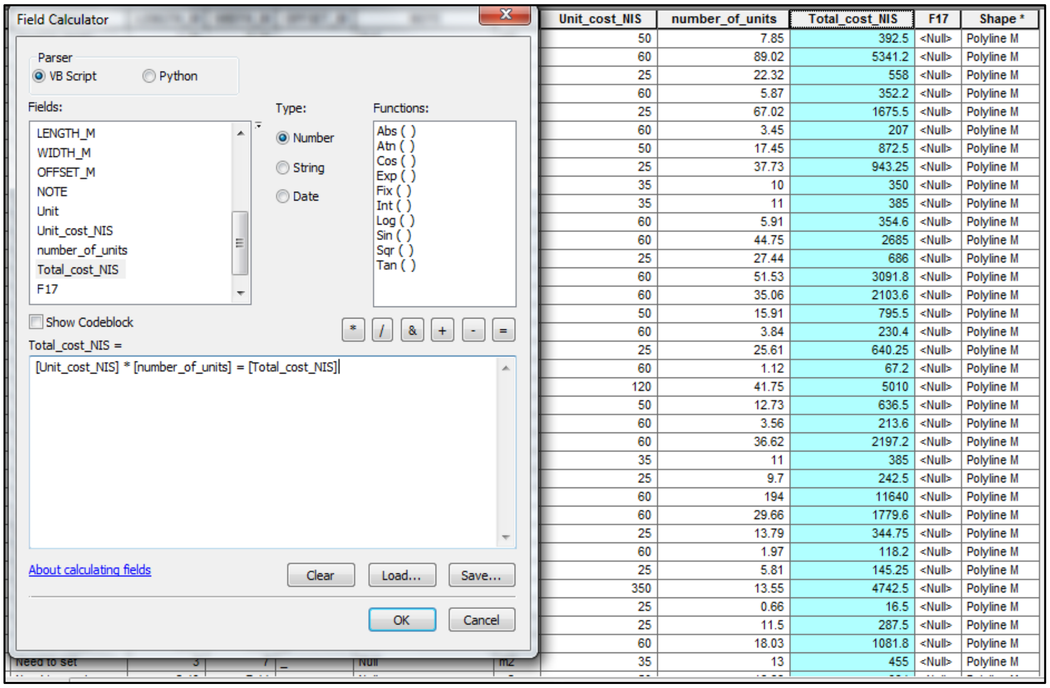
ITEM	Unit	Unit cost (NIS)
Crack	m	25.00
Trench	m2	60.00
Guardrail	m	350.0
Pump	m2	50.00
Retaining wall	m2	1500
Widening	m2	120
Paint	m2	35
Hole	m2	40
Patch	m2	60
Cat eye	-	45

Table (4.1): Events Maintenance Cost, Street Department, Hebron Municipality 2017.

Unit cost: The cost of maintaining every event on the street such as Crack, Pump, Hole, Patch….etc.

Total cost = Unit cost * Number of units.

The cost of maintenance was calculated for all events on Abu Ktelah Street using GIS field calculator from point and line event tables as shown in figure (4.10).



Unit_cost_NIS	number_of_units	Total_cost_NIS	F17	Shape *
50	7.85	392.5	<Null>	Polyline M
60	89.02	5341.2	<Null>	Polyline M
25	22.32	558	<Null>	Polyline M
60	5.87	352.2	<Null>	Polyline M
25	67.02	1675.5	<Null>	Polyline M
60	3.45	207	<Null>	Polyline M
50	17.45	872.5	<Null>	Polyline M
25	37.73	943.25	<Null>	Polyline M
35	10	350	<Null>	Polyline M
35	11	385	<Null>	Polyline M
60	5.91	354.6	<Null>	Polyline M
60	44.75	2685	<Null>	Polyline M
25	27.44	686	<Null>	Polyline M
60	51.53	3091.8	<Null>	Polyline M
60	35.06	2103.6	<Null>	Polyline M
50	15.91	795.5	<Null>	Polyline M
60	3.84	230.4	<Null>	Polyline M
25	25.61	640.25	<Null>	Polyline M
60	1.12	67.2	<Null>	Polyline M
120	41.75	5010	<Null>	Polyline M
50	12.73	636.5	<Null>	Polyline M
60	3.56	213.6	<Null>	Polyline M
60	36.62	2197.2	<Null>	Polyline M
35	11	385	<Null>	Polyline M
25	9.7	242.5	<Null>	Polyline M
60	194	11640	<Null>	Polyline M
60	29.66	1779.6	<Null>	Polyline M
25	13.79	344.75	<Null>	Polyline M
60	1.97	118.2	<Null>	Polyline M
25	5.81	145.25	<Null>	Polyline M
350	13.55	4742.5	<Null>	Polyline M
25	0.66	16.5	<Null>	Polyline M
25	11.5	287.5	<Null>	Polyline M
60	18.03	1081.8	<Null>	Polyline M
35	13	455	<Null>	Polyline M

Figure (4.10): Calculate the Total Cost of Maintenance

Total rehabilitation cost for Abu Ktelah street = 192,200 NIS.

4.8 Made a Symbology

At its simplest level of representation, spatial data exists as points, lines, areas, or rasters. You encode meaning into these basic shapes through a process of symbolization. Symbols allow you to illustrate a unique difference between features, some difference in magnitude between features, or another characteristic. Symbolization can take on a range of functions on a map but should be clear, concise, and easily understood by the user. In many ways, symbolization can be regarded as the coding of map features to communicate meaning.

Figure (4.11) shows the symbology for line event table using ITEM field to display various line events.

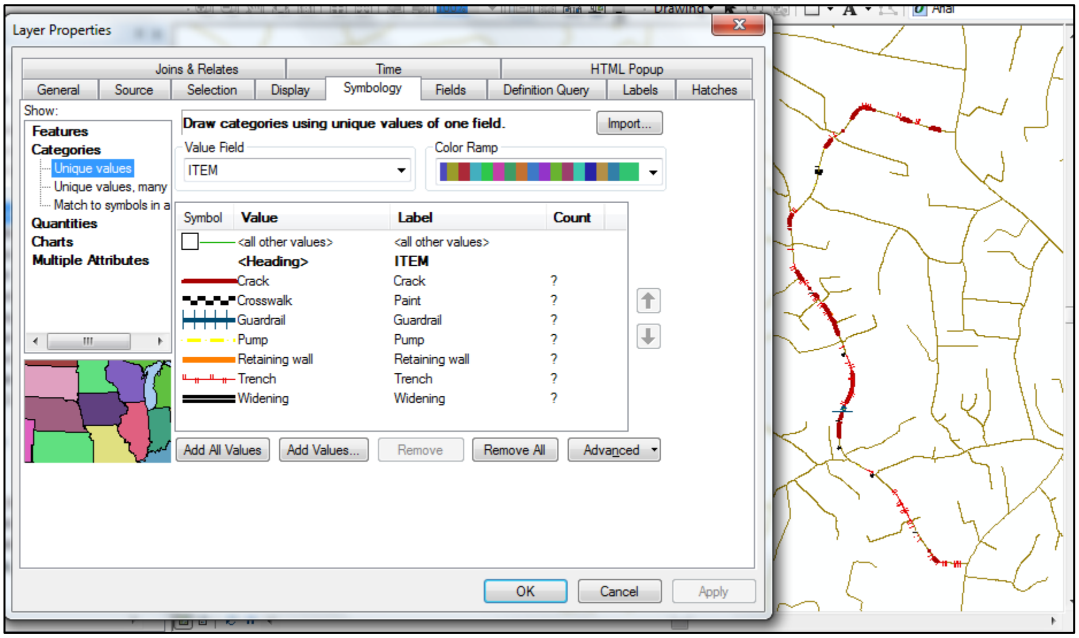


Figure (4.11): Line Event

Map1 in appendix I show the distribution of line event in the study area.

Figure (4.12) shows the symbology for point event table using ITEM field to display various point events.

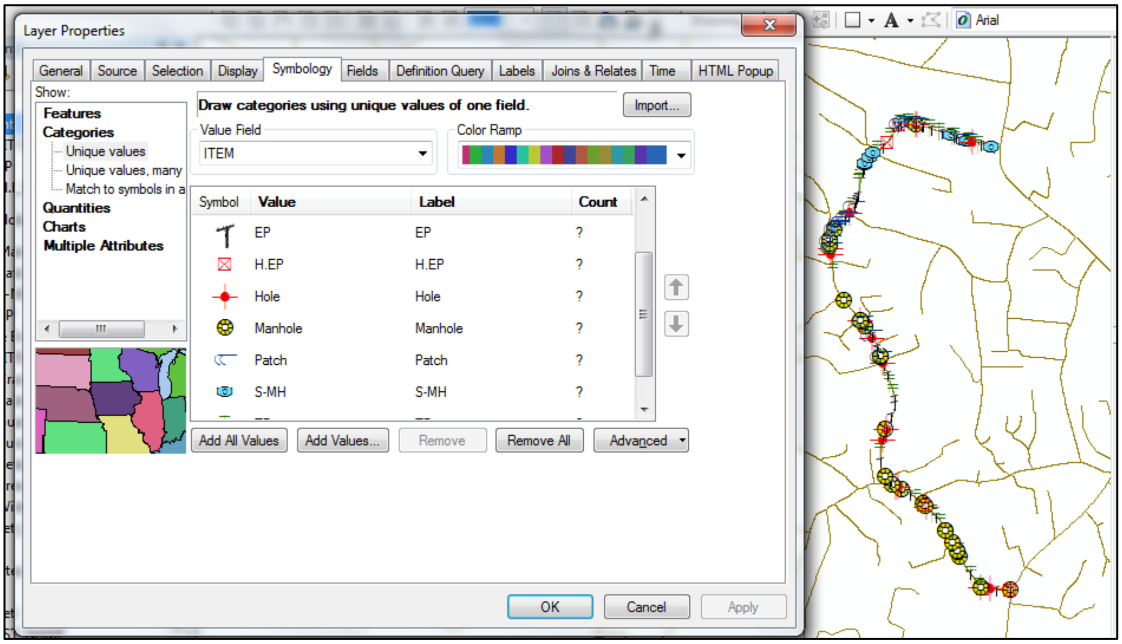


Figure (4.12): Point Event

Map2 in appendix I show the distribution of point events in the study area.

4.9 Linear Referencing and online ArcGIS Server (ArcGIS web map)

What is ArcGIS Server?

ArcGIS Server is software that makes your geographic information available to others in your organization and optionally anyone with an Internet connection. This is accomplished through web services, which allow a powerful server computer to receive and process requests for information sent by other devices. ArcGIS Server opens your GIS to tablets, smartphones, laptops, desktop workstations, and any other devices that can connect to web services.

ArcGIS Server opens your GIS to many types of devices through web services. You can take the resources you're familiar with through ArcGIS, such as map documents and geoprocessing models, and publish them to your server to create GIS web services. The services can be consumed in any application or device that can make a web service call using HTTP.

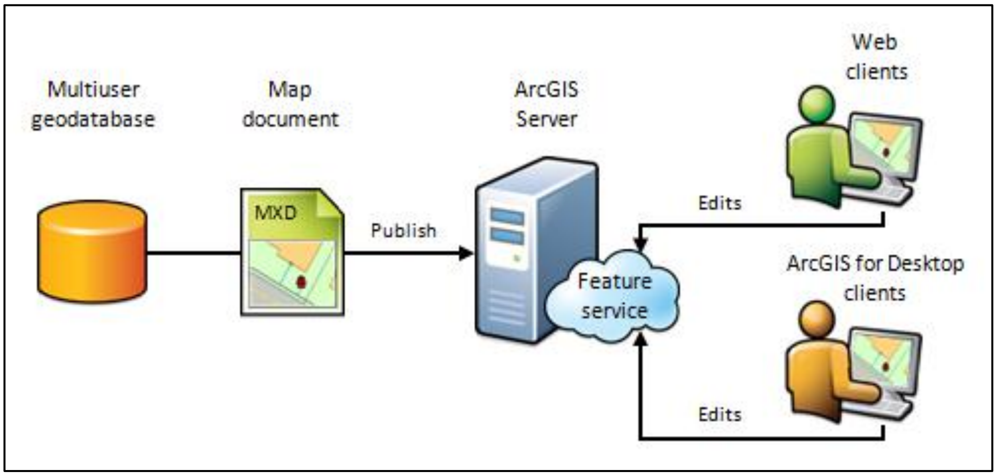


Figure (4.13): ArcGIS Server

ArcGIS Server components

- **GIS server—**Hosts and runs services. The GIS server consists of a server object manager (SOM) and one or more server object containers (SOCs).
- **Web server—**Hosts Web applications and Web services that use the objects running in the GIS server.
- **Clients**—Web browsers can be used to connect to Web applications running in the Web server. Desktop applications can connect either through HyperText

  Transfer Protocol (HTTP) to ArcGIS Web services running in the Web server, or connect directly to the GIS server over a LAN or WAN.

Advantages of using ArcGIS server

- **Get an online ArcGIS web map**.

  ArcGIS web map is an interactive display of geographic information that you can use to tell stories and answer questions.

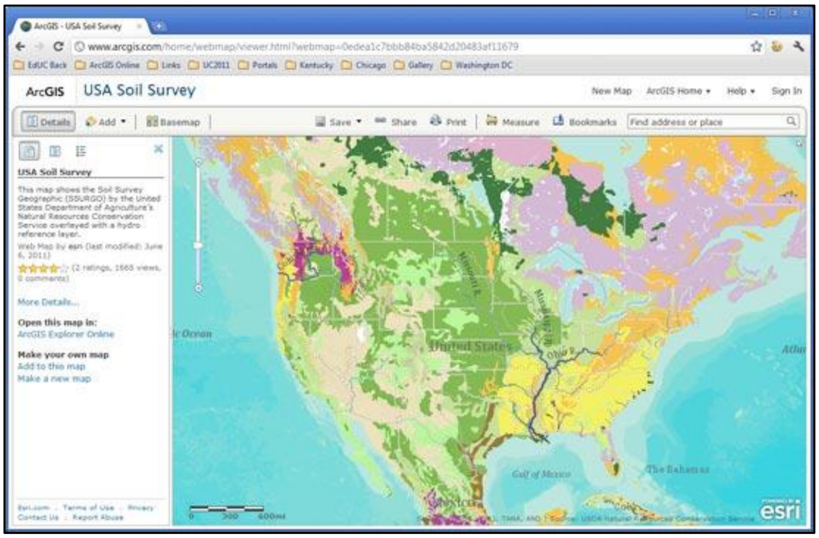


Figure (4.14): Online ArcGIS Web Map

- **No need to using ArcGIS Desktop**

- **Facilitate work in the field using GIS collector**

  Collector for ArcGIS is a great tool to get started on field data collection with a mobile phone or tablet computer. For the experienced desktop GIS user, Collector provides a mechanism for field data gathering and populating

  GIS attributes tables. For the individual in the field, Collector offers easy to complete template based forms that require no GIS experience. Collector is integrated with ArcGIS Online for Johns Hopkins, the library's supported web

GIS portal for sharing and making available geospatial data. Data gathered using a mobile device is automatically uploaded to a private section of ArcGIS Online. For areas that lack mobile connectivity, gathered data can be temporarily stored on the device and then easily uploaded when service is available.

ArcGIS server usage constraints

- Cost is very high about 100,000$.
- The system requires a committee of IT experts, server, domain and Board.

CHAPTER FIVE

CONCLUSIONS & RECOMMENDATION

This chapter contains:

5.1 Conclusions

5.2 Recommendations.

CONCLUSION & RECOMMENDATION

5.1Conclusions

A linear referencing system (LRS) is a support system for the storage and maintenance of information on events that occur along a network. A LRS consists of an underlying network that supplies the backbone for location, a set of objects with well-defined geographic locations. A LRM determines an unknown location on the basis of a defined path along the underlying transportation network, a distance along that path location, and optionally-an offset from the path.

We can say, LRS shows the different conditions of a street without any need to segment the original street by using an event table. So, we have one geometry and several routes.

The overall cost maintenance of Abu Ktelah Street is 192,200 NIS.

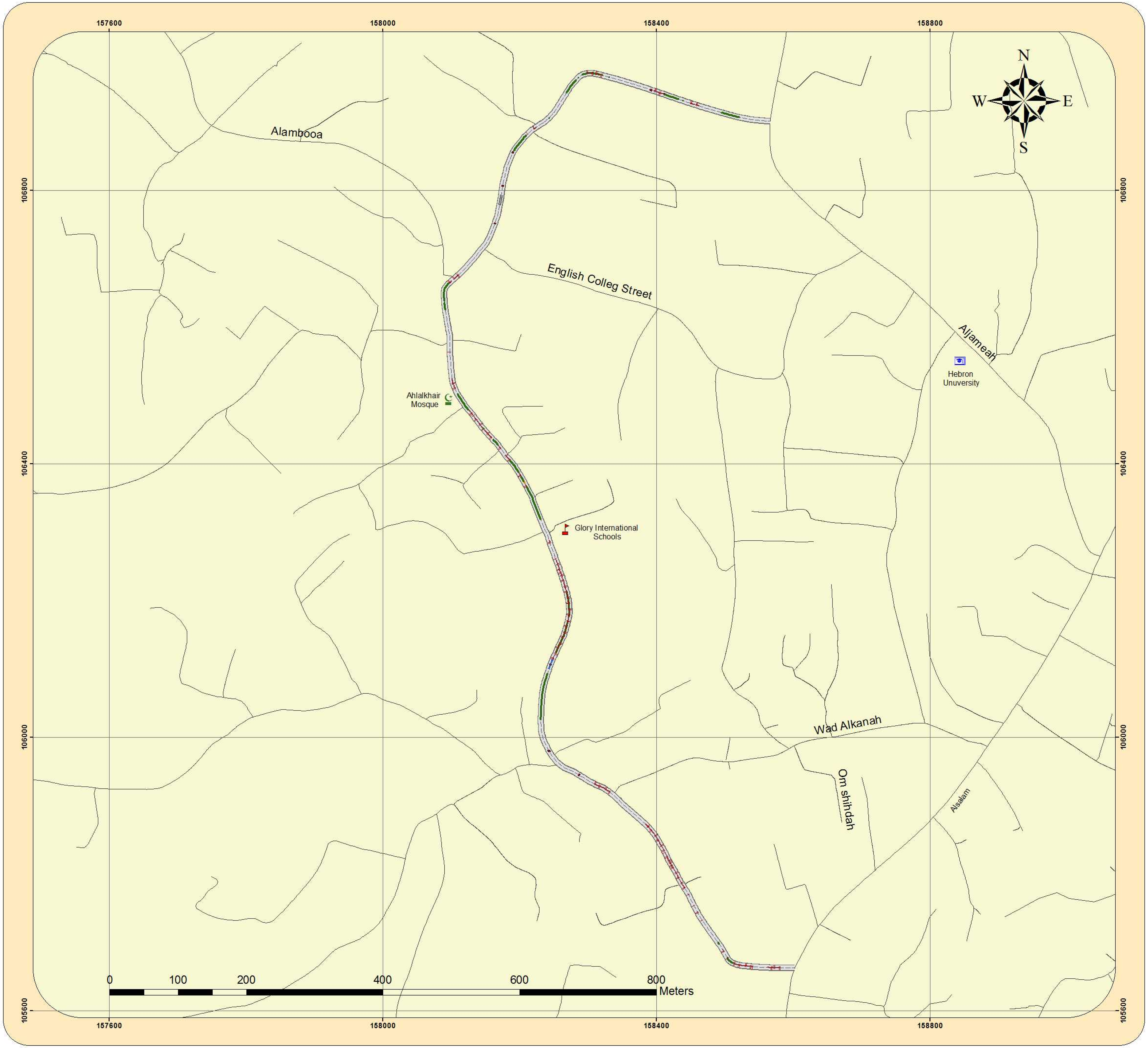
5.2 Recommendations

As a result, it is highly recommended to use linear referencing for ArcGIS Server method for managing streets day to day operations. It can be used for;

- Assessing pavement conditions.
- Maintaining, managing, and valuing assets—for example, traffic signs and signals, guard rails, toll booths, and detectors.
- Reviewing and coordinating construction projects
- And calculating the coast of street maintenance.

Note:

We wanted to use ArcGIS Service to develop our project but we can't because the crack version of it is not available in the ministry of local government.

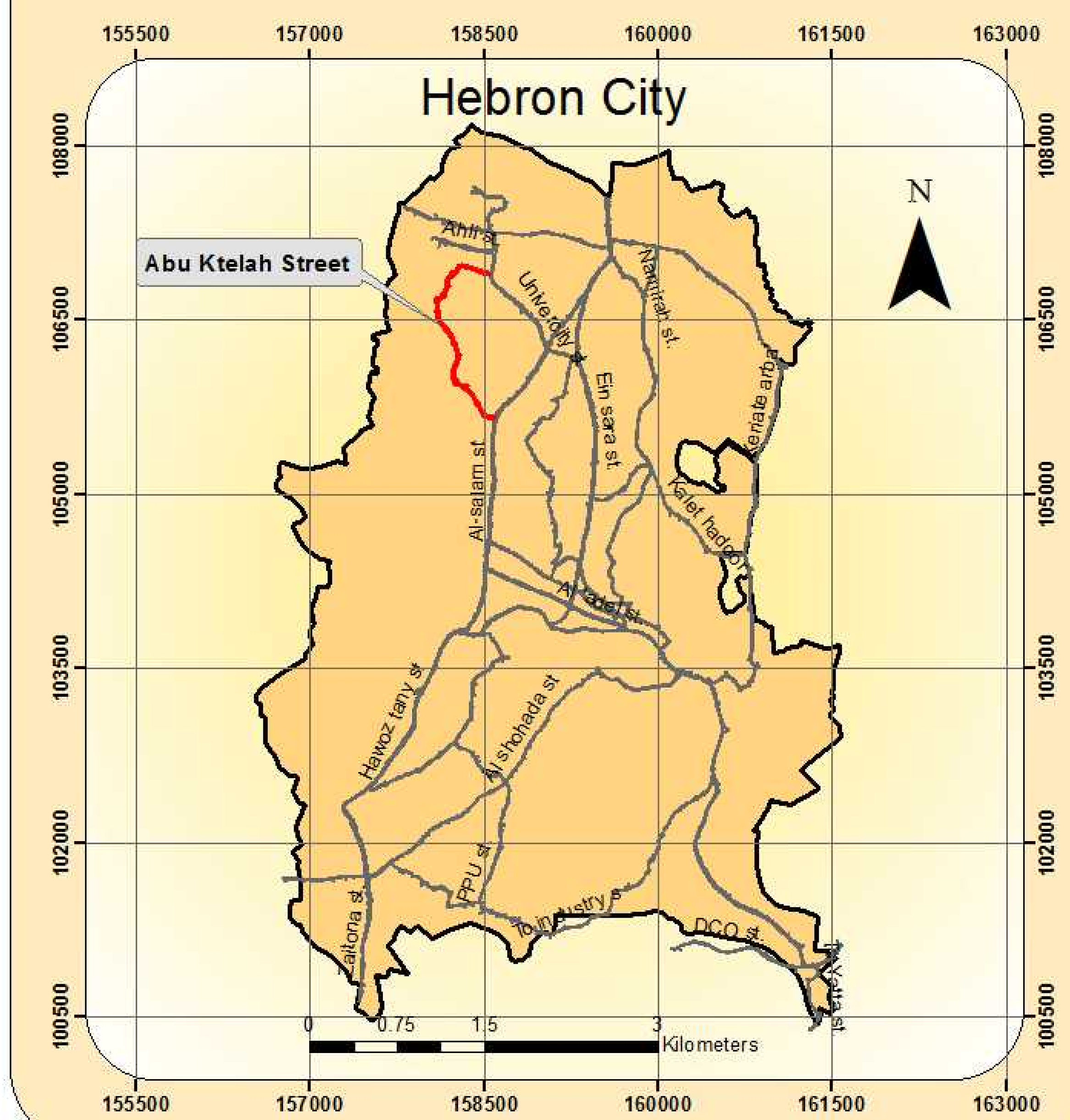


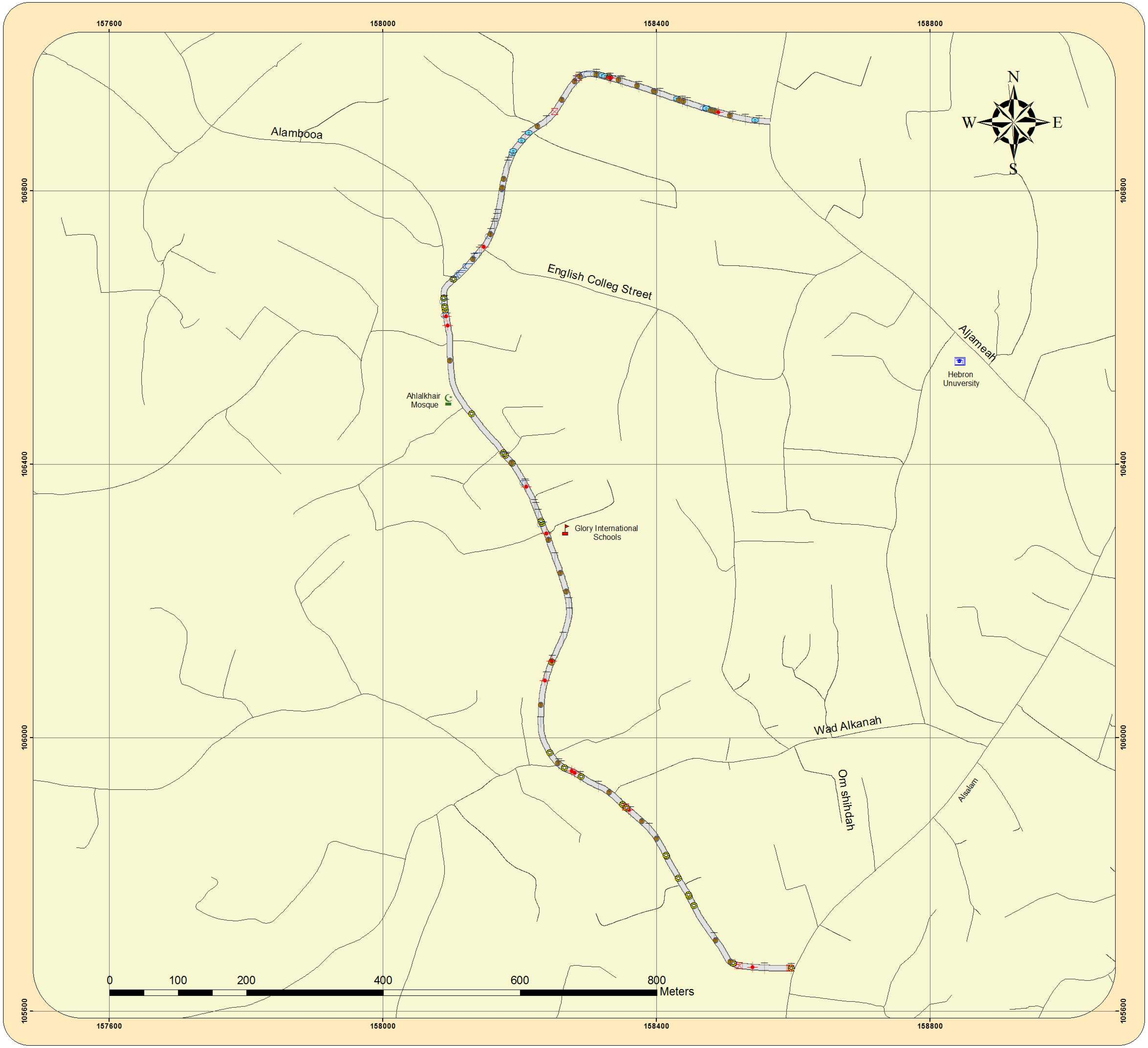
Abu Ktelah Street

Line Event Map

Event Type

- Crack
- Guardrail
- Paint
- Pump
- Retaining wall
- Trench
- Widening





Abu Ktelah Street

Point Event Map

Event Type

- EP
- H.EP
- Hole
- Manhole
- Patch
- S-MH
- TP

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