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The development of the conceptual methodology for identifying bridges along a path of travel on a highway system for evaluating an overload permit formula is presented. Simple network models of highway systems with defined nodes (intersections) and links (road segments) and highway and bridge identification attributes are used to determine routes of travel given general directions. Once the links to be crossed over are identified, bridge information is retrieved from BRINSAP through control section or bridge attributes on the links of the model.

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TOWARDS THE IMPLEMENTATION OF AN OVERLOAD PERMIT FORMULA USING NETWORK MODELS AND BRINSAP

An Interim Report on

Study No. 2/10-5-91-1266

OVERWEIGHT PERMIT RULES BASED ON BRIDGE STRESSES

by

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August 1992

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OR PERMIT PURPOSES

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

LENGTH

Symbol	When You Know	Multiply By	To Find	Symbol
in	inches	2.54	centimetres	cm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km

AREA

Symbol	When You Know	Multiply By	To Find	Symbol
in^2	square inches	645.2	centimetres squared	cm^2
ft^2	square feet	0.0929	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
mi^2	square miles	2.59	kilometres squared	km^2
ac	acres	0.395	hectares	ha

MASS (weight)

Symbol	When You Know	Multiply By	To Find	Symbol
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg

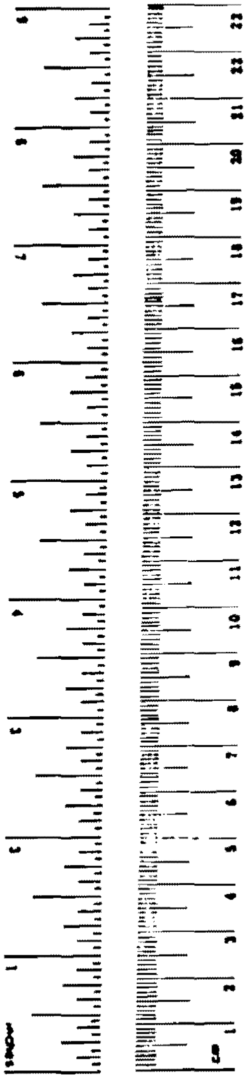
VOLUME

Symbol	When You Know	Multiply By	To Find	Symbol
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.0328	metres cubed	m^3
yd^3	cubic yards	0.0765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS TO SI UNITS

LENGTH

Symbol	When You Know	Multiply By	To Find	Symbol
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi

AREA

Symbol	When You Know	Multiply By	To Find	Symbol
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
km^2	kilometres squared	0.39	square miles	mi^2
ha	hectores (10 000 m^2)	2.53	acres	ac

MASS (weight)

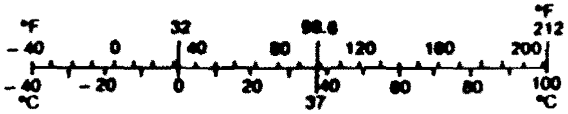
Symbol	When You Know	Multiply By	To Find	Symbol
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T

VOLUME

Symbol	When You Know	Multiply By	To Find	Symbol
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



These factors conform to the requirement of FHWA Order 5190.1A.

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* SI is the symbol for the International System of Measurements

ABSTRACT

The development of the conceptual methodology for identifying bridges along a path of travel on a highway system for evaluating an overload permit formula is presented. Simple network models of highway systems with defined nodes (intersections) and links (road segments) and highway and bridge identification attributes are used to determine routes of travel given general directions. Once the links to be crossed over are identified, bridge information is retrieved from BRINSAP through control section or bridge attributes on the links of the model.

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CHAPTER 1
INTRODUCTION, BACKGROUND AND OBJECTIVES

1.0 INTRODUCTION

The Texas Department of Transportation (TX DOT) is the authority of transportation in the State of Texas. The state of Texas is divided into various transportation districts. Each district contains several counties. This is done to decentralize department activities and increase the efficiency of the administration of the transportation system. In Texas there are 24 districts and 254 counties. At each county headquarter, a branch office of the Texas Department of Transportation maintains all local data and activities of transportation. The district headquarter coordinates all county activities within the district. Finally, the state office coordinates all district activities within the state.

1.1 NATURE OF PROBLEM

A problem faced in our highways is the constraint imposed on transportation due to limitations of the pavements and bridges on the roads. These limitations typically constrain vehicles to minimum heights and widths, to minimum and maximum lengths (depending on the number of axles) and to a maximum allowable weight. On Texas roads, the maximum legal gross weight, without a permit, is 80,000 pounds.

However, with current demands of society and industry, there are times when a truck must carry a load that exceeds the legal limit. In this situation, the trucker or the individual responsible for the transport requests an overload permit.

The Central Permit Office (CPO) of TX DOT handles all requests for overload permits. The CPO strives to issue all permits as rapidly as possible, over routes that can accommodate the size and weight of load. For heavy loads, the permit applicant must provide details of the equipment to be transported, the trailer to be used (number of axles, axle spacing, wheel gage etc.), the origin and destination, and the tentative route. The CPO will determine if the numbers of axles and tires are sufficient for not damaging the pavement. The information is then passed to the Division of Bridges and Structures for bridge evaluations.

Engineers of the Bridge Division evaluate each individual bridge on the proposed route. They determine if it has sufficient strength to sustain the vehicle and its load. During the process, they physically identify all bridges to be crossed, retrieve the structural plans pertaining to each bridge, and analyze each bridge. The CPO will then approve or deny the permit request based upon the analyses performed. Furthermore, the CPO may require an alternate route, a maximum speed limit and a police escort.

The primary problems associated with the process of issuing overload permits for super heavy vehicles are as follows. First, the time it takes to process the permit request is usually long. Second, the process requires a tremendous amount of engineering efforts. And third, permit fees are low when compared to the cost of issuing the permits.

1.2 PROJECT OBJECTIVES

This is a joint project conducted by the Texas Transportation Institute (TTI) and the University of Texas at El Paso (UTEP). The overall objective is the development and implementation of a Bridge Load Formula to ease the process of evaluating bridges for issuing overload permits in Texas. It is expected that the formula will be a function of both the bridge and vehicle characteristics. The development of the formula is being conducted by TTI. The work at UTEP consists of investigating the implementation of such a formula by automating the identification of bridges along a given route and the retrieval of bridge characteristics from a data base. This data base is the one used for the Bridge Inventory, Inspection and Appraisal Program

(BRINSAP) [1].

1.3 OBJECTIVE OF THIS REPORT

The objective of this document is to report on the activities accomplished at UTEP during the fiscal year 1990-91. These activities consisted of a) development of the conceptual methodology for identifying the bridges along a given path of travel using simple network models, b) utilization of BRINSAP for retrieving the bridge characteristics, and c) linkage between maps and BRINSAP using control section maps and digitized geographic maps.

1.4 POSSIBLE SOLUTION

Paths of travel are always determined using highway maps. If these maps had the exact location and an identification label of all bridges, then by a simple inspection, an individual can collect the identifications of all bridges to be crossed. Then, each bridge file can be retrieved for evaluating and analyzing the bridge.

The obvious solution to simplify and to speed up the above process is to use network models of the highways and the data base file of BRINSAP. First, a network model of a highway map can be created. This model may consist of nodes (simulating road intersections and/or interchanges) and links (simulating road segments between two intersections). Each node can have attributes such as the coordinates, the system and number of the highways being intersected, and others. Each link or road segment can have several attributes that may include: route system, route highway number, length, and control section numbers, number of bridges within the link, bridge identifications within the link, bridge location, etc. Using a network model, all the road segments (links) on a path of travel can be identified. Thus, if the bridge identifications are attributes to the road segments, then all bridges to be crossed can be identified. Once the bridges are identified, their characteristics can be extracted from BRINSAP. The Bridge Load Formula can then be evaluated to determine the adequacy of the bridge with respect to the overload.

It is possible to generate network models by hand from existing maps. However, if the technique were to be implemented throughout Texas, then it is imperative to generate the models from digitized geographic maps and/or from BRINSAP. Thus, the questions that arise are: How do we generate a network model, automatically or semi-automatically? Which types of maps are needed? How do we attribute the bridge data to the links of the network model? And how do we guarantee that all bridges are considered and that future bridges be included?

1.5 SCOPE OF THE RESEARCH

This research only considers the on-system highways and bridges. The proof of concepts on the use of network models for evaluation of bridges and routes have been performed using maps of Pecos and Harris Counties.

CHAPTER 2

CONCEPTUAL METHODOLOGY FOR IDENTIFYING BRIDGES AND EVALUATING BRIDGE FORMULA

2.0 INTRODUCTION

This Chapter presents a brief overview of network models and route selection, summarizes BRINSAP and describes the types of maps made available for this work.

2.1 NETWORK MODELS AND ROUTE SELECTION

Network models are widely used for studying flow problems. They are used in areas such as electrical circuits, transportation, manufacturing processes, construction management, etc.. In most of these areas, the ultimate goal is to minimize the path between two points. In our research, we are not particularly interested in minimizing the path between two points but to use the models for bridge identification and information retrieval. Since network theory may be complex, the concepts are summarized in terms of the problem being studied.

Any highway map can be represented as in Figure 1. A network model has at least two sets of elements, a set of nodes (representing highway intersections) and a set of links (representing road segments). Let the set of nodes be defined as:

$G = (g_1, g_2, \ldots\ldots, g_n)$.

Where, g_i is the node identification, and n is the total number of nodes in the network. The set of links is defined as:

$L = (L_1, L_2, \ldots\ldots, L_m)$.

Where, L_i is the link identification, and m is the total number of links in the network. Note that for the network to exist, each link needs two connection points. For example, for the network of Figure 1, L_1 is connected between g_1 to g_3. Define the set of link connections as:

$C = \{ (c_1,c_2)_1, (c_1,c_2)_2, \ldots,(c_1,c_2)_m \}$.

Where, $(c_1,c_2)_i$ is a pair of nodes taking the identifications of g_j.

Network models can be used for the study of flow (route selection) between two points. We see in Figure 1 that there are many paths of travel between any two points. Shortest path theorems exist to select a path that minimizes the number of links between two points or the attributes of the links (length, etc.).

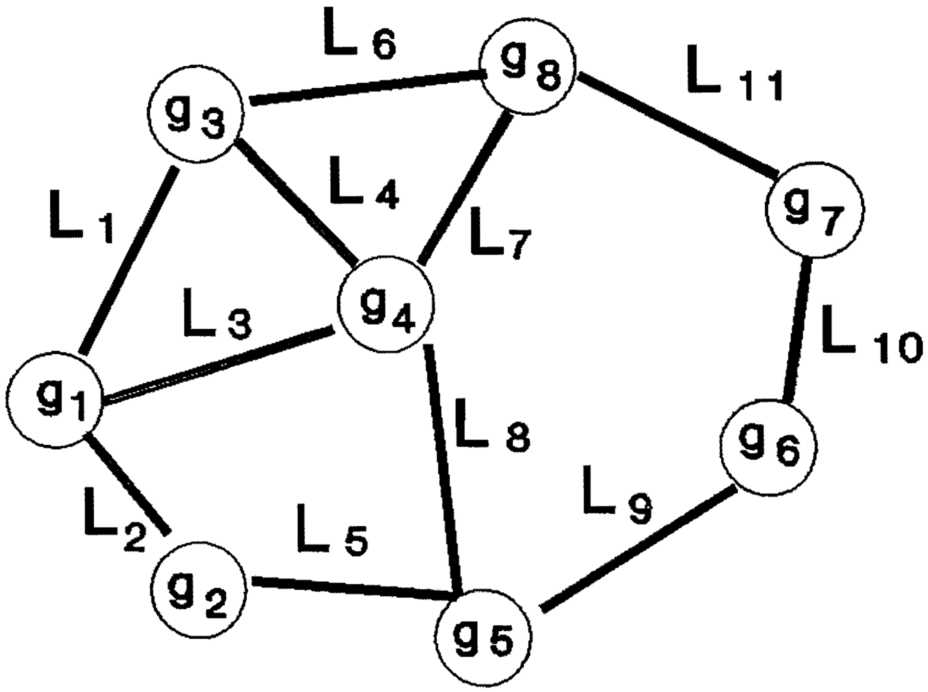

Figure 1 A Schematic Network

In this research, we do not intend to use shortest path theorems. Instead, attributes of the links and the nodes can be used to select all the links along a given desired path. The attributes that can be assigned to the nodes and link are many. The selection of the attributes is determined by the type of information available. The following attributes can be assigned to the nodes (intersections): planar or geographic coordinates, the number of roads intersecting at the node along with the link identifications, etc.. Likewise, the attributes that can be assigned to the links, besides the connection points, are as follows: system type (Interstate, US, State Highway, Farm Market Roads, etc.), highway identification number, number of control sections, control section numbers, length of road segment, number of bridges in the link, bridge identification numbers, etc.

The definition of the attributes may define the type of scheme to follow for route selection and bridge information retrieval. For route selection, the intersection coordinates, the information on the links connecting into the intersection, and the system type and highway number of the links can be used for selecting a route given a general path of travel. The general path of travel may consist of the principal routes and directions to be followed without specifying the individual road segments or links that will be travelled on. For example, to travel from Clear Lake City to Austin, the general path can be stipulated as: start at node "x" on IH-45; go north; take IH-10 west; take loop IH-610 north; exit at US-290 and continue to Austin. In the process, many intersections and links will be crossed. The route selection scheme can be accomplished by moving from node to node. At each node, the highway number of the links intersecting it can be used to decide which link to continue. Using this process, a complete list of all links to be travelled on can be compiled to create a subset of the network links. Then, the bridge identification attributes of the links in this subset thus identify the bridges that will be crossed. Then the process of retrieving the bridge information from BRINSAP is almost automatic. The problem of this approach is that it requires the bridge attributes. Alternatively, control section and bridge structure numbers can be used. For example, the subset of links can have attributes of control sections and bridge structure numbers. Since BRINSAP also has the control section number in which the bridge is located, then all bridges on the identified control sections can be retrieved. The problem with the latter is that control sections do not always begin or end at intersection points. Thus, the list of bridges will also include bridges that will not be travelled on.

2.2 SUMMARY OF AVAILABLE INFORMATION

The information available to the researchers are as follows: BRINSAP data files for Districts 6, 12 and 24, Control Section maps of Districts 6, 12 and 24, digitized maps of Harris County, and digitized control section maps of the above districts. It should be noted that the BRINSAP data for District 12 excludes the bridges for Montgomery and Waller Counties.

2.2.1 BRINSAP

BRINSAP stands for Bridge Inventory, Inspection and Appraisal Program. BRINSAP is TX DOT's program to implement the National Bridge Inspection Standards issued by the Federal Highway Administration [1]. The BRINSAP program has the following objectives:

1. Ensure the prompt discovery of any deterioration or structural damage that could become hazardous to the traveling public or that could become more costly to repair if corrective measures are not taken.
2. Maintain an up-to-date inventory that indicates the condition of all bridges on public roadways.
3. Maintain service records from which to appraise the relative value of various types of construction and repair.
4. Determine the extent of minor deterioration requiring routine maintenance and repair work as the basis for planning bridge maintenance programs.
5. Determine the extent of major deterioration requiring rehabilitation or replacement as the basis for planning bridge replacement and rehabilitation programs.

A bridge is officially defined as a structure including supports, erected over a depression or an obstruction, such as water, highway or railway, and having a track or passageway for carrying traffic or other moving loads and having an opening measured along the center of the roadway, track or passageway, of 20 feet or more between undercopings of abutments or backwalls, or spring lines of arches, or extreme ends of openings for multiple boxes; or having an inside diameter of 20 feet or greater in the case of pipes.

BRINSAP contains the records of each bridge. The structure of BRINSAP is shown in Appendix I. The database contains 179 fields. The bridge records that have been found to serve the purpose of this research are as follows:

1. Control Road ID/Section Number
2. Milepoint
3. Structure Number
4. Route System
5. Features Crossed
6. Critical Bridge
7. Facilities Carried Over
8. Location
9. Latitude
10. Longitude
11. Design Load
12. Minimum Vertical Clearance Over Bridge Roadway
13. Minimum Vertical Clearance
14. Superstructure Condition
15. Substructure Condition
16. Safe Load Capacity
17. Structure Length
18. Loading Type
19. Main Span Type
20. Major Approach Span Type
21. Minor Approach Span Type
22. Total Number of Spans
23. Maximum Span Length
24. Roadway Width
25. Operation and sufficiency ratings

The fields such as control section number, milepoint, location, features crossed, latitude and longitude can be used to provide the linkage between the BRINSAP and the maps. The structure length, design load, loading type, main span type and other fields may be used for the Bridge Load Formula.

2.2.2 CONTROL SECTION MAPS

Texas Department of Transportation uses various types of maps for its use. One of them is the Control Section Map (Figure 2). Every highway is divided into small segments called control sections. The control sections are used for road inventory. A control section is identified by a six digit code such as 0271-10, 1006-01 etc. The first four digits indicate the control number of the principal route; the next two digits indicate the control section number. The second number increases sequentially along the principal route. The maps also contain data of the length of each control section in miles.

2.2.3 DIGITIZED MAPS

Texas DOT has implemented the use of Intergraph [2] software for all drawings and maps they publish. Digitized drawings currently exist for control section maps, traffic maps and others. However, these are simple drawings and do not have geographical accuracy. Texas DOT recently began the adoption of digitized geographic maps originating from satellite surveys collected by the U.S Geological Survey. These maps have excellent accuracy but initially failed to include details of road names, highways numbers etc.. So the Division of Transportation Planning of TX DOT has modified the maps and began labeling all the characteristics of the maps, including symbols for the bridge locations. This work is in progress since they are labelling one county at a time. Several county highway maps have already been completed, including Harris County. Digitized maps offer the advantage that they can be easily visualized on a computer screen. Data processing is also facilitated.

2.3 LINKING BRINSAP AND CONTROL SECTION MAPS

By establishing a network model with control section attributes on the links, the

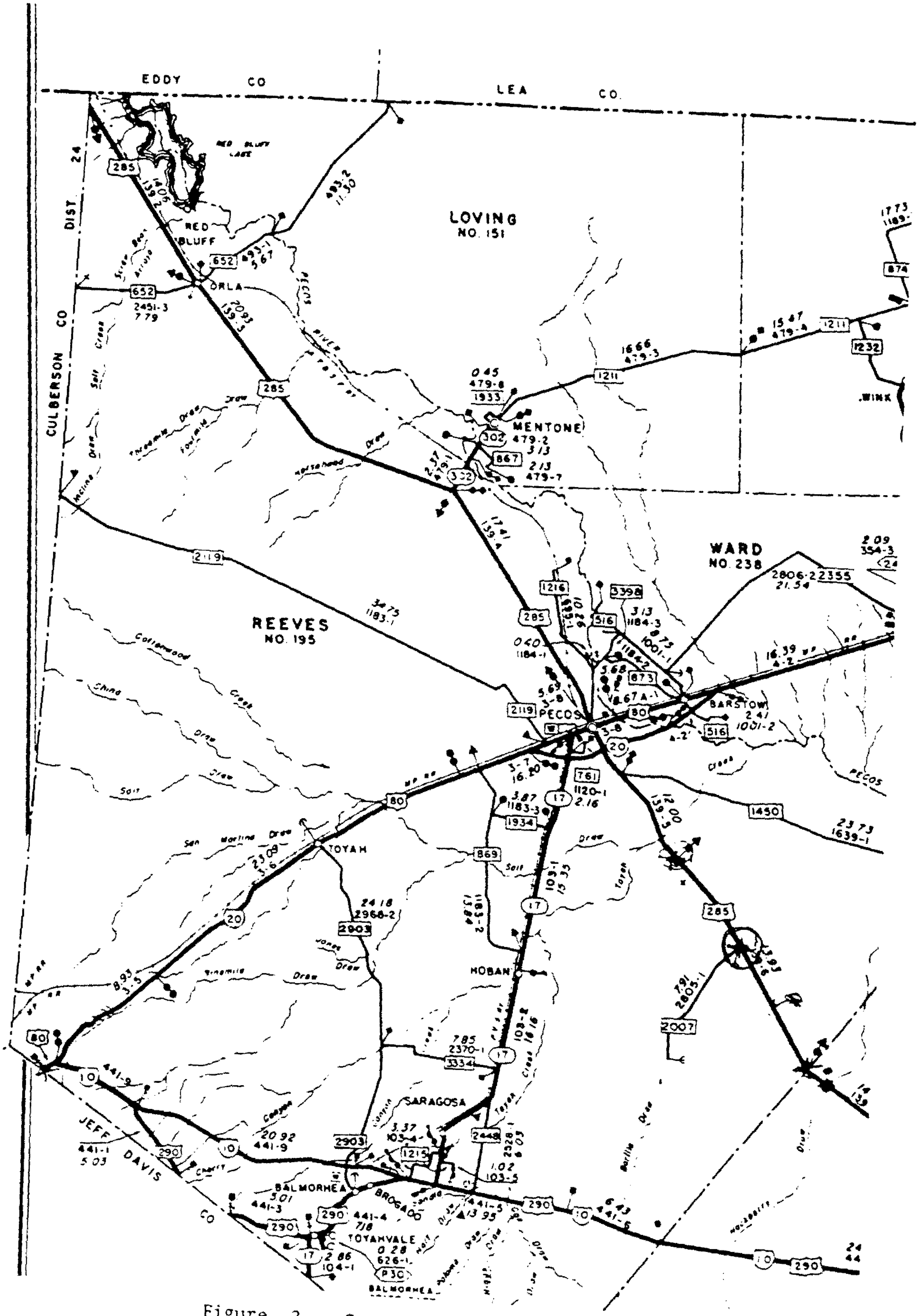

Figure 2. Control Section Map

control section information can serve as the linking mechanism between the highway system and BRINSAP. This can be done by using the common data of control section numbers on both the map and BRINSAP. By using the control section numbers, all the bridges that correspond to these sections can be retrieved. On the network model, the identification of road segments on the path of travel implies that the particular control sections will be on the path. Once the control section numbers are selected, then the corresponding fields of BRINSAP can be searched and the corresponding bridges retrieved.

The problem faced by using this concept is that the control sections do not begin or terminate at every road intersection. Because of this, a control section may span two or more links. This can create a problem of identifying more bridges than the actual number on the path. The network model can be generated with CAD software using a map of the system roads and the control section attributes can then be defined manually.

2.4 LINKING BRINSAP AND DIGITIZED GEOGRAPHIC MAPS

This section deals with the definition of bridge attributes to the links of a network model. Note that if the bridge identifications are attributed to the road segments they belong, the BRINSAP information retrieval is direct. We do not have to go through the control sections to identify the bridges on a path.

Digitized maps have great accuracy in the drawing elements. Thus, if the bridge coordinates are known, then the bridge location can be plotted over the geographic map. However, these maps are generally available in planar x-y coordinates. This coordinate system is based on the Lambert conformal conic projection with two standard parallels for each zone. Reference [3] explains the plane coordinate system used in the State. However, BRINSAP only has geographic longitude and latitude coordinates (spherical). Therefore, to accomplish the mapping and identification of the bridges, it is essential to perform a coordinate transformation. Mapping of the bridge locations facilitates the creation of the bridge attributes of the links.

It should be noted that the information provided by the BRINSAP data comes into question. BRINSAP has been generated through years of efforts; most of the geographic coordinates of the bridges have been entered by hand in the Division of Transportation Planning. Furthermore, the geographic coordinates in BRINSAP have a resolution of one-tenth of one minute (about ± 300 ft). Therefore, not all bridges will lay on a road segment, but they will be close enough for the bridges to be attributed to the links.

CHAPTER 3

STUDY ON THE USE OF CONTROL SECTION MAPS AND BRINSAP

3.0 INTRODUCTION

This chapter describes the method used to arrive at a network model of a highway map that contains links with control section attributes. The road segments of this network model have attributes such as highway number, control section number, length of control section, etc.. The basic idea of this concept is to identify the links on the path of travel, then interface with BRINSAP using the control section numbers. This is done by searching in BRINSAP for all bridges that are located on the control sections identified. A computer program was written to select the links along the desired highway path.

3.1 CREATION OF CONTROL SECTION MAP NETWORK MODEL

An initial study was conducted using a small portion of a highway system map of District 6 (around Pecos). This map shows the control section numbers and is illustrated in Figure 3. Figure 4 shows the node and link definitions that were used to define the network model. Table 1 lists the node definitions, as depicted in Figure 4, and the highway numbers intersecting the nodes. Table 2 lists the link numbers, the connecting nodes, the number of control sections, the section numbers, and the highway numbers of the links.

A node is a point of intersection of two or more highways. Each node is given a unique number which identifies it. For example, the intersection point of IH-20 with US-290 is defined as node number of 2 (see Figure 4). A link is the portion of highway between any two successive nodes or intersections. Each link is also given a unique identification number. For example, the segment of IH-20 between the nodes 2 and 5 is defined as a link number 26. Note that to define the link, the connecting nodes need to be attributed to the link.

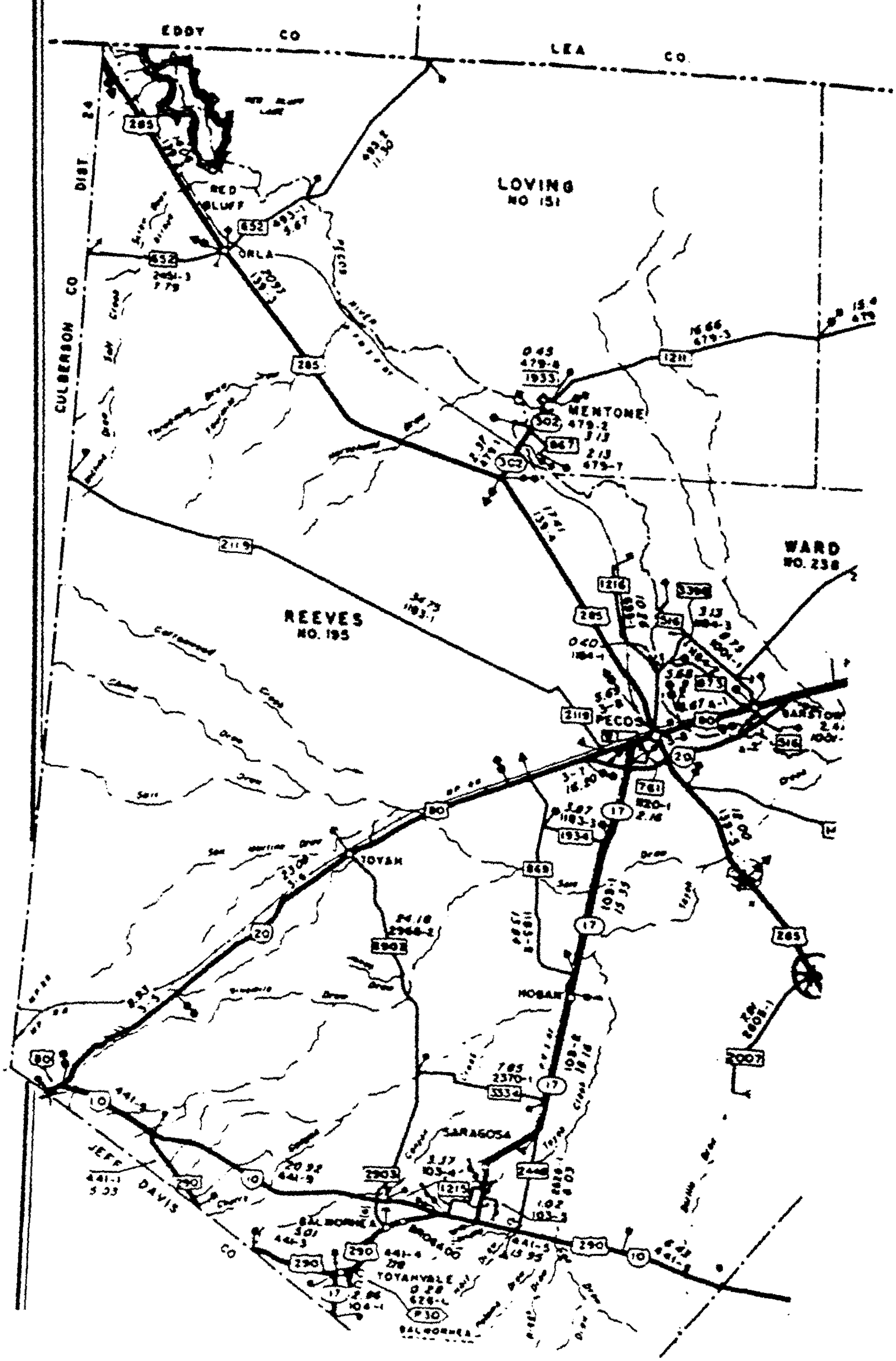

Figure 3. Case Study Control Section Map

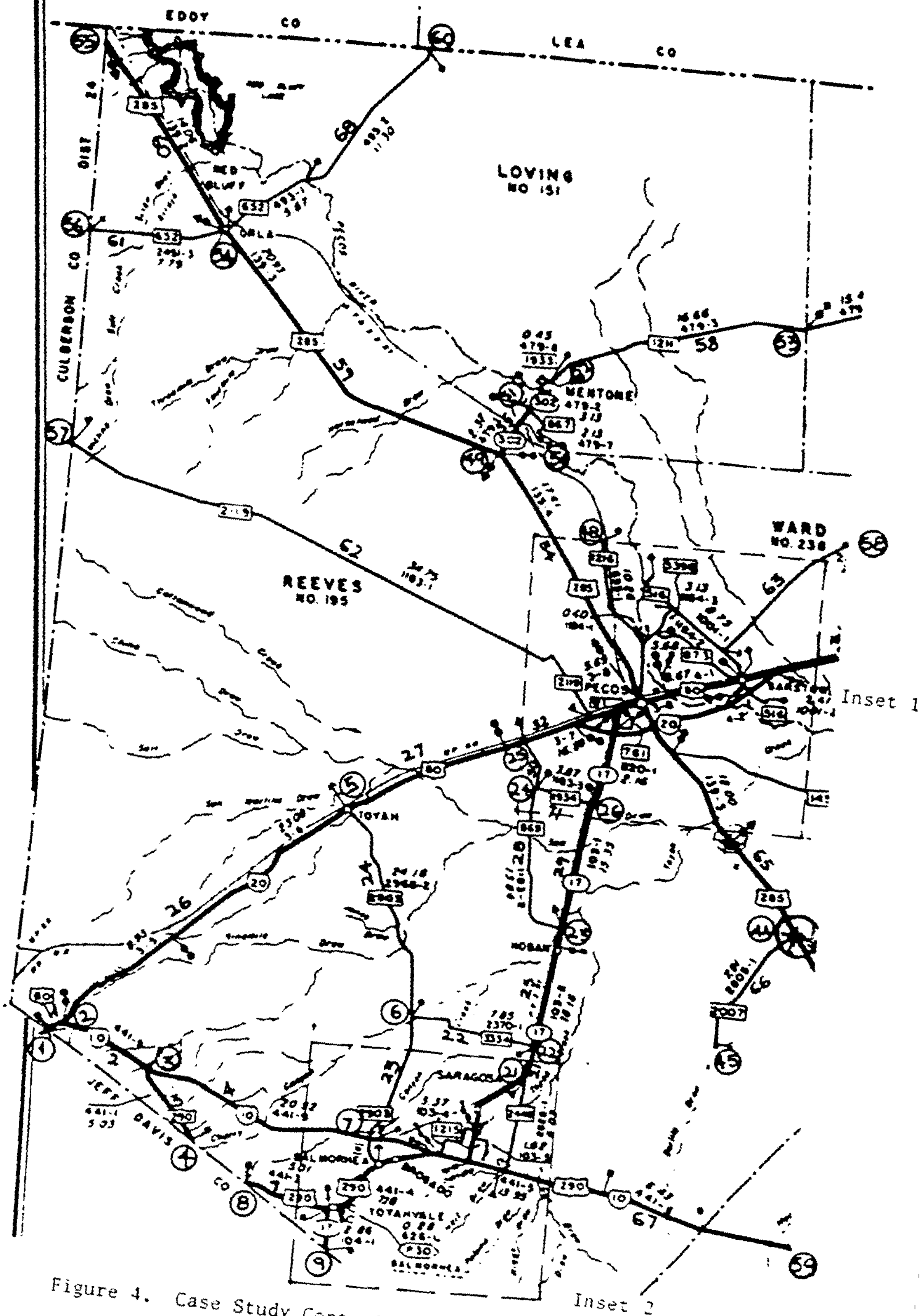

Figure 4. Case Study Control Section Map with Node and Link Definitions

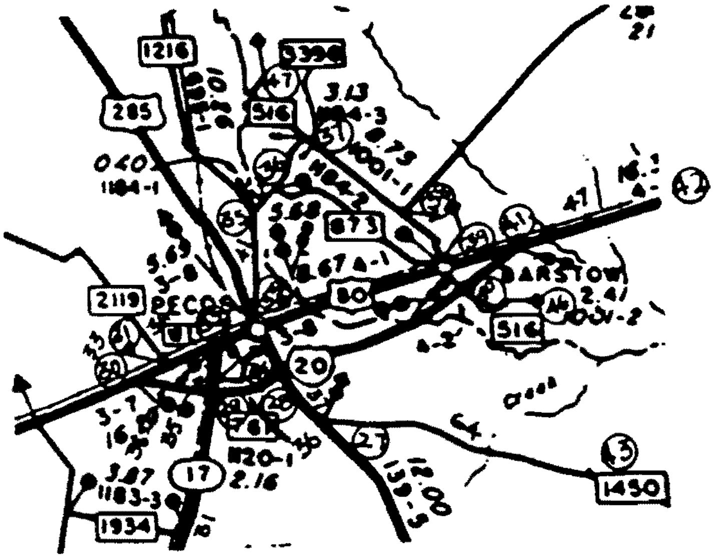

Figure 4a. Enlarged View of Inset 1

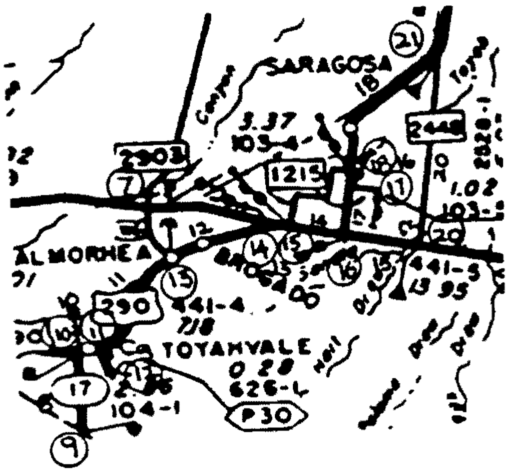

Figure 4b. Enlarged View of Inset 2

Table 1 - Definition of Network Nodes of Figure 4, with Intersecting Highway Numbers

Node No	Road 1	Road 2
1	IH10	IH10
2	IH20	IH10
3	IH10	US290
4	US290	US290
5	IH20	FM2903
6	FM2903	FM3334
7	IH10	FM2903
8	US290	US290
9	SH17	SH17
10	SH17	US290
11	US290	P30
12	P30	P30
13	US290	FM2903
14	IH10	US290
15	IH10	FM1215
16	IH10	SH1
17	FM1215	FM1215
18	SH17	FM1215
20	IH10	FM2448
21	FM2448	SH17
22	FM3334	SH17
23	SH17	FM869
24	FM869	FM1934
25	FM869	IH20
26	SH17	FM1934
27	US285	1450
28	IH20	US285
29	IH20	SH17
30	IH20	US80
31	US80	FM2119
32	US80	SH17
33	US285	FM1216
34	US80	US285
35	FM1216	FM3398
36	FM873	FM3398
37	FM516	FM3398
38	FM516	FM2355
39	US80	FM516
40	IH20	FM516
41	IH20	US80
42	IH20	IH20
43	FM1450	FM1450
44	US285	FM2007
45	FM2007	FM2007
46	FM516	FM516
47	FM516	FM516
48	FM1216	FM1216
49	US285	SH302
50	FM867	FM867
51	SH302	FM867
52	SH302	FM1211
53	FM1211	FM1211
54	US285	FM652
55	US285	US285
56	FM652	FM652
57	FM2119	FM2119
58	FM2355	FM2355
59	IH10	IH10
60	FM652	FM652

Table 2. Definition of Links of Network Model of Figure 4, with Connecting Node and Control Sections within Link.

Link No.	Node 1	Node 2	No. of Sections	Sect. 1	Sect. 2	Highway No.
1	1	2	1	441-9		IH10
2	2	3	1	441-9		IH10
3	3	4	1	441-1		US290
4	3	7	1	441-9		IH10
5	7	14	2	441-9	441-8	IH10
6	13	7	1	2968-2		FM2903
7	8	10	1	441-3		US290
8	10	9	1	104-1		SH17
9	11	12	1	626-1		P30
10	10	11	1	441-4		US290
11	11	13	1	441-4		US290
12	13	14	1	441-4		US290
13	14	15	1	441-5		IH10
14	15	16	1	441-5		IH10
15	16	20	1	441-5		IH10
16	17	18	1	103-5		FM1215
17	16	18	1	103-5		SH17
18	18	21	1	103-2		SH17
20	20	21	1	2528-1		FM2448
21	21	22	1	103-2		SH17
22	6	22	1	2370-1		FM3334
23	7	6	1	2968-2		FM2903
24	6	5	1	2968-2		FM2903
25	22	23	2	103-1	103-2	SH17
26	2	5	2	3-5	3-6	IH20
27	5	25	2	3-6	3-7	IH20
28	23	24	1	1183-2		FM869
29	23	26	1	103-2		SH17
30	24	25	1	1183-2		FM869
31	26	29	1	103-1		SH17
32	25	30	1	3-7		IH20
33	30	31	1	3-8		US80
34	31	32	1	3-8		US80
35	29	32	1	103-1		SH17
36	29	28	1	4-2		IH20

Table 2. Definition of Links of Network Model of Figure 4, with Connecting Node and Control Sections within Link.

Link No.	Node 1	Node 2	No. of Sections	Sect. 1	Sect. 2	Highway No.
37	27	28	1	139-5		US285
38	30	29	1	4-2		IH20
39	34	28	1	139-5		US285
40	28	33	1	139-5		US285
41	33	35	1	695-1		FM1216
42	34	39	1	4-1		US80
43	39	40	1	1001-2		FM516
44	28	40	1	4-2		IH20
45	39	41	1	4-1		US80
46	40	41	1	4-2		IH20
47	41	42	1	4-2		IH20
48	38	39	1	1001-1		FM516
49	37	38	1	1001-1		FM516
50	36	37	1	1184-3		FM3398
51	35	36	1	1184-1		FM3398
52	35	48	1	695-1		FM1216
53	37	47	1	1001-1		FM516
54	33	49	1	139-4		US285
55	49	51	2	479-1	479-2	SH302
56	50	51	1	479-7		FM867
57	51	52	1	479-2		SH302
58	52	53	1	479-3		FM1211
59	49	54	1	139-3		US285
60	54	55	1	139-2		US285
61	54	56	1	2451-3		FM652
62	31	57	1	1183-1		FM2119
63	38	58	1	2806-2		FM2355
64	27	43	1	1639-1		FM1450
65	44	27	2	139-5	139-6	US285
66	44	45	1	2805-1		FM2007
67	20	59	2	441-5	441-6	IH10
68	54	60	2	493-1	493-2	FM652
69	36	39	1	1184-2		FM873
70	40	46	1	1001-2		FM516
71	24	26	1	1183-3		FM1934

3.2 IMPLEMENTATION OF NETWORK MODEL WITH CONTROL SECTIONS

To implement the decision process of selecting the links on a travel path, and consequently the control sections, a FORTRAN program was written. This program utilizes the network data as defined in Tables 1 and 2 and takes as input the starting node, ending node, the highway numbers to be followed and the directions (east, west, north or south). It is implied that the points of origin and destiny correspond to nodes or intersections. It should also be noted that the input requires a direction, but the defined network data does not implicitly have this information. However, if careful attention is given to the definitions of the connecting nodes of the links in Table 2, it can be observed that the order of the connecting nodes dictates the direction. If the link has a primary route in the east-west sense, the first connection node is the east most node. Likewise, for a link with primary travel in the south-north sense, the most southern node is defined as connection 1. This scheme is used by the program to determine the correct choice of direction. For example, suppose that a vehicle is to travel from node 6 to node 25, following FM 2903 north and IH-10 east. From Figure 4, the links to travel will be 24 and 27. The program starts by first identifying the numbers of the links connected to node 6. That is, links 22, 23 and 24. From the highway number attribute of the links, it chooses links 23 and 24 to be candidate routes. However, since the connections of link 23 are 7-6 and those for link 24 are 6-5, and since the direction of travel is north, the correct link must have its first connecting node as 6. Therefore, link 24 is identified. Then the next node to be examined will be node 5 because it is the second node of link 24. Then, the program recognizes that links 26 and 27 are the candidate paths (from the highway number). The correct link is similarly chosen. Thus, the program recognizes that links 24 and 27 will be travelled and also assumes that the corresponding control section attributes will be travelled. For this very simple example, it should be noted that the control sections that are chosen are 2968-2 (for link 24) and 3-6 and 3-7 (for link 27).

This example also illustrates some problems with this technique. Control section 3-6 extends over links 26 and 27 and control section 3-7 extends over links 27 and 32. Therefore, bridges will be selected that are not on the path of travel.

3.3 EXAMPLE PROBLEM

This second example illustrates a longer path of travel than the example previously discussed. A vehicle is to travel from ORLA (node 54) to near HOBAN (node 23) along US-285 south, IH-20 west and US-17 south. The program then gets the first link which has the attributes that matches with the starting node and starting highway number. The program then gets all the links that form a chain. That is, the program gets a second link whose starting node is the same as the ending node of the first link, and that has the same highway number. The process is repeated until the program finds a link whose ending node corresponds to the intersection of the first segments of highways defined for the path of travel. The program then goes on to find the chain of links on the second highway. This procedure is continued until it finds the destination node. At this point the program terminates giving all the links that lie on the path of travel as the output. The link numbers defining the path are 59, 54, 40, 31 and 29. Once these link numbers are known, the control sections and the bridges on the control sections are also known.

3.4 DISCUSSIONS

The results presented in this chapter were based on the use of network models with control section attributes. There are some advantages and disadvantages of this methodology. One advantage is that the preparation of the network model is simpler because fewer attributes are assigned to the links and nodes. However, the obvious drawback is that the control sections do not begin or end at intersection points. Some control sections span over two or more links. For example, the control section 3-6 spans over the links 26 and 27, that is, a portion of the control section lies on link 26 and the remaining portion of the control section lies on link 27. When the control sections are retrieved, based on the links on the path of travel, then the entire control sections will be retrieved. That means all the bridges that correspond to the entire control section are retrieved when they are extracted from BRINSAP. But only those bridges that lie on the portion of the control section that falls on the path of travel are required. Therefore, by using this concept, more bridges are retrieved than the necessary ones.

To avoid this problem, segmentation of control sections is necessary. Segmentation of control section means dividing the control sections into small ones so that they will be exactly parted at the nodes. This can be accomplished by defining mileposts. But to do this, the problem faced is mapping of the bridges from BRINSAP to the segmented control sections. The milepoint and location of the bridge fields could be used to locate the bridges on the map. The mapping of bridges by this method is found to be error prone since the exact location of the bridges using these fields can not be marked on the control section map. Mapping of the bridges that lay at the intersections of highways is found more error prone since the bridges can lie on either side of the intersection and the exact location cannot be distinguished from the available data.

CHAPTER 4

STUDY ON THE USE OF DIGITIZED MAPS AND BRINSAP

4.0 INTRODUCTION

It was seen in the previous chapter that the use of control section attributes has disadvantages. These were the direct results of the bridges being identified indirectly through control sections. Obviously, the best possible alternative is to have bridge identifications directly attributed to the links. The problem with this is the massive data that needs to be defined and the verifications that the definitions are free of errors. Thus, this chapter explores the use of digitized geographic maps to define bridge attributes to the links by using the bridge geographic coordinates from BRINSAP.

The Texas Department of Transportation is currently implementing the use of digitized geographic maps. These maps have significantly more details about various highways and the detailing goes as far as mapping streets. Figure 5 illustrates the level of details that can be found in these digitized geographic maps. This particular plot corresponds to a small portion of North Houston around the intersection of IH-45 and IH-610. It should be emphasized that for the work required on the system routes, this level of detail is not necessary. Fortunately, these digitized maps were built in layers, where, for example, all city streets may be located in a particular layer of the CAD drawing. Thus, the unnecessary city streets and off-system roads can be easily excluded or deleted from the CAD drawings.

Since these digitized maps are in planar coordinates (rectangular), a transformation of the latitude and longitude coordinates of the bridges is required. Theoretically, when the coordinates of the bridges are transformed correctly, the mapping points must lie on the highway system. This is also a good way to identify errors in the latitude and longitude coordinates in BRINSAP. Once on the links of the digitized map, the attributes can be easily defined.

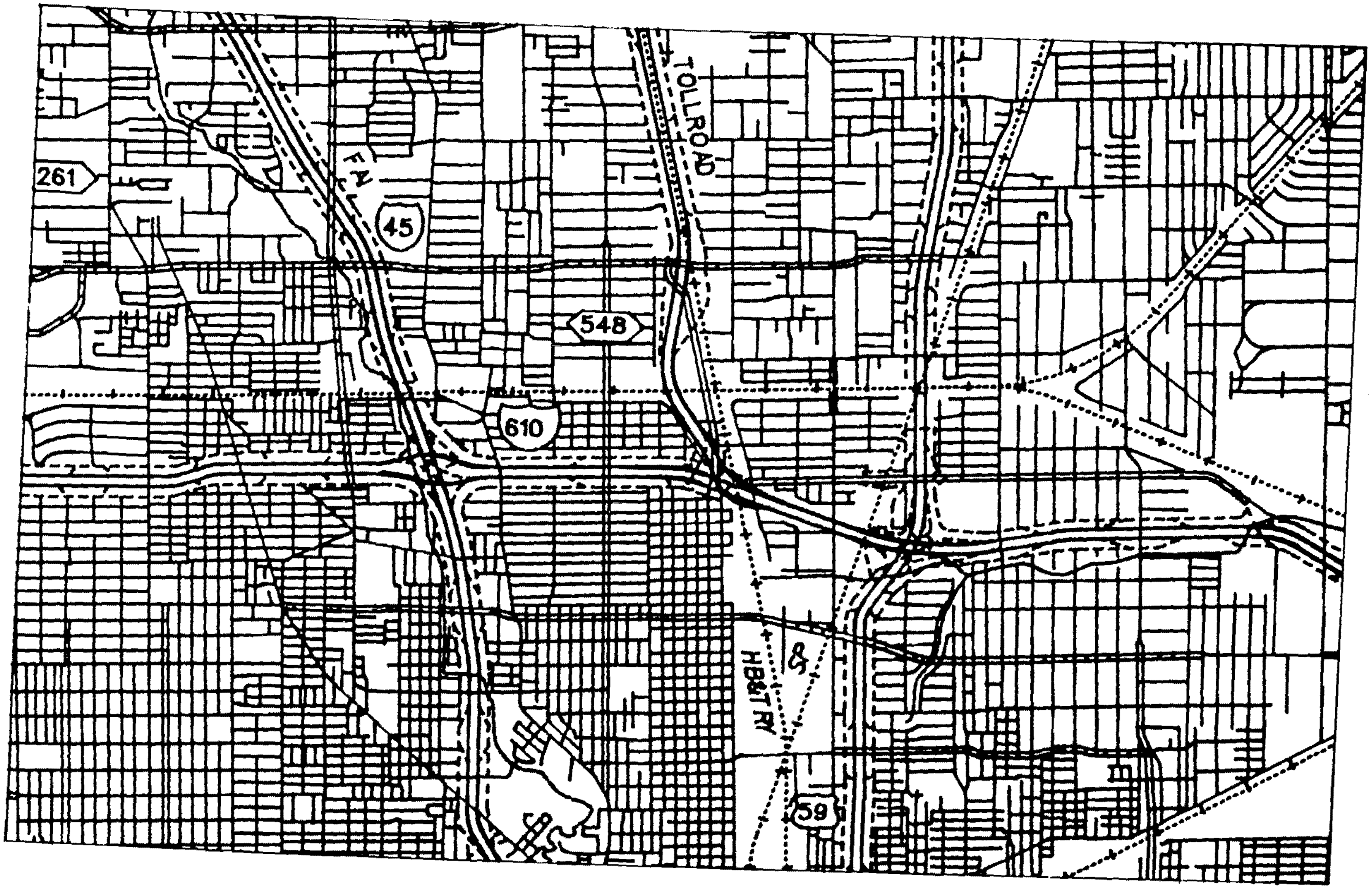

Figure 5. A Sample Digitized Geographic Map

To do this, another digitized map of control reference points is used. A control point can be defined as a point whose coordinates are known, both in latitude longitude coordinates and in X, Y rectangular coordinates. Using these control points, a system of equations can be obtained to transform the coordinates of the bridges from latitude and longitude into X and Y coordinates of the digitized maps.

The present study has been conducted on digitized maps of Harris County toward the development of a network model with bridge attributes.

4.1 ACCESSIBILITY OF DIGITIZED MAPS

The digitized geographic maps of Harris County used in this study were provided by the Division of Transportation Planning of TX DOT. The map of Harris County came in a set of files or quad sheets. Each quad sheet corresponds to a surface area covered by 7.5 minutes (longitude) by 7.5 minutes (latitude). There were 52 separate files for Harris County. Along with this map, there is a file of control points spaced every 2.5 minutes in both directions. The geographic coordinates and the planar coordinates of these points are both known. These control points were used to perform the transformation of coordinates. This is discussed in Section 4.2.

The software used is the Microstation PC CAD package of the Intergraph Corporation [2]. Initially, version 3.30 was used. However, there were several problems with this version. Version 4.0 is now in use. The advantage of this software is that it contains a relational data base interface. It is possible to generate data files directly from the drawings. This is extremely attractive because network models can be defined using this feature of the software.

4.2 TRANSFORMATION OF COORDINATES

The procedure to transform geographic to planar coordinates is done by using nine of the control points as shown in Figure 6. These points are symmetric about both X and Y axes and cover the entire portion of the digitized Harris County. Since these points are equally spaced in a longitude-latitude plane, the array of control points map into a square in a natural coordinate space as shown in Figure 7. Note that any given longitude-latitude point can be easily located in the natural plane. That is, the natural coordinates of such a point can be found given the longitude and latitude values. The CAD software was used to retrieve the planar X-Y coordinates of the nine control points. The latitude, longitude, and the planar X-Y coordinates of the control points are shown in Table 3.

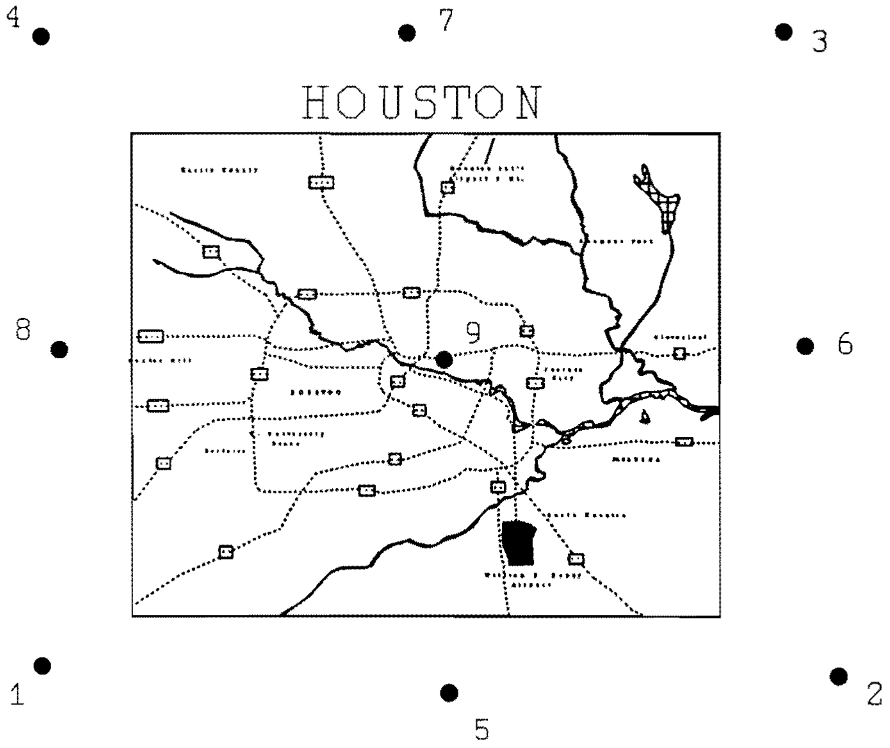

Figure 6 - Control points used for transformation of coordinates.

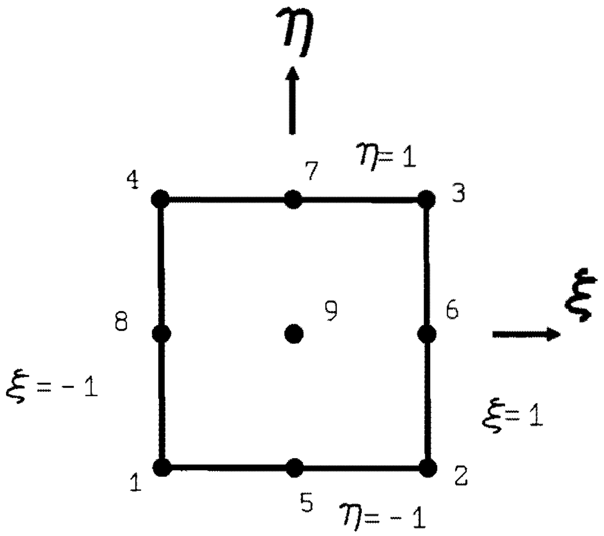

Figure 7 Natural Coordinates used for Mapping.

Table 3. Geographic and Planar Coordinates of Control Points covering Harris County. These Points were used for transformation of coordinates

Control Point	Longitude	Latitude	X (ft)	Y (ft)
1	96° 2.5′	29° 12.5′	2943609.5	511870.9
2	94° 52.5′	29° 12.5′	3315609.7	523143.7
3	94° 52.5′	30° 22.5′	3300645.8	947110.2
4	96° 2.5′	30° 22.5′	2932870.7	935972.6
5	95° 27.5′	29° 12.5′	3129623.8	517036.2
6	94° 52.5′	29° 47.5′	3308127.7	735106.5
7	95° 27.5′	30° 22.5′	3116772.4	941084.6
8	96° 2.5′	29° 47.5′	2938239.1	723900.3
9	95° 27.5′	29° 47.5′	3123205.5	729038.7

Because the coordinates of these points are known in both systems, given the geographic coordinates of any point within the area, the corresponding planar coordinates can be obtained by interpolation. The following two steps were used. First, the longitude and latitude coordinates of the bridge location were converted to natural coordinates. That is, to coordinate values between -1 and +1. Second, from interpolation theory, relationships between the planar coordinates and natural coordinates were used to determine the X-Y coordinate values. These two expressions are given by:

$$x=\sum_{i=1}^{9} N_i(\xi,\eta)\,x_i$$

$$y=\sum_{i=1}^{9} N_i(\xi,\eta)\,y_i$$

Where, x_i and y_i are the set of coordinate values for the ith control point, and N_i is the interpolating function associated with the ith control point. These functions are given by:

$$N_1=\frac{1}{4}(1+\xi)(1-\eta)-\frac{1}{2}N_5-\frac{1}{2}N_8-\frac{1}{4}N_9$$

$$N_2=\frac{1}{4}(1-\xi)(1-\eta)-\frac{1}{2}N_5-\frac{1}{2}N_6-\frac{1}{4}N_9$$

$$N_3=\frac{1}{4}(1-\xi)(1+\eta)-\frac{1}{2}N_6-\frac{1}{2}N_7-\frac{1}{4}N_9$$

$$N_4=\frac{1}{4}(1+\xi)(1+\eta)-\frac{1}{2}N_7-\frac{1}{2}N_8-\frac{1}{4}N_9$$

$$N_5=\frac{1}{2}(1-\xi^2)(1-\eta)-\frac{1}{2}N_9$$

$$N_6=\frac{1}{2}(1-\xi)(1-\eta^2)-\frac{1}{2}N_9$$

$$N_7=\frac{1}{2}(1-\xi^2)(1+\eta)-\frac{1}{2}N_9$$

$$N_8=\frac{1}{2}(1+\xi)(1-\eta^2)-\frac{1}{2}N_9$$

$$N_9=(1-\xi^2)(1-\eta^2)$$

Therefore, by following this mapping scheme, it is always possible to take the longitude and latitude values of a bridge location, and compute the corresponding X-Y planar coordinates that are consistent with the digitized geographic map.

4.3 BRIDGES OF HARRIS COUNTY

The longitude and latitude coordinates of the bridges in the BRINSAP file were first transformed to the rectangular coordinates of the digitized geographic maps. A macro within the CAD software was created to read the X-Y coordinates and to plot a point at the corresponding bridge location. The BRINSAP data file for Harris County made available to us contained 1,248 on-system bridges. The mapping of the bridges of Harris County had the objective to determine the adequacy of the geographic BRINSAP coordinates to define the correct bridge locations for link attributes.

Figure 8 shows a Houston area map indicating the segments of the map shown in Figures 9 through 14. These figures show the on-system roads and the mapped bridge locations. In Figures 9 through 14, the dots indicate the mapped bridge location as obtained by transforming the longitude-latitude BRINSAP data.

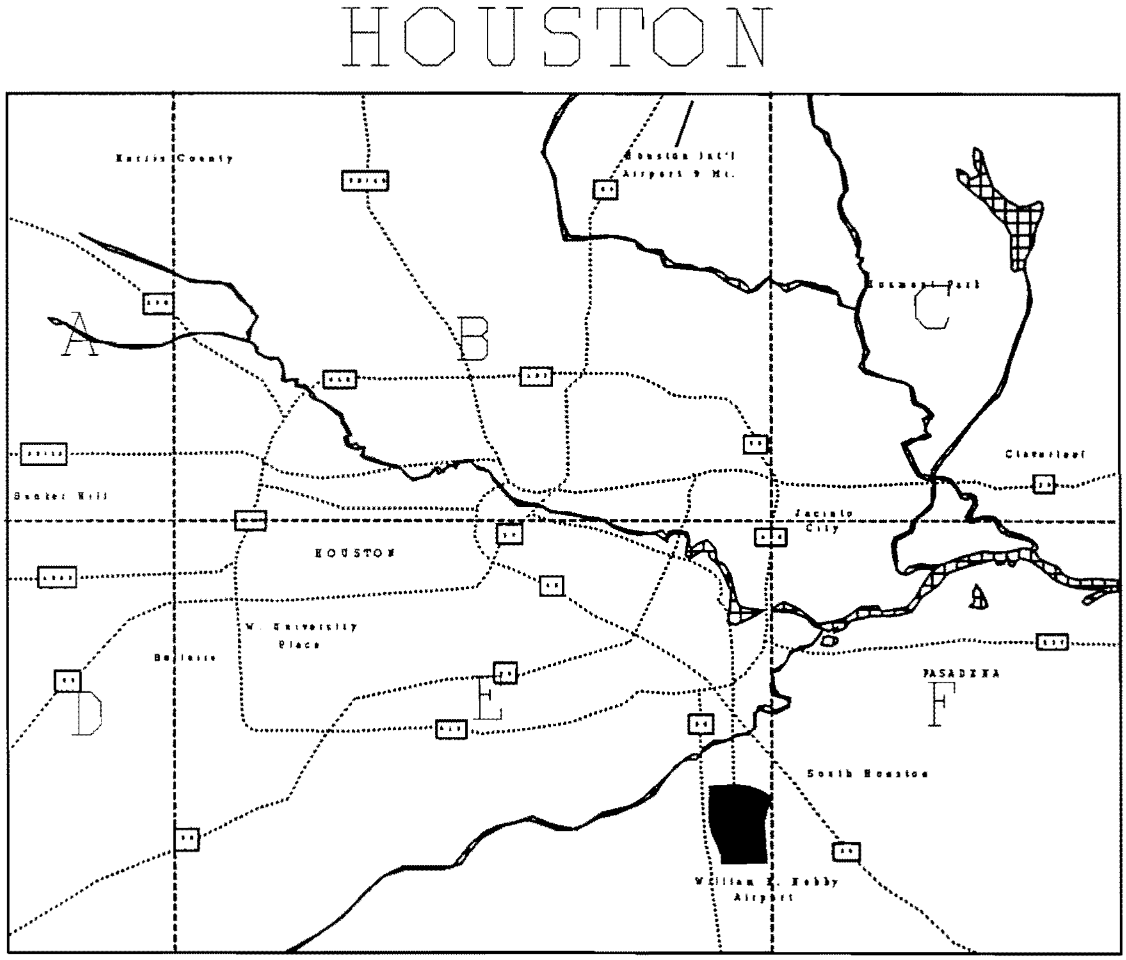

Figure 8 - Houston area Map showing the portions of the map that are plotted in Figures 9 through 14.

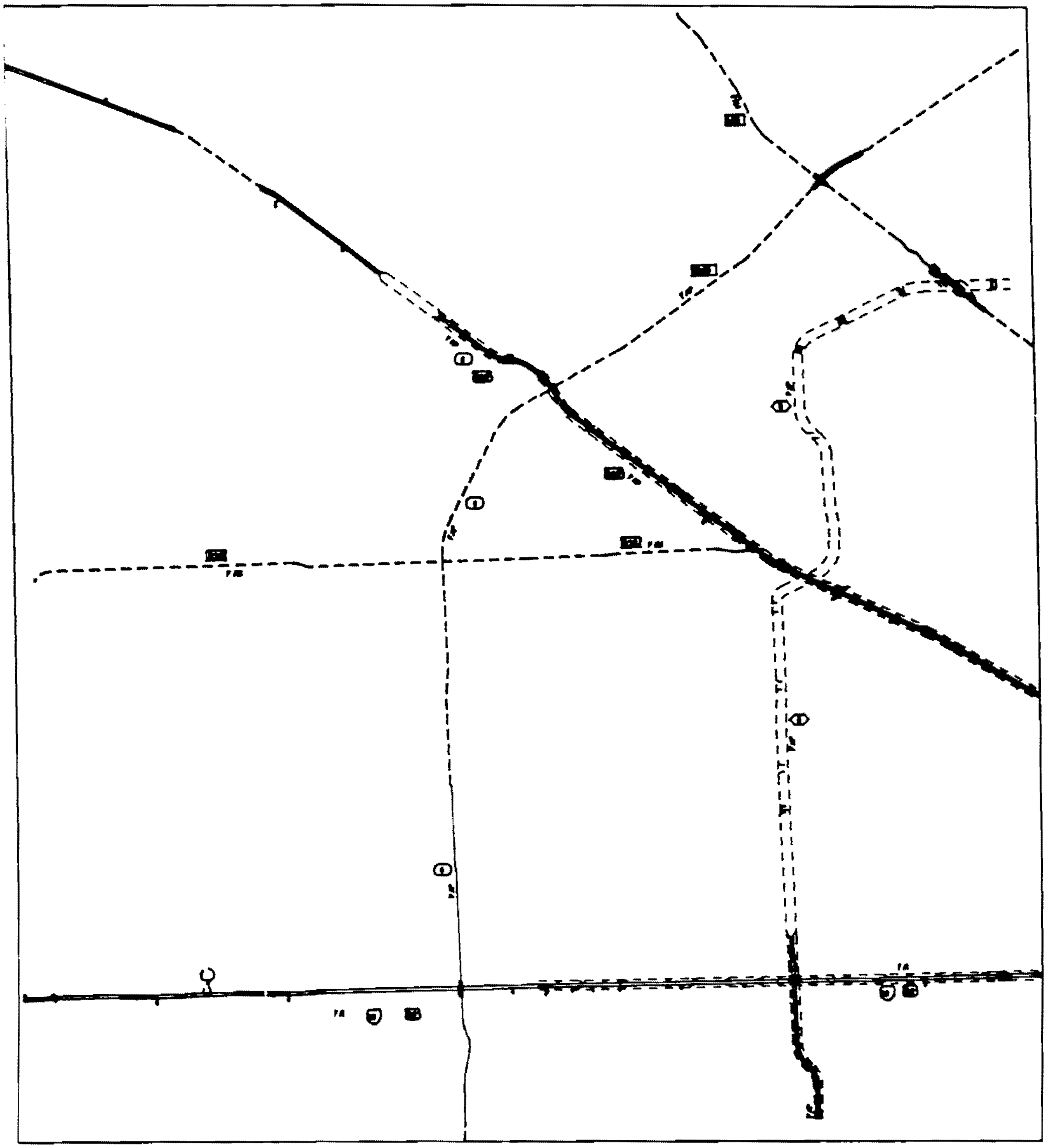

Figure 9. Northwest Map of Harris County with Bridges

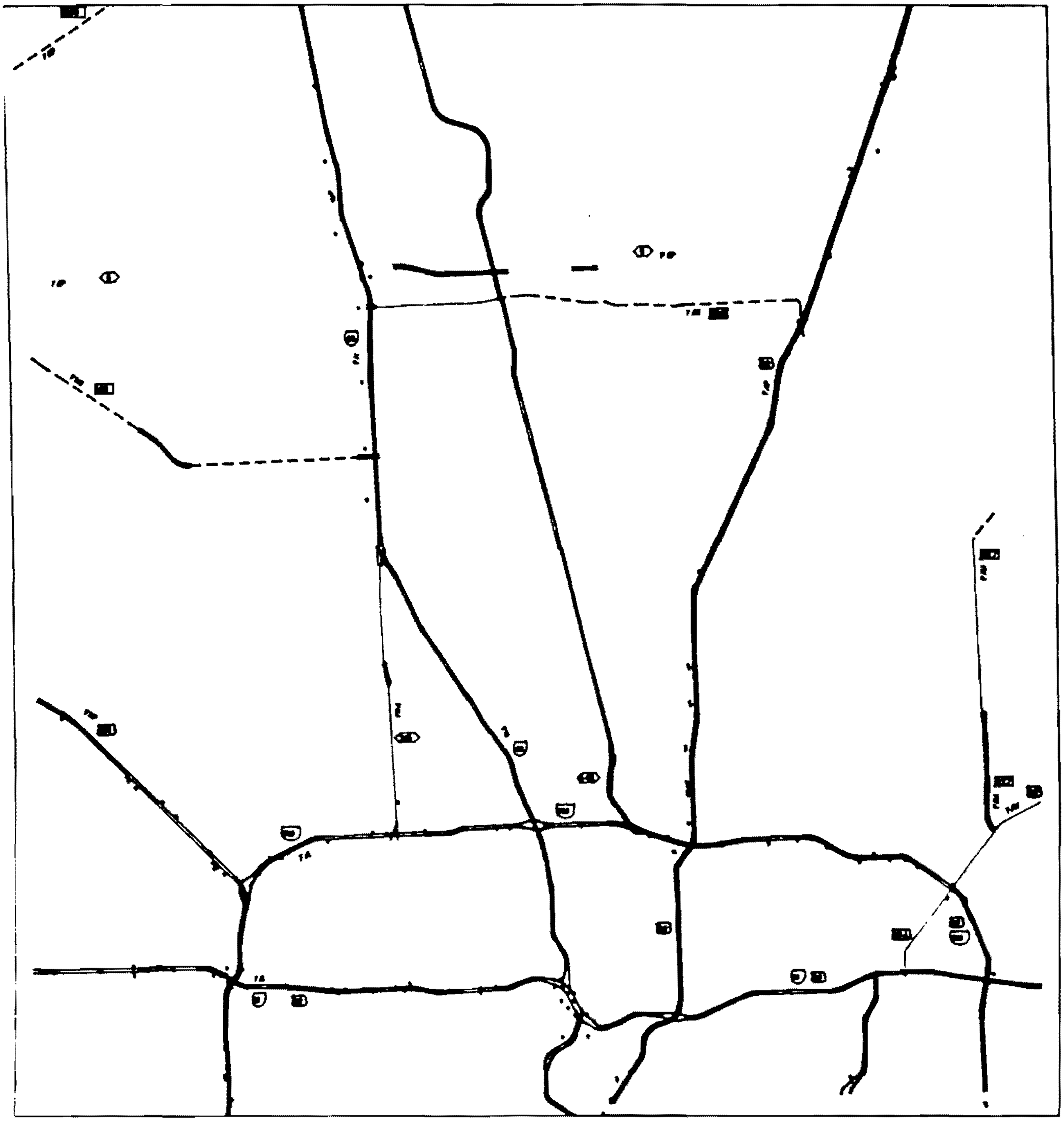

Figure 10. North Map of Harris County with Bridges

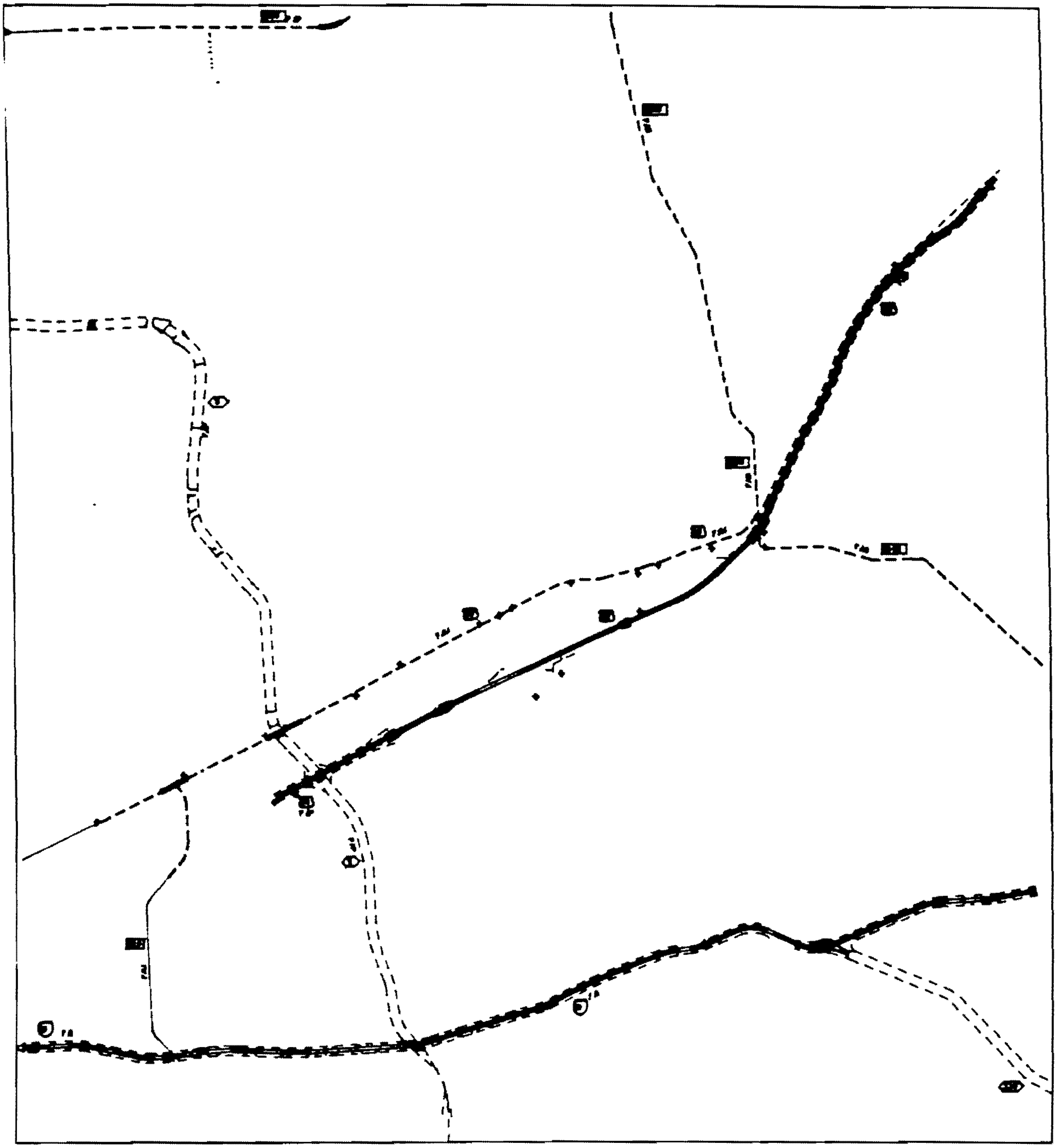

Figure 11. Northeast Map of Harris County with Bridges

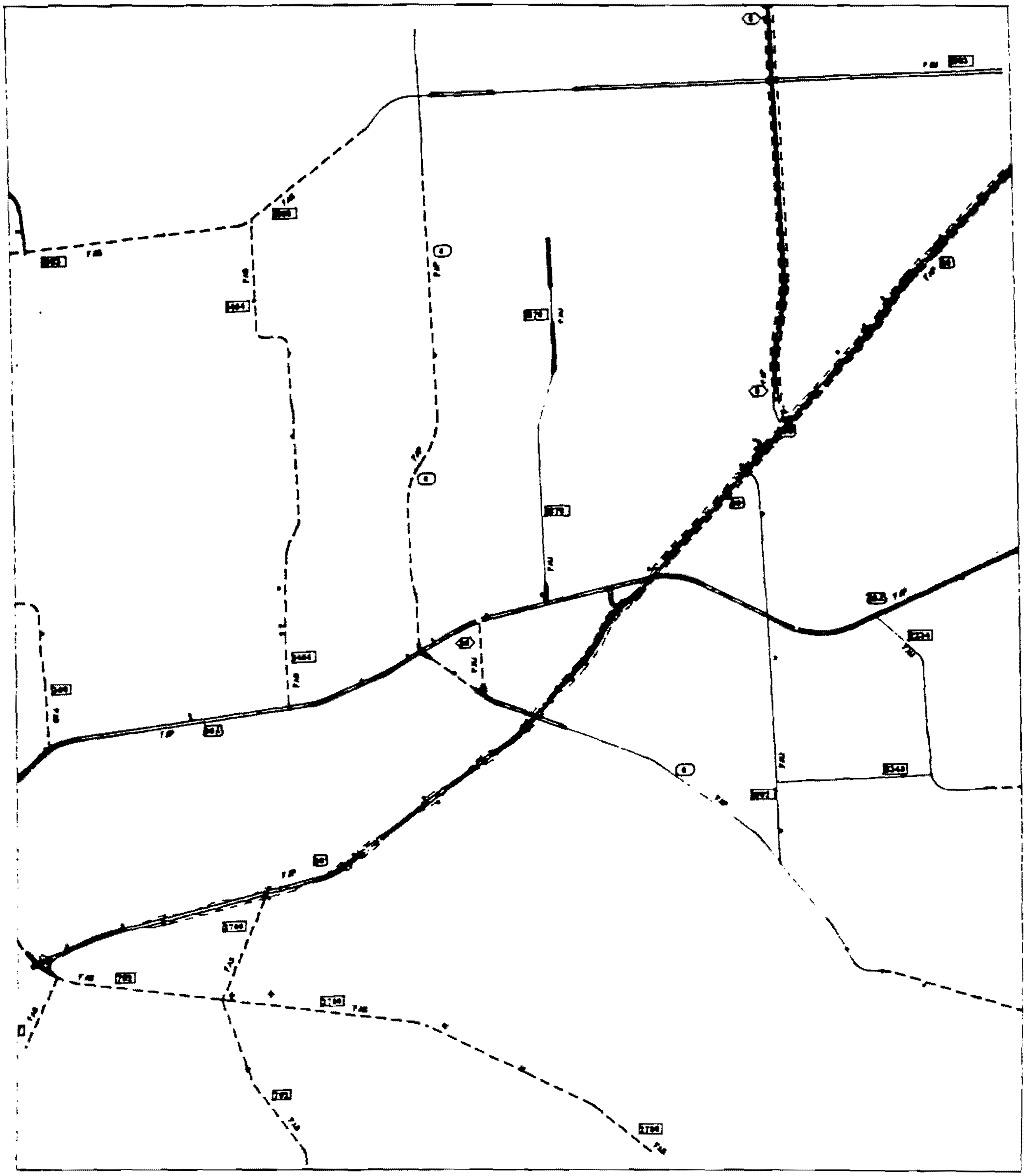

Figure 12. Southwest Map of Harris County with Bridges

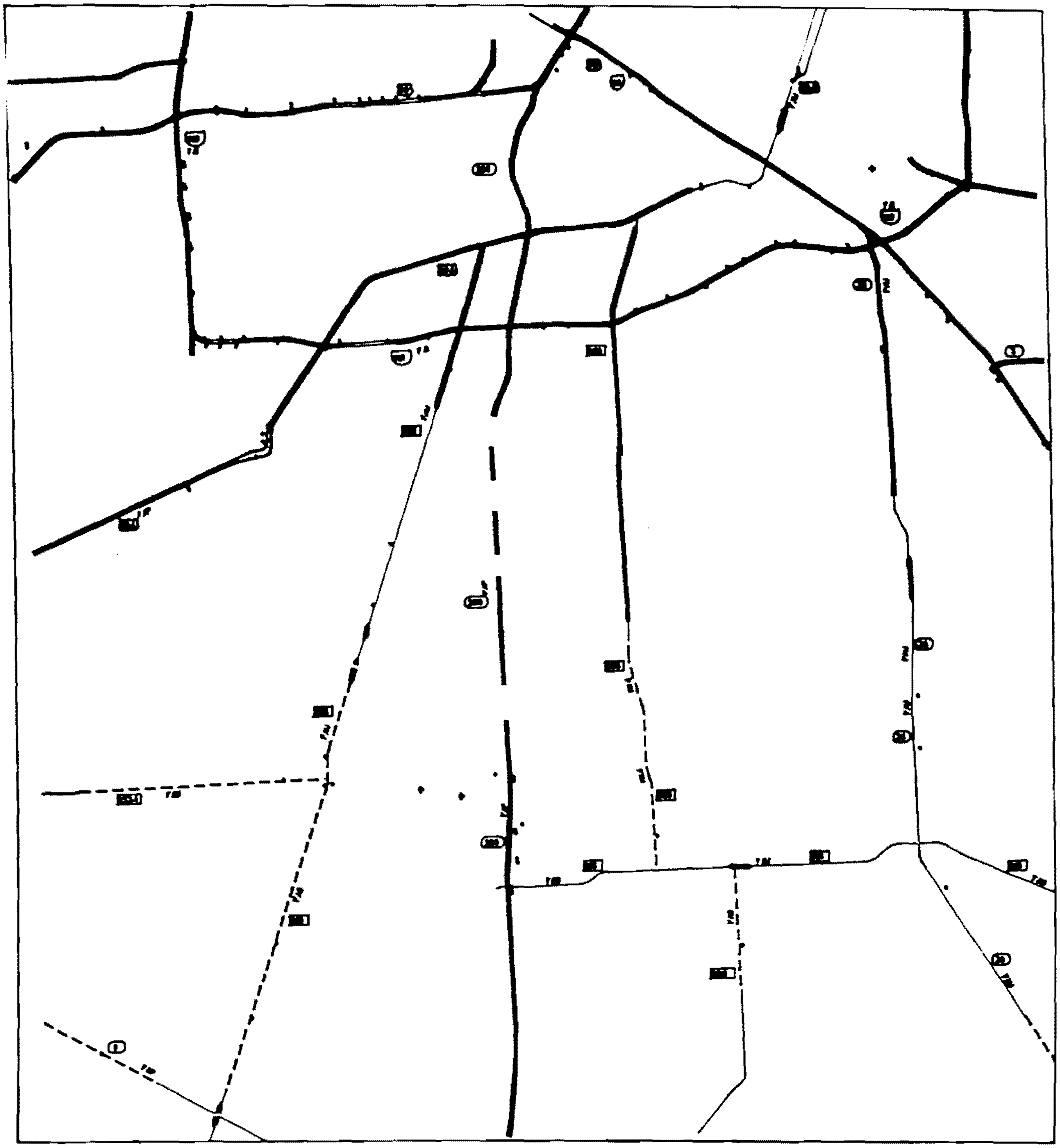

Figure 13. South Map of Harris County with Bridges

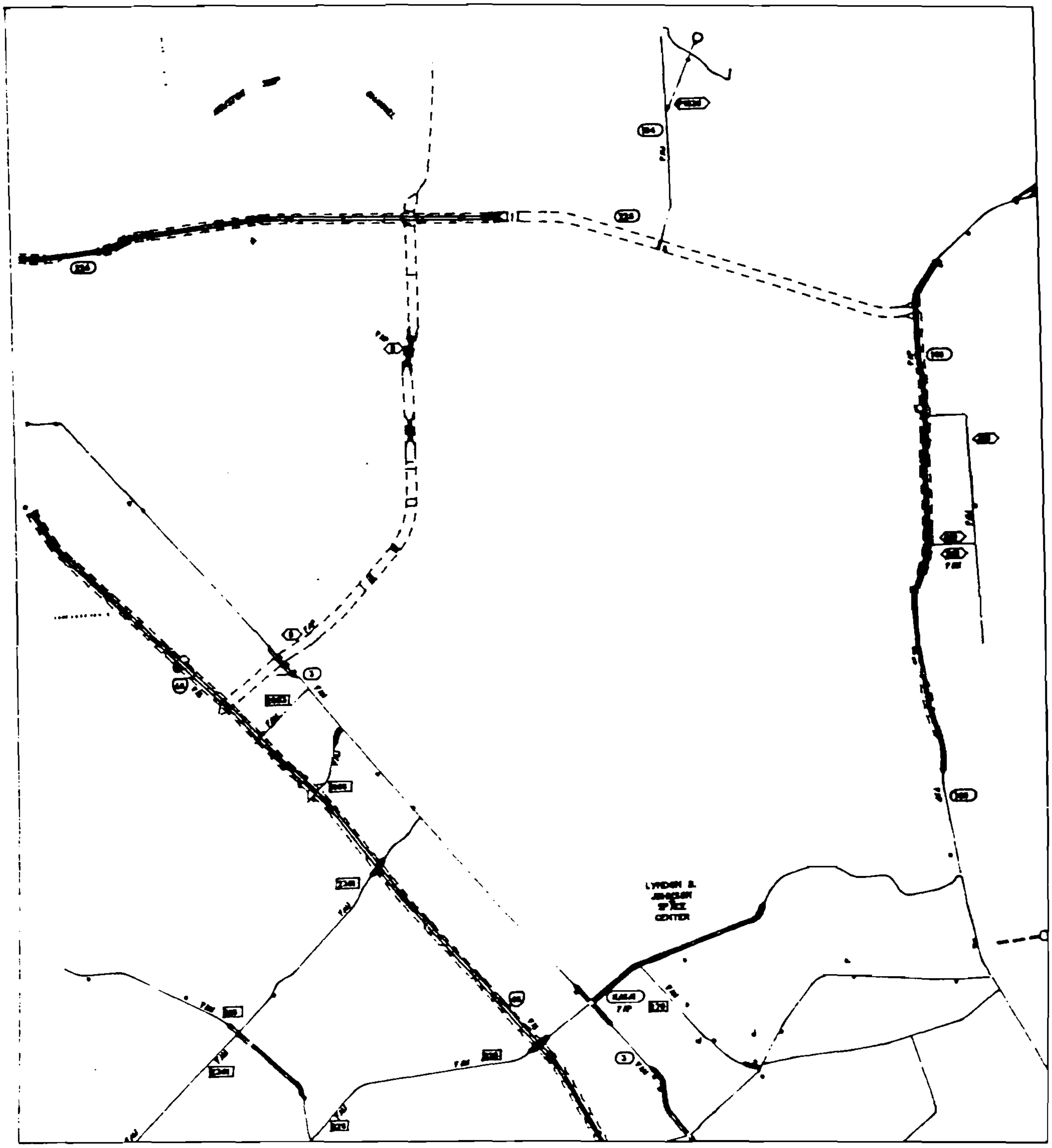

Figure 14. Southeast Map of Harris County with Bridges

Figure 9 (northwest part of Harris County) shows that most of the bridges were mapped correctly. Some of them were mapped a little off from the center line of the highway. Figure 10 (north part of Harris County) shows that there were some bridges that did not map close to the center line of the highways. Similar comments apply to the other Figures.

In summary, out of the 1,248 bridges mapped, 1,077 bridges were within 300 ft from the centerline of the highway, 171 bridges were at distances greater than 300 ft from the centerline. However, 141 of them were within 1000 ft from the centerline, the other 30 had mistyped longitude and/or latitude coordinates or did not have the coordinate values at all in BRINSAP. Table 4 lists the 141 bridges that were mispositioned by more than 300 ft and less than 1000 ft. Table 5 lists the bridges that had the wrong geographic coordinates in the BRINSAP file. We discovered that for some of these 30 bridges, one of the numbers was mistyped. It should be noted that the bridges listed in Table 4 were all identified and were positioned correctly in the digitized map. Out of the 30 bridges of Table 5, we utilized the location descriptions provided in BRINSAP to locate them correctly. We were successful for 11 bridges. However, we intend to use the road inventory sheets of TX DOT to correctly identify the remaining bridges.

Table 4. List of Bridges that were Mispositioned in Map.

Sl.#	Rec#	Str#	Cont-Sec	HW_No	Location of Bridge
1	675	186	0027-10	US-90	LAWNDALE STREET
2	688	233	0027-13	US-59	US59(NB) TO I45
3	689	235	0027-13	US-59	US59(SB) TO I45
4	709	081	0027-13	US-59	ELEV. EXPRESSWAY
5	710	172	0027-13	US-59	ELEV. EXPRESSWAY
6	711	181	0027-13	US-59	SAN JACINTO ST.
7	712	180	0027-13	US-59	CAROLENE & WHEELER
8	714	170	0027-13	US-59	ELEVATED EXP. WAY
9	723	182	0027-13	US-59	EDLOE ST. U/P
10	729	179	0027-13	US-59	I-610 CONN "E"
11	730	428	0027-13	US-59	I-610 CONN "D"
12	731	412	0027-13	US-59	I-610 & US-59
13	732	427	0027-13	US-59	I-610 CONN "C"
14	733	088	0027-13	US-59	RICE SVE O/P
15	735	228	0027-13	US-59	US-59 & I-45 INTER
16	767	102	0028-01	US-90	1.7MI NE OF FM526
17	774	196	0028-02	US-90	1MI S OF OLD US90
18	817	094	0050-08	US-290	HUFFMEISTER ROAD
19	818	092	0050-08	US-290	HUFFMEISTER ROAD
20	819	091	0050-08	US-290	FM-1960
21	820	093	0050-08	US-290	FM-1960 O/P
22	826	109	0050-08	US-290	JONES ROAD O/P
23	827	110	0050-08	US-290	2.9MI SE OF FM1960
24	828	113	0050-08	US-290	.3MI SE OF JONES RD
25	829	114	0050-08	US-290	.3MI SE OF JONES RD
26	841	070	0050-09	US-290	COLE CREEK
27	842	083	0050-09	US-290	COLE CREEK
28	843	071	0050-09	US-290	COLE CREEK
29	845	072	0050-09	US-290	SOUTH FORK COLE CRK
30	846	088	0050-09	US-290	SOUTH FORK COLE CRK
31	847	073	0050-09	US-290	SOUTH FORK COLE CRK
32	848	089	0050-09	US-290	FAIRBANK N. HOUSTON

Table 4. List of Bridges that were Mispositioned in Map.

Sl.#	Rec#	Str#	Cont-Sec	HW_No	Location of Bridge
33	854	077	0050-09	US-290	BINGLE ROAD O/P
34	855	078	0050-09	US-290	43RD STREET O/P
35	872	008	0051-02	SH-3	.1MI N SH3/FM2351
36	875	046	0051-02	SH-3	CLEAR CREEK
37	876	032	0051-06	SH-3	BERRY GULLY
38	877	033	0051-06	SH-3	BERRY GULLY
39	878	029	0051-06	SH-3	2MI N OF I-45/SH3
40	990	166	0271-06	I-10	MASON ROAD
41	991	167	0271-06	I-10	MASON ROAD MKT RR
42	992	440	0271-06	I-10	MASON CREEK
43	993	441	0271-06	I-10	MASON CREEK
44	994	442	0271-06	I-10	MASON CREEK
45	996	163	0271-06	I-10	FRY ROAD
46	997	161	0271-06	I-10	2.9MI W OF I45/SH6
47	999	160	0271-06	I-10	BARKER-CYPRESS ROAD
48	1015	231	0271-07	I-10	WEST BELT
49	1016	232	0271-07	I-10	MKT RR
50	1049	273	0271-07	I-10	REINERMAN PED. O/P
51	1051	308	0271-07	I-10	SHEPHERD DRIVE
52	1052	274	0271-07	I-10	SHEPHERD DRIVE
53	1083	099	0271-14	I-610	WHITE OAK BAYOU
54	1094	449	0271-14	I-610	CONN "F" SPUR-548
55	1097	450	0271-14	I-610	HB&T RR KELLY ST.
56	1098	386	0271-14	I-610	JENSEN DRIVE
57	1099	470	0271-14	I-610	JENSEN DRIVE
58	1156	378	0271-15	I-610	MANCHESTER STREET
59	1157	379	0271-15	I-610	MANCHESTER STREET
60	1169	384	0271-16	I-610	ASTROWORLD ACCESS
61	1177	153	0271-16	I-610	WILLOW WATERHOLE BAY
62	1178	154	0271-16	I-610	WILLOW WATERHOLE BAY
63	1217	251	0271-16	I-610	I-610 & SH-288
64	1218	448	0271-16	I-610	I-610 & SH-288

Table 4. List of Bridges that were Mispositioned in Map.

Sl.#	Rec#	Str#	Cont-Sec	HW_No	Location of Bridge
65	1219	277	0271-16	I-610	I-610 & SH-288
66	1220	278	0271-16	I-610	I-610 & SH-288
67	1221	401	0271-16	I-610	I-610 7 SH-288
68	1222	452	0271-16	I-610	SH288 RAMP G
69	1223	453	0271-16	I-610	SH288 RAMP H
70	1236	105	0271-17	I-610	T&NO R.R & WESTPARK
71	1237	417	0271-17	I-610	I-610 & US-59 CONN"B"
72	1238	416	0271-17	I-610	I-610 & US-59 CONN "A"
73	1240	157	0271-17	I-610	FM 1093
74	1261	088	0389-05	SH-146	FAIRMONT PARKWAY
75	1271	064	0389-12	SH-146	3MI N OF BAYTOWN TUNNEL
76	1302	198	0500-03	I-45	FRIENDSWOOD LINK ROAD
77	1303	145	0500-03	I-45	2MI N OF I45 & FM528
78	1304	144	0500-03	I-45	EL DORADO O/P
79	1316	207	0500-03	I-45	POLK STREET
80	1382	281	0500-03	I-45	DOWNTOWN TERMINUS
81	1383	062	0500-03	I-45	SH-35 RAMP "J"
82	1384	216	0500-03	I-45	ELEVATED EX-WAY
83	1385	226	0500-03	I-45	US59 N.B.
84	1386	229	0500-03	I-45	IH45(SB) PIERCE ELV.
85	1387	234	0500-03	I-45	US59 NB O-P
86	1388	227	0500-03	I-45	IH45 SB
87	1389	236	0500-03	I-45	US59 SB O-P
88	1390	068	0500-03	I-45	JEFFERSON ST.
89	1412	093	0500-03	I-45	LITTLE WHITE OAK BAY
90	1437	080	0500-03	I-45	PARKER ROAD O-P
91	1439	078	0500-03	I-45	LITTLE YORK RD
92	1440	230	0500-03	I-45	SPUR 261 O-P
93	1490	007	0502-01	I-610	BROADWAY BLVD
94	1491	074	0502-01	I-610	BROADWAY BLVD
95	1493	258	0502-01	I-610	IH 45
96	1494	266	0502-01	I-610	CONN S TO NB I45

Table 4. List of Bridges that were Mispositioned in Map.

Sl.#	Rec#	Str#	Cont-Sec	HW_No	Location of Bridge
97	1495	259	0502-01	I-610	IH 610S W.B.
98	1496	053	0502-01	I-610	IH610 FR RD
99	1497	049	0502-01	I-610	SH35 S.B.
100	1564	253	0508-01	I-10	IH-10 MAINLANES
101	1565	255	0508-01	I-10	GREENS BAYOU
102	1577	385	0508-01	I-10	CARPENTOR BAYOU
103	1627	198	0508-07	SPUR-330	SPRING GULLY
104	1628	220	0508-07	SPUR-330	SPRING GULLY
105	1629	250	0508-07	SPUR-330	GOOSE CREEK
106	1684	036	0720-03	FM-249	FLOOD CONT CHANNEL
107	1696	007	0981-01	FM-528	FM 528 OVER DRAIN
108	1716	009	1062-04	FM-2100	DRAIN
109	1717	018	1062-04	FM-2100	JACKSON BAYOU
110	1719	002	1258-04	FM-1093	PINEY POINT BRANCH
111	1724	033	1685-01	FM-1960	DRAINAGE DITCH
112	1731	025	1685-03	FM-1960	FM1960 OVER DRAIN
113	1737	004	1685-03	FM-1960	CEDAR BAYOU CREEK
114	1745	021	1685-07	SPUR-184	DRAINAGE DITCH
115	1746	023	1685-07	SPUR-184	DRAINAGE DITCH
116	1747	004	1743-01	FM-1876	H.C.F.C. DITCH
117	1748	003	1743-01	FM-1876	KEEGANS BAYOU
118	1749	001	1812-01	FM-1942	CLAWSON DITCH
119	1750	002	1812-01	FM-1942	DRAW
120	1751	005	1812-01	FM-1942	FM1942 & MAIN CANAL
121	1752	002	1844-01	FM-2351	CLEAR CREEK
122	1761	055	2483-01	THR	NORTHGATE OP
123	1765	054	2483-01	THR	M.P.R.R. O-P
124	1766	053	2483-01	THR	RILEY FUSSELL RD OP
125	1767	052	2483-01	THR	LEXINGTON WOODS OP
126	1768	051	2483-01	THR	ALDINE-WESTFIELD
127	1782	065	2483-01	THR	AIRTEX DRIVE OP
128	1783	063	2483-01	THR	M.P.R.R. OP

Table 4. List of Bridges that were Mispositioned in Map.

Sl.#	Rec#	Str#	Cont-Sec	HW_No	Location of Bridge
129	1790	018	2483-01	THR	MPRR & HCFCD DITCH
130	1854	089	3256-01	BW-8	WHITE OAK BAYOU
131	1855	090	3256-01	BW-8	WHITE OAK BAYOU
132	1856	091	3256-01	BW-8	DRAINAGE FEEDER #5
133	1857	093	3256-01	BW-8	DRAINAGE FEEDER #5
134	1858	113	3256-01	BW-8	HCFCD DITCH
135	1859	114	3256-01	BW-8	HCFCD DITCH
136	1862	025	3256-02	BW-8	GREENSPOINT RD
137	1863	026	3256-02	BW-8	GREENSPOINT RD
138	1864	027	3256-02	BW-8	IMPERIAL VALLEY
139	1865	028	3256-02	BW-8	IMPERIAL VALLEY
140	1878	059	3256-03	BW-8	FRESH WATER CANAL
141	1881	063	3256-03	BW-8	DRAINAGE DITCH

Table 5. List of Bridges with Wrong BRINSAP Geographic Coordinates.

Sl.#	Rec#	Str#	Cont_Sec	HW-No	Location of Bridge
1	690	161	0027-13	US-59	US-59 & SH-288 Inter
2	783	203	0028-02	US-90	MILLER ROAD #3
3	784	204	0028-02	US-90	MILLER ROAD #3
4	786	205	0028-02	US-90	MILLER ROAD #2
5	787	206	0028-02	US-90	MILLER ROAD #2
6	811	121	0050-06	US-290	.8MI NW OF MUESCHKE RD
7	812	122	0050-06	US-290	.8MI NW OF MUESCHKE RD
8	1253	087	0389-03	SH-146	SH201 & SH146 INTER
9	1288	268	0389-13	SH-201	AT SPUR 330
10	1289	269	0389-13	SH-201	AT SPUR 330
11	1290	074	0389-13	SH-201	GOOSE CREEK
12	1291	073	0389-13	SH-201	GOOSE CREEK
13	1292	075	0389-13	SH-201	S.P.R.R. O/P
14	1293	076	0389-13	SH-201	S.P.R.R.
15	1328	042	0500-03	I-45	BELLFORT/HOWARD DRIVE
16	1733	035	1685-03	FM-1960	NO NAME DRAIN
17	1786	066	2483-01	THR	GREENS ROAD
18	1789	064	2483-01	THR	FNTG. RD CONNECTOR
19	1818	068	3256-01	BW-8	HEMPSTEAD RD
20	1848	064	3256-01	BW-8	BUFFALO BAYOU
21	1860	069	3256-01	BW-8	SPRR
22	1861	070	3256-01	BW-8	COLE CREEK
23	1874	087	3256-02	BW-8	SPRR
24	1875	088	3256-02	BW-8	SPRR
25	1876	082	3256-02	BW-8	GARNERS BAYOU
26	1877	083	3256-02	BW-8	GARNERS BAYOU
27	1886	054	3256-03	BW-8	DRAIN
28	1887	086	3256-03	BW-8	DRAINAGE DITCH
29	1897	016	3256-03	BW-8	PASADENA BLVD
30	1898	017	3256-03	BW-8	PASADENA BLVD

CHAPTER 5

SUMMARY

5.0 SUMMARY

This document has reported on the activities that were conducted for project 1266 at the University of Texas at El Paso. These activities consisted of a) development of the conceptual methodology for identifying the bridges along a given path of travel using simple network models, b) utilization of BRINSAP for retrieving the bridge characteristics, and c) linkage between maps and BRINSAP using control section maps and digitized geographic maps. Most of the efforts have been concentrated in the development of network models with a BRINSAP interface to identify routes of travel and the bridges on the routes of travel. Once the bridges are identified, the bridge characteristics from BRINSAP can be used for the evaluation of the Bridge Load Formula under development at the Texas Transportation Institute.

Most of the investigations conducted during the fiscal year 1990-91 consisted of methods for the easy development of the network models using the Intergraph CAD software, the linkage of maps and BRINSAP through control sections, and the linkage of network models and BRINSAP using bridge attributes defined on the network models. We also have considered digitized maps and bridges of the On-system routes of Harris County. We successfully implemented a mapping technique to map bridge locations from BRINSAP on the digitized map. The longitude and latitude coordinates of the bridge locations are retrieved from BRINSAP, then the coordinates are transformed to planar coordinates of the map and the location is plotted on the map. This technique has revealed some problems with the geographic coordinates of BRINSAP. Out of 1,248 on-system bridges in Harris County, 141 were mispositioned by more than 300 ft and less than 1000 ft from the correct locations. Thirty bridges simply had no coordinates or the BRINSAP coordinates were totally wrong.

APPENDIX I

Structure of BRINSAP data base

FROM TO	SIZE FIELD	NO OF DEC	FIELD CHAR.	ITEM NAME
1	1		X	FILE NO
2-3	2		9	DISTRICT
4-6	3		9	COUNTY
7-10	4		X	CONTROL/ ROAD ID
11-12	2		X	SECTION
13-17	5	3	9	MILE POINT
18-20	3		9	STRUCTURE NUMBER
21	1		X	DUPLICATE ROUTE OVER
22	1		X	ROUTE STR. FUNCT.
23-27	5		X	BLANK
28	1		9	ROUTE DESIGN
29	1		X	BLANK
30-31	2		X	ROUTE SYSTEM
32-35	4		X	ROUTE NUMBER
36	1		X	ROUTE DIRECTION
37-40	4		X	FUTURE REF-MK
41	1		X	FUTURE REF-MK SUFFIX
42	1		X	FUTURE REF-MK (+/-) DISPL
43-47	5		X	FUTURE REF-MK DISPL
48-52	5		9	CITY/PLACE CODE
53-76	24		X	FEATURE CROSSED
77	1		X	CRITICAL BRIDGE
78-81	4		9	MI-POINT DATE (PRINC)
82-85	4		9	MI-POINT DATE (INTERSECT)
86-90	5		X	BLANK
91-108	18		X	FACILITY CARRIED OVER
109-133	25		X	LOCATION
134-137	4		9	RT MIN. VERT CLEAR (OVER)
138-142	5	1	9	LATITUDE (DEG/MIN/10TH)

Structure of BRINSAP data base				
FROM TO	**SIZE FIELD**	**NO OF DEC**	**FIELD CHAR.**	**ITEM NAME**
143-148	6	1	9	LONGITUDE (DEG/MIN/10TH)
149-150	2		9	BYPASS DETOUR LENGTH
151	1		9	TOLL
152-153	2		9	CUSTODIAN
154-155	2		9	OWNER
156-157	2		9	MAINTENANCE SECT NO.
158	1		9	PROJECT TYPE
159-170	12		X	CONT/SECT/JOB-WHEN BUILT
171-172	2		9	FUNCTIONAL CLASS
173-176	4		9	YEAR ORIGINALLY BUILT
177-178	2		9	LANES ON STRUCTURE
179-180	2		9	LANES UNDER STRUCTURE
181-186	6		9	AN. AVG. DAILY TRAF.(AADT)
187-188	2		9	YEAR OF AADT
189	1		9	DESIGN LOAD
190-192	3		9	APPROACH WIDTH
193	1		9	MEDIAN
194-195	2		9	SKEW
196	1		9	STRUCTURE FLARED
197-200	4		X	TRAFFIC SAFETY FEATURE
201	1		9	HISTORICAL SIGNIFICANCE
202	1		X	NAVIGAT. CONTROLS
203-205	3		9	NAVIGAT. VERTICAL CLEAR
206-209	4		9	NAVIGAT. HORIZONTAL CLEAR
210	1		X	OPERATIONAL STATUS
211	1		X	LOADING TYPE
212-214	3		9	LOADING IN 1000 LBS.
215-216	2		9	TYPE SER. ON / UNDER
217-220	4		9	MAIN SPAN TYPE
221-224	4		9	MAJOR APPROACH SPAN TYPE
225-228	4		9	MINOR APPROACH SPAN TYPE

Structure of BRINSAP data base

FROM TO	SIZE FIELD	NO OF DEC	FIELD CHAR.	ITEM NAME
229-230	2		9	CULVERT TYPE
231	1		9	TUNNEL TYPE
232-234	3		X	SUBSTRUCTURE MAIN SPAN
235-237	3		X	SUBSTR. MAJOR APPR. SPAN
238-240	3		X	SUBSTR. MINOR APPR. SPAN
241-243	3		9	NUMBER MAIN SPAN
244-246	3		9	NO. MAJOR APPROACH SPAN
247-249	3		9	NO. MINOR APPROACH SPAN
250-253	4		9	TORAL NUMBER SPANS
254-257	4	1	9	TOTAL HORIZONTAL CLEAR
258-261	4		9	MAXIMUM SPAN LENGTH
262-267	6		9	STRUCTURE LENGTH
268-270	3	1	9	LEFT SIDEWALK
271-273	3	1	9	RIGHT SIDEWALK
274-277	4	1	9	ROADWAY WIDTH
278-281	4	1	9	DECK WIDTH
282-285	4		9	VERT. CLEAR OVER (FT/IN)
286	1		X	VERT. CLEAR REF. FEATURE
287-290	4		9	VERT. CLEAR UNDER (FT/IN)
291	1		X	LATERAL CLEAR ERF. FEATURE
292-294	3	1	9	RIGHT LATERAL CLEAR
295-297	3	1	9	LEFT LATERAL CLEAR
298-302	5		X	BLANK
303	1		X	DECK CONDITION
304	1		X	SUPERSTRUCTURE CONDITION
305	1		X	SUBSTRUCTURE CONDITION
306	1		X	CHANNEL PROTECTION
307	1		X	CULVERT
308-310	3		9	OPERATION RATING
311	1		X	RDWY APPROACH CONDITION
312-314	3		9	INVENTORY RATING

Structure of BRINSAP data base

FROM TO	SIZE FIELD	NO OF DEC	FIELD CHAR.	ITEM NAME
315	1		X	STRUCTURE EVALUATION
316	1		X	DECK GEOMETRY
317	1		X	UNDER CLEAR. VERT. & HORIZ
318	1		9	SAFE LOAD CAP. (POSTED)
319	1		X	WATERWAY ADEQUACY
320	1		X	APPROACH ROADWAY ALIGN.
321-323	3		9	TYPE WORK REPLACEMENT
324-329	6		9	LENGTH IMPROVEMENT
330-335	6		X	TX-FRACT CRITICAL STEEL
336-338	3		X	BLANK
339-344	6		9	LAST INSPECTION (MMDDYY)
345-346	2		9	DESIGNATED INSPECT. FREQ
347-349	3		X	FRACTURE CRITICAL BRIDGE
350-352	3		X	UNDERWATER INSPECTION
353-355	3		X	OTHER SPECIAL INSPECTION
356-359	4		X	FRACT. CRITI. DETAIL(MMYY)
360-363	4		X	UNDERWATER INSPECT(MMYY)
364-367	4		X	OTHER SPEC. INSPECT(MMYY)
368-373	6		9	BRIDGE IMPROVEMENT COST
373-379	6		9	ROADWAY IMPROVEMENT COST
380-385	6		9	TOTAL PROJECT COST
386-387	2		9	YEAR. IMPROVE COST ESTI.
388-392	5		X	BORDER BRIDGE
393-407	15		X	BORDER BRIDGE STR. NO
408	1		9	DEFENSE HIGHWAY DESIGN
409	1		X	PARALLEL STR. DESIGN
410	1		9	DIRECTION OF TRAFFIC
411	1		X	TEMPORARY STR. DESIGN
412-413	2		9	FEDERAL AID SYSTEM
414-418	5		X	RESERVED (FHWA)
419-422	4		9	YEAR RECONSTRUCTED (19--)

Structure of BRINSAP data base				
FROM TO	SIZE FIELD	NO OF DEC	FIELD CHAR.	ITEM NAME
423	1		9	WIDENING CODE
424	1		X	DECK STR. TYPE MAIN SPAN
425-427	3		X	MAIN SPAN WEARING SURFACE
428	1		X	DECK STR - MAJ. APPR SPAN
429-431	3		X	MAJOR APPR. SPAN WEAR.SURF
432	1		X	DECK STR - MIN. APPR SPAN
433-435	3		X	MINOR APPR. SPAN WEAR.SURF
436-437	2		X	AADT TRUCK PERCENT
438	1		9	DESIGNATE NATIONAL NETWORK
439	1		X	PIER / ABUTMENT PROTECT
440	1		X	NBIS BRIDGE LENGTH
441	1		X	SCOUR CRITICAL BRIDGES
442-447	6		9	FUTURE AADT
448-449	2		X	YEAR OF FUTURE AADT
450-452	3		X	MIN. NAVIGAT. VERT. CLEAR
453-460	8		9	COST ORIGINAL CONSTRUCTION
461	1		X	DEFICENT / OBSOLETE
462-465	4		9	SUFFICIENCY RATING
466-475	10		X	X-REF PRINC RT. ID
476	1		X	X-REF STR. FUNCT. PRINC.RT
477-488	12		X	BLANK
489-498	10		X	X-REF I.R. ID.
499	1		X	X-REF I.R. STR. FUNCT.
500-511	12		X	BLANK
512-531	20		X	DISTRICT USE
532-535	4		X	I.R. CONTROL / RD. ID
536-537	2		X	I.R. SECTION
538-542	5	3	9	I.R. MILEPOINT
543-545	3		9	I.R. STRUCTURE NO.
546	1		X	I.R. DUPLICATE OVER
547	1		X	I.R. STR. FUNCT.

Structure of BRINSAP data base

FROM TO	SIZE FIELD	NO OF DEC	FIELD CHAR.	ITEM NAME
548	1		9	I.R. DESIGNATION
549	1		X	I.R. HWY SYSTEM
550-551	2		X	I.R. HWY SYSTEM
552-555	4		X	I.R. HWY NUMBER
556	1		X	I.R DIR
557-560	4		X	I.R. FUTURE REF - MK
561	1		X	I.R. FUTURE REF-MK SUFFIX
562	1		X	I.R. FUT. REF-MK (+/-)DISP
563-567	5		X	I.R. FUTURE REF-MK DISPL
568-571	4		9	I.R. HORIZ. CLEAR
572-575	4	2	9	I.R. MIN. VERT. CLEAR
576-577	2		9	I.R. BYPASS LENGTH
578	1		9	I.R. TOLL
579-580	2		9	I.R. FUNCT. CLASS
581-586	6		9	I.R. AADT
587-588	2		9	I.R. YEAR OF AADT
589	1		9	I.R DEFENSE HWY DISIGNAT.
590	1		X	I.R. PARALLEL SRT. DISIGN.
591	1		9	I.R. DIRECTION OF TRAFFIC
592	1		X	I.R. TEMP. STR. DESIGNAT.
593-594	2		9	I.R. FEDERAL AID SYSTEM
595-596	2		X	I.R. AADT. TRUCK PERCENT
597	1		9	I.R. DESIGN. NATION NETWK
598-603	6		X	I.R. FUTURE AADT
604-605	2		X	I.R. YEAR OF FUTURE AADT
606-610	5		X	BLANK

REFERENCES

1. Bridge Inventory, Inspection and Appraisal Program - Manual of Procedures; State Department of Highways and Public Transportation - Safety and Maintenance Operations Division September 1984.

2. Intergraph's Microstation PC (ver 4.0) User's guide, Refernce guide and Customization guide January 1991.

3. Plane Coordinate Projection Tables of Texas (Lambert) - U.S. Department of Commerce - Coast and Geodetic Survery - Special Publication No.252 1950.