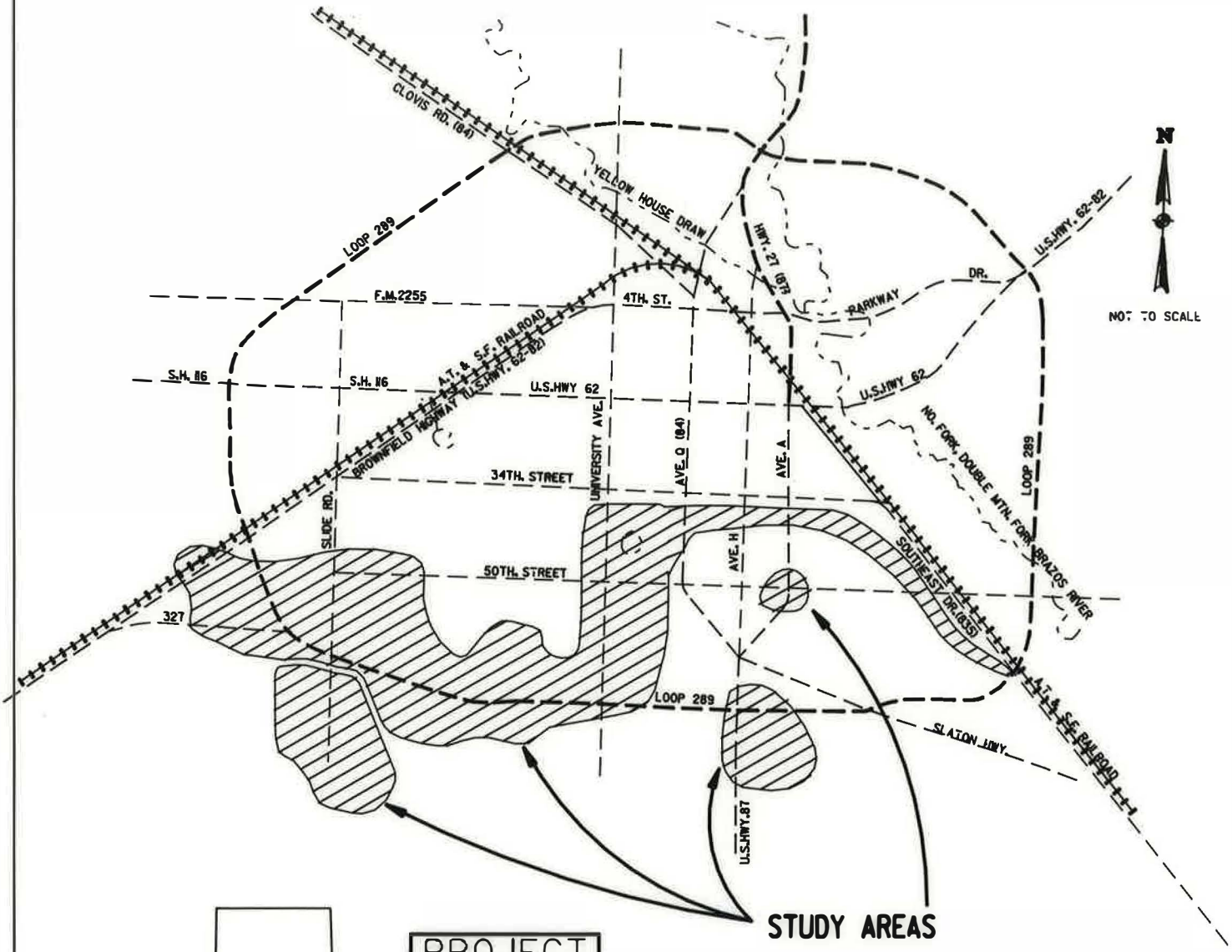
A DRAINAGE STUDY OF PLAYA LAKE SYSTEMS IN SOUTH LUBBOCK

FOR THE

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS - SCIENTISTS - SURVEYORS
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS

AVO 9102
DECEMBER, 1988



VICINITY MAP
SOUTH LUBBOCK DRAINAGE STUDY
CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.

DATE 1988	
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A

DRAINAGE STUDY

OF

PLAYA LAKE SYSTEMS

IN

SOUTH LUBBOCK, TEXAS

FOR

THE CITY OF LUBBOCK, TEXAS

Prepared By

Albert H. Halff Associates, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137

In Association With
Texas Tech University
Water Resources Center
and
Abacus Engineering and Surveying
Lubbock, Texas

December 1988
AVO 9102

For

the

City of Lubbock, Texas

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Mayor

Joan Baker
Mayor Pro-Tem

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Maggie Trejo
T. J. Patterson
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December, 1988
AVO 9102

City of Lubbock
1625 13th Street
Lubbock, Texas 79401

Attn: Mr. Larry J. Cunningham
City Manager

Dear Mr. Cunningham:

Transmitted herewith is a report entitled Drainage Study of Playa Lake Systems in South Lubbock, Texas, as authorized by the City Council of the City of Lubbock.

It is our hope and belief that this report will provide needed guidance toward: (1) The prudent development of the watersheds and floodplains of the South Lubbock Playa Lakes Systems, and (2) The improvements required to reduce flood damages in existing developments.

These watersheds vary from undeveloped upper areas to nearly 100 percent developed areas. Collectively, the South Playa Lakes Systems provide for the City's ultimate drainage and contains most of the parks and open spaces in South Lubbock.

Developing a flood control and flood plain management plan to make wise utilization of the playa lake system has been both a challenge and a privilege. We are appreciative of the contributions made by the residents of Lubbock, the City Staff, the Texas Water Development Board, Texas Tech University Water Resource Center, and Abacus Engineering in the preparation of this report.

Respectfully submitted,

ALBERT H. HALFF ASSOCIATES, INC.

Troy Lynn Lovell

Troy Lynn Lovell, P.E.
Vice President

STATE OF TEXAS
TROY L. LOVELL
34319
REGISTERED PROFESSIONAL ENGINEER

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ACKNOWLEDGEMENTS

The firm Albert H. Halff Associates, Inc., wishes to acknowledge the valuable assistance of the many organizations and individuals who have assisted in the preparation of this report. We wish to express our gratitude to all those listed below who have contributed their time and effort to this study.

From the City of Lubbock, Mr. Keith Smith, Mr. Emory Potts, Mr. Larry Hertel, Mr. L.D. Sherman, and Mr. Larry Hoffman, all of whom have provided invaluable assistance and advice.

Mr. Bob Wear, Texas Water Development Board, Dr. Lloyd Urban and Dr. Bill Claborn, Texas Tech University, Water Resources Center, and Mr. Jon Cieszinski, Abacus Engineering, for their efforts and input in the production of the study.

The employees of Halff Associates who have worked most closely with the project include: Mr. B. Anatole Falagan, Mr. Craig R. Wilkening, Mr. Troy Lynn Lovell, Mr. Michael Moya, Mr. John Hood, Mr. Don Peck, Mr. Jerry Roberts, Mr. Richard Westmith, Mr. Walter Skipwith, Ms. Brenda Diller, Mr. Will Reese, Ms. Vicki Moore and Ms. Millie Demetros. Halff Associates deeply appreciates the dedicated efforts of all the groups and individuals who have helped during the performance of this study.

DEFINITIONS

BASELINE CONDITIONS. For this report, the flood plain and flood damages resulting from future, fully-urbanized discharges and the existing playa lake configurations. Used for comparison to assess the effectiveness of a flood control alternative.

DESIGN FLOOD. The peak discharge resulting from a design storm.

DESIGN STORM. A storm duration which produces a runoff hydrograph of a given frequency to be used in the evaluation of an improvement to a playa lake or overflow route.

DISCHARGE. As applied to a playa lake, the rate of outflow, or overflow volume of water flowing out of a given playa lake within a given period of time, usually quoted in cubic feet per second (cfs) or gallons per minute (gpm).

DRAINAGE AREA. The area tributary to a playa lake, stream, sewer, or drain. Also called catchment area, watershed, and river basin.

FLOOD. An overflow onto land not normally covered by water and that is used or usable by man. Floods have two essential characteristics: The inundation of land is temporary; and the land is adjacent to and inundated by overflow from a playa lake, or an overflow route between successive playas.

FLOOD FREQUENCY. A means of expressing the probability of flood occurrences as determined from a statistical analysis of representative streamflow or rainfall and runoff records. A 10-year frequency flood would have a probability of exceedance of once in 10 years (a 10 percent chance of being equalled or exceeded in any given year). A 50-year frequency flood would have a probability of exceedance of once in 50 years (a 2 percent chance of being equalled or exceeded in any given year). A 100-year frequency flood would have a probability of exceedance of once in 100 years (a 1 percent chance of being equalled or exceeded in any given year). A 500-year frequency flood would have a probability of exceedance of occurrence in the order of once in 500 years (a 0.2 percent chance of being equalled or exceeded in any given year).

FLOOD PLAIN. The relatively flat area or low lands adjoining a playa lake or along an overflow route, which has been or may be covered by flood water.

PLAYA. A large, natural, saucer-like depression in the topography into which storm water naturally flows and is retained.

ABSTRACT

The City of Lubbock, situated in central Lubbock County, Texas, is drained in the southern portions of the City by playa lake systems E1, E2, F, and Southwest System (Playas 30, 29, 28, and 91). A vicinity map for the study area is on the inside cover of this report. Flooding has occurred in the past on these systems of interconnected playas, with the most recent flood occurring in October, 1983. The playas are in various stages of urbanization, with the uppermost portion of system E1 almost completely undeveloped. Flood plain delineation of the 19 playa lakes and their overflow routes indicates that the 100-year flood* will damage or surround approximately 750 homes or businesses. The total 100-year flood plain in the study area covers about 3.7 square miles. Appendix A contains detailed flood plain delineation maps of the study area.

Baseline conditions were established using existing playa lake storage capacities and overflow routes combined with rainfall-runoff based on a fully developed, or completely urbanized watershed. Average annual flood damages were computed for benefit cost comparisons. Nine flood control alternatives were analyzed for the study area, focusing on diversion of flows out of System E-1 to the Double Mountain Fork of the Brazos River (Yellowhouse Canyon), managing a 10-year flood within certain portions of System E-1, and creating additional storage in the study area via playa lake drawdowns. Construction cost estimates were prepared. Benefits were computed as reduced annual damages from flooding of structures and their contents. Flood control alternatives were assumed to have a 50 year project life, and a interest rate of 8.625% was used to compute annual costs. An intangible value analysis was performed to address each plan's non-monetary benefits. Four categories of non-monetary benefits were analyzed: 1) Degree of Safety from flooding, 2) Environmental quality, 3) Neighborhood Enhancement, and 4) Aesthetics.

As described in Chapters VI and VII, the study recommendations to reduce flooding potential are as follows:

* NOTE: The 100-year flood that is referenced throughout this report is based on a fully-developed or completely urbanized watershed.

1. Alternative 8 - The construction of an eleven wells, groundwater pumping system along Loop 289 in System E-1, that would reduce the existing pool elevations and create flood storage in those playa lakes. The pumped water would be treated and added to the City's ground level storage tank at Memphis Avenue and 82nd Street. The benefits of this alternative would be reduced flood damages in System E-1, in the vicinity of Loop 289. Non-monetary benefits would be an enhanced degree of safety from flooding, a reduced threat of rising groundwater, enhanced water supply, and an increase in neighborhood aesthetics. The estimated construction cost is $507,600, with annual operations and maintenance costs of $42,100. The total average annual costs would be $86,600, with average annual benefits of $347,170, and a benefit-to-cost ratio of 4.0 to 1.0. Benefits for this alternative would be highly sensitive to the ultimate groundwater drawdowns achieved in the field.

2. Alternative 4 - The construction of a 10-year design storm drain that would divert water from Playa Lake 21 to Yellowhouse Canyon. Benefits would be in the form of reduced flooding damages in the vicinity of Playa lake 21. Non-monetary benefits would be an increased degree of safety from flooding and enhanced neighborhood aesthetics. The estimated construction cost is $2,603,500. Average Annual costs would be $228,200, with average annual benefits of $360,410, and a benefit-to-cost ratio of 1.58 to 1.0.

3. Alternative 7 - The present overflow control for Playa Lake 37 (Bill McAlister Park), which consists of small culverts at Loop 289 should not be modified without increasing upstream flood storage. Concept plans show a proposed 110-feet wide thoroughfare crossing Loop 289 at the overflow control point for Playa Lake 37. This proposed thoroughfare alignment should not be allowed without design features to maintain the current level of flood control created by the highway.

   If the proposed thoroughfare is constructed in its present alignment, Playa Lake 37 should be excavated to prevent overflows

for the 100 year flood. Benefits would be in the form of reduced flooding in System E-1, downstream of Playa Lake 37. Non-monetary benefits would be an increased degree of safety from flooding for all future development around Playa Lake 37, enhanced neighborhood aesthetics, and removal of the threat of overflow from Playa Lake 37. The estimated construction cost is $7.26 million. Annual operation and maintenance costs would be $11,000. Total average annual costs would be $647,400, with annual benefits of $284,800, and a benefit-to-cost ratio of 0.44 to 1.0.

4. Citizens living in those areas within the 100-year floodplain should be encouraged to purchase flood insurance under the National Flood Insurance Program (NFIP). The City should continue it's current policy of limiting the amount of land reclaimed from playa lakes, and maintaining the existing flood storage capacity. The City should require that finished floor elevations surrounding a playa lake be set at least one foot above the future, fully-developed watershed, 100-year lake water surface elevation. It is further recommended that the City formally adopt the flood elevations shown in this report for its flood plain management program.

In addition to the recommendations described above, Halff Associates strongly urges the City to continue to perform drainage studies on those undeveloped playa lake systems that are targeted for development in the future. The studies would identify future, fully-developed floodplains for these systems, which should be preserved for the storage of floodwaters at playa lakes and the conveyance of floodwaters between them. The resulting greenbelt should be used as a City park/recreation area.

This study was prepared by Albert H. Halff Associates, Inc. for the City of Lubbock with partial funding provided by the Texas Water Development Board (TWDB Contract No. 8-483-504). The opinions and recommendations in this study do not necessarily reflect the opinions of the City of Lubbock engineering staff or the Texas Water Development Board.

I. INTRODUCTION

I. INTRODUCTION

A. GENERAL

The purpose of this study is to provide a comprehensive, updated flood control - flood plain management plan for playa lake systems E1, E2, F, and the Southwest system. Figure I-1 is a watershed map of the study area. These systems drain a majority of the southern half of the City of Lubbock. The study involved the following playa lakes within each system:

System Name	Playa Lake Number
E1	39, 37, 31, 27, 26, 25, 24, 23, 19, 20, 21
E2	22
F	18, 17, 16
Southwest	30, 29, 28, 91

Detailed descriptions and limits of study for each system are included in Chapter II. See Appendix A for the detailed flood plain delineation sheets of the study area.

B. SPECIFIC REPORT OBJECTIVES

The basic objectives of this report are as follows:

1. Compile pertinent existing engineering data and newly developed information into a comprehensive report with an up-to-date flood plain delineation of the study area.

2. Formulate alternative flood control plans and analyze the effects of proposed improvements. Prepare cost estimates for the various alternatives. Prepare benefit-cost comparisons for the recommended plans. Compare the various alternatives.

3. Based on the analysis of the various alternatives, make specific recommendations to the City. Recommendations include prioritizing the proposed improvements. These recommendations and priorities are presented with accompanying engineering data to guide the City in a planned program of needed improvements.

4. Coordinate all phases of the study, from data gathering to final design recommendations, with the City Engineering Staff.

In addition to the basic objectives listed above, the following criteria are evaluated in the planning of any proposed improvements:

1. Neighborhood enhancement and acceptance.

2. Minimize relocation or alteration of residential and business properties and disruption of services to citizens.

3. Attempt to formulate practical, affordable alternative plans to solve flooding problems.

C. COMMUNITY DESCRIPTION

The City of Lubbock is situated in the center of Lubbock County, Texas. Located in the High Plains section of Texas, the city is approximately 325 miles northwest of Dallas and about 340 miles northeast of El Paso. Lubbock's estimated 1988 population is 190,000.

The climate is semiarid. Summer and winter average monthly temperatures range from 92 degrees F to 25 degrees F, respectively. Average annual precipitation is 18 inches (Reference 1).

The main drainage features of Lubbock are (Yellowhouse Canyon) the North Fork of the Double Mountain Fork of the Brazos and the playa lake systems which exist throughout the city. The playa lakes are large

LEGEND

- SYSTEM BOUNDARIES
- SUBBASINS
- MAJOR THOROUGHFARES
- RAILROADS
- STREAMS
- PLAYAS & OVERFLOW ROUTES

N

NOT TO SCALE

CLOVIS RD. (84)
YELLOW HOUSE DRAW
HWY. 27 (87)
U.S.HWY. 62-82
LOOP 289
F.M. 2255
4TH. ST.
PARKWAY
DR.
U.S.HWY.82
S.H. 116
S.H. 116
A.T. & S.F. RAILROAD
U.S. HWY. 62
U.S.HWY. 62
BROWNFIELD HIGHWAY (U.S.HWY. 62 & 82)
INDIANA AVE.
UNIVERSITY AVE.
AVE. Q (84)
AVE. H (UNDER CONSTRUCTION)
AVE. A
NO. FORK, DOUBLE MTN. FORK BRAZOS RIVER
YELLOWHOUSE CANYON
34TH. STREET
SLIDE RD.
QUAKER AVE.
SYSTEM "E2"
A.T. & S.F. RAILROAD SOUTHEAST DR.
50TH. ST.
66TH. STREET
SLATON HWY.
FLOW
LOOP 289
82TH. STREET
U.S.HWY. 87
SYSTEM "E1"
SYSTEM "SOUTHWEST"
SYSTEM "F"

PLAYA 39
PLAYA 37
PLAYA 31
PLAYA 27
PLAYA 26
PLAYA 22
PLAYA 21
PLAYA 20
PLAYA 19
PLAYA 16
PLAYA 17
PLAYA 18
PLAYA 30
PLAYA 29
PLAYA 28
PLAYA 25
PLAYA 24
PLAYA 23
PLAYA 91

WATERSHED MAP
SOUTH LUBBOCK DRAINAGE STUDY
CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.

DATE 1988

DESIGN BAF DRAWN BD,CADD

FIGURE I-1

AVO 9102

saucer-like depressions in the topography. Runoff from heavy rains can fill the playa lakes and cause flooding to adjacent properties from rising lake elevations. In addition, overflows can pass from playa lake to playa lake causing potential street flooding and flooding of homes and businesses.

D. PRINCIPAL FLOOD PROBLEMS

1. Causes of Flooding Problems

Several factors have contributed to the flooding problems which now occur in many areas of the City. Urbanization increases the volume of storm water from any rainfall event, due to the large amount of new impervious areas, in the form of streets, parking lots, sidewalks, roofs, etc. Development also changes the timing of the runoff; water arrives at the playa lakes earlier in the storm event than in predevelopment storms, due to the improved conveyance provided by the streets.

The existing City development ordinances make it possible for a developer to execute a "cut and fill" plan, removing material from the bottom of the lake area and filling in other portions of the lake in order to provide additional development area. Removal of the bottom sediments can increase the ease of seepage of water from the playa lake into the underlying water table. Prior to alteration, much of this water evaporated, rather than percolating to the groundwater. For some period of time after the modification of a lake, it generally appears to contain the storm runoff by losing large quantities of water to the groundwater. Although some of the lakes have subsequently "sealed" and may not contribute large volumes to the groundwater, others still "leak" and continue to add to the trend of a rising water table. This trend has been amplified by reduced pumping of groundwater by either the City or for agricultural uses.

These several factors have combined to produce the situation now common throughout the City. The water table has risen in many places close enough to the bottom of many of the lakes to prevent or inhibit the seepage of water from the lake into the subsurface. In some cases, the groundwater is hydraulically connected to the lake and may even flow into the lake. This results in water being held in the playa lakes for longer periods of time. Thus, when the next storm occurs, the lakes may have little room to store the runoff. When this occurs during a heavy rainfall, spill often occurs from a playa lake, and floodwaters will travel along natural or man-made routes (low areas) to the next downstream playa lake.

Streets (a man-made overflow route) may flood because of inadequate capacity to convey the storm water. This capacity is determined by the cross section of the street and the longitudinal slope of the street. The carrying capacity can be decreased by blockage of the flow cross section caused by parked vehicles as well as by deterioration of the street surface. Some streets flood because of inability to carry the water from the surrounding area, while others flood because they were designed as the floodway between two playa lakes.

For this study, the principal flood problems analyzed were those related to playa lake flooding and flooding from playa lake overflow that occurs in the flow paths between the lakes.

2. History of Flooding

Past history for the City of Lubbock indicates that the most likely time of year for flooding to occur is between May and October. Generally, flood-producing rainfall is of two types, thunderstorm and frontal storms. Thunderstorms frequently cause flash flooding from small drainage basins, while frontal storms

are more likely to cause flooding in watersheds having relatively large areas.

There have been several major floods in the City of Lubbock. Significant floods have occurred on May 7, 1949, August 1966, June 1, 1967, May 11, 1970, and on October 19, 1983. The rain storms of May 11, 1970 were caused by a tornado which passed through the city. In addition, certain areas of Lubbock flood on a relatively frequent basis (every two years or so). The study area has experienced flooding as recently as July 1987. In southwest Lubbock, flooding of major streets and the frontage roads along Loop 289 has become a common occurrence after heavy rainfall.

The following excerpts from newspaper articles provide descriptions of past flood events:

LUBBOCK AVALANCHE JOURNAL, June 2, 1967

". . . A massive storm system that generated hurricane force winds and a small tornado stunned Lubbock with a five-inch-plus cloudburst Thursday, turning much of the Hub City into a vast ocean, causing widespread damage and apparently only two minor injuries . . . Rains measuring up to 5.70 inches had virtually paralyzed the city shortly before midnight, and all barricades on hand had been set up to block scores of inundated streets, underpasses, and roadways. Police stood by at other critical points."

LUBBOCK AVALANCHE JOURNAL, October 20, 1983

". . . At 7:17 p.m., the service said, the rainfall record for a 24-hour period was shattered. The old mark was 5.7 inches, dating from June 1, 1967. At the 28-hour mark the measurement stood at 6.44 inches and no letup was expected until this afternoon or

night . . . Also of concern at that time was potential flooding at the Godeke Branch of the library at 6601 Quaker Avenue. At 9 p.m. employees worked feverishly to protect books as the fear of water rising continued . . . Water was into the lawns of homes near Clapp Park at about 40th and Avenue U at 7 p.m. . . . Water began to get into houses in the area of 64th Street and Raleigh Avenue (Leroy Elmore Park) shortly before 8 p.m."

The cover of this report has a photograph of the October 1983 flood.

II. STUDY AREA DESCRIPTION

II. STUDY AREA DESCRIPTION

For detailed maps of the study, please refer to Figure A-1 and Sheets 1-35 of Appendix A.

A. SYSTEM E1

Playa Lake System E1 drains generally from west to east, along the southern section of Loop 289 (See Figure I-1). From Playa Lake 39 to its confluence with the North Fork of the Double Mountain Fork of the Brazos River (Yellowhouse Canyon), the system traverses 16.5 miles, draining a 24.32 square mile area, excluding System E-2. Land use along the system is predominantly single family residential, with some industrial land uses in the eastern portion of the watershed, and with commercial properties and public facilities scattered throughout the basin. The system is composed of 11 playa lakes (39, 37, 31, 27, 26, 25, 24, 23, 19, 20, and 21), 7 of which are designated city park areas.

The area has steadily urbanized since the data for the 1982 Flood Insurance Study (F.I.S.) was prepared in 1979-80 (Reference 1).

With the exception of Playa Lakes 39 and 37, all of the playa lake overflow routes have been developed, with flows from playa lake to playa lake traveling through channels, streets, alleys, and residential property. The system crosses Loop 289 at three locations. Pertinent data for each of the crossings can be found in Table II-I.

The City has two 20 cfs pumps at Clapp Park (Playa Lake 21) which are used to lower the playa lake elevation when it is too high. The operation of the pumps is manual, with discharge into a 42-inch storm sewer that travels east along 42nd Street. At Avenue L and 37th Street, the 42-inch pipe ties into a 96-inch storm sewer that continues eastward and eventually discharges into Yellowhouse Canyon.

As previously described in Chapter I, the major storms that have occurred in the Lubbock area have left recorded accounts of flooded structures in System E-1. Numerous storms have consistently flooded streets, fields, and parking lots over the years.

TABLE II-1
SYSTEM E-1 BRIDGES AND CULVERTS

Reach Playa Lake	Location	Structure	Upstream Flowline Elevation
39-37	A.T. & S.F. RR	Wood Beam Bridge	3259.9
39-37	Brownfield Hwy	3 - 5' x 2' Boxes	3259.4
37-31	Loop 289, Main Lanes	2 - 5' x 2' Boxes	3264.0
37-31	Loop 289, E.Frontage Rd.	3 - 5' x 2' Boxes	3263.6
26-25	Loop 289, N.Frontage Rd.	12 - 24" Pipes	3229.2
26-25	Loop 289, Main Lanes	8 - 8' x 4' Boxes	3229.2
26-25	Loop 289, S.Frontage Rd.	12 - 24" Pipes	3229.0
23	Loop 289, N.Frontage Rd.	3 - 36" Pipes	3217.5
23	Loop 289, Main Lanes	3 - 7' x 4' Boxes	3217.4
23	Loop 289, S.Frontage Rd.	3 - 36" Pipes	3215.7

B. SYSTEM E2

Playa Lake System E2 is a "tributary" to System E1, consisting of one playa lake (22). It flows from north to south, along Elgin Avenue between 63rd and 69th Streets (See Figure I-1). System E2 joins System E1 at Playa Lake 23. System E2's overflow path is 2400 feet long, and its contributing watershed is 1.02 square miles.

Land use in the watershed is predominantly single family residential with scattered clusters of public, commercial, and multifamily property. Playa Lake 22 is located in the A.M. Leftwich City Park. The major storms that have occurred in the Lubbock area have left no recorded accounts of flooded structures in System E-2.

C. SYSTEM F

Playa Lake System F (Playa Lakes 18, 17, 16) drains generally from south to north and is located near the intersection of Highway 87 (future Interstate 27) and Loop 289 (See Figure I-1). In the 1982 F.I.S., the system was composed of Playa Lakes 82, 18, and 17. Since the publication of the 1982 F.I.S., Playa Lake 82 has been filled in. This action occurred when the playa lake was outside city jurisdiction. Construction has also begun on the extension of Interstate 27 through the City, with major regrading of Playa Lake 17 already completed. The highway construction plans call for a 36 inch reinforced concrete pipe outfall to maintain the Playa Lake 17 normal pool. The 36" pipe will join the existing 42" diameter 50th Street outfall, which currently drains Playa Lake 16 into Yellowe Canyon. Therefore, for this report, Playa Lake 16 is joined with Playa Lakes 17 and 18 and considered part of System F.

System F drains 4.4 square miles, with 8200 linear feet of 36" pipe connecting Playa Lake 17 to the 50th Street outfall, which is a 14,846 foot long, 42" diameter concrete pipe, beginning at the intersection of 50th Street and Avenue A, and ending at East Loop 289, where it discharges into Yellow Canyon. Land use around Playa Lakes 18 and 17 is predominantly single family residential, with some undeveloped areas, and small clusters of commercial and light industrial. In the Playa Lake 16 watershed, land use is also predominantly single family residential, with commercial warehouses, truck dealerships, and repair shops located in the vicinity of the playa lake.

Playa Lakes 18 and 17 were studied in detail in the 1982 Flood Insurance Study, while Playa Lake 16 was given a Zone A classification based on approximate study methods. The major storms that have occurred in the area have left no recorded accounts of flooded structures in System F.

D. SOUTHWEST SYSTEM

The Southwest System is the title given in this report to four playa lakes located in the extreme southwestern portion of the City (See Figure I-1). The four playa lakes are 30, 29, 28, and 91. Playa Lake 91, located at the southeast corner of 82nd Street and Slide Road, is the downstream end of this system. The Southwest System is 1.7 miles long, and drains a 2.61 square mile area. The landuse is predominantly single-family residential, with some multi-family, Whiteside Elementary School, Jack Stevens City Park and the Lakeridge Golf Course. The Southwest System was not studied in detail for the 1982 F.I.S. The entire system was given a Zone A classification, indicating that approximate methods were used.

From Playa Lake 30, the lake overflows along Albany and Aberdeen Avenues downstream to Playa Lake 29 (Jack Stevens Park). Outflow from Playa Lake 29 is regulated by 3-5'x3' box culverts which pass under Slide Road and into Playa Lake 28. Tailwater conditions from Playa Lake 28 are such that these culverts function properly only for extremely low flows. For flood events of a 10-year frequency or greater, a majority of the outflow from Playa Lake 29 overtops Slide Road. The overflow path between Playa Lakes 28 and 91 crosses 82nd Street before emptying into Playa Lake 91.

The areas surrounding the Southwest System have experienced rapid development, most of which has occurred since the publication of the 1982 Flood Insurance Study. There are no recorded accounts of flooded structures in the area.

III. STUDY PROCEDURES

III. STUDY PROCEDURES

The technical content of this report is based on acceptable hydrological, hydraulic, and economic analyses methods.

A. HYDROLOGIC STUDIES

1. Model Development

Hydrologic analyses were conducted by Halff Associates using the Soil Conservation Service's "TR-20" hydrologic model (Reference 2). The procedures used to develop the baseline hydrologic models were as follows:

a. Using U.S.G.S. Quadrangle Maps, City topographic maps and plans, and previous F.I.S. work maps, determine drainage area boundaries and time of concentration values. See Paragraph 2, which describes the establishment of the upper drainage area limits.

b. Using City topographic maps, grading plans from plats, and Highway Department grading plans, prepare storage-elevation data for each playa lake.

c. Compute rating curves at playa overflow points from the backwater models of the overflow routes, and prepare storage-elevation-discharge curves for both playa lakes and overflow routes.

The pump station at Clapp Park (Playa Lake 21) was not considered part of the outflow rating curve for Playa Lake 21, because the pumps are manually operated and pumping is dependent upon the hydraulic conditions in the downstream storm sewer.

d. Using a Computer Aided Drafting and Design (CADD) System, superimpose the City's future conditions land use map onto the drainage area map, determine soil types for each subarea (Reference 3), and compute the runoff curve numbers ("CN") for each sub-area.

Evaluation of the hydrologic models included the development of synthetic unit hydrographs at key locations, reservoir routing at playa lakes, and flood routing.

The hydrologic analyses prepared for this study reflect future, fully-urbanized watershed conditions. Flood events of a magnitude which are expected to be equalled or exceeded once on the average of any 2-, 5-, 10-, 25-, 50-, 100-, or 500-years have been selected as having special significance for this study, and tables of peak discharges for the 10-, 50-, 100-, and 500-year floods can be found in Chapter IV of this report.

The 10-, 50-, 100-, and 500-year floods have a 10, 2, 1 and 0.2 percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long term, <u>average</u> period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood in any 50-year period is about 40 percent (four in 10).

2. Establishing Upper Drainage Area Limits

A large watershed above Playa Lakes 39 and 37 was analyzed to determine if this upper drainage area would contribute any flood flows to System E-1 under future fully developed conditions.

This area of 11.1 square miles and 12 playa lakes was examined with the following assumptions:

a. The existing configuration of the playa lakes was used as they appeared on available city topographic maps and U.S.G.S. 7.5' quadrangle maps.

b. A volume of 2-inches of runoff was used as a starting condition for each playa lake.

c. The physical characteristics of the playa lakes would not be altered due to future urbanization.

d. Storage in the playa lake would not be affected by rising groundwater.

e. Land uses reflect future fully urbanized conditions.

Based on the results of a TR-20 hydrologic model of this upper watershed, it was concluded that this area would not contribute any volume into Playa Lakes 37 and 39 for flood events up to and including the 500-year flood. See Figure III-1 for a map showing the limits of this upper watershed.

3. Calibration

The hydrologic model was calibrated using rainfall records kept by the City for the October 1983 floods. The rainfall data consisted of point rainfall amounts for Sunday, October 16, Tuesday, October 18, and up to noon Friday, October 21, 1983. High water marks for this time period were estimated from slides taken by the City during an aircraft survey of the flooded areas on October 21, 1983. The rainfall amounts obtained were input into the hydrologic model and computed water surface elevations were compared to estimated highwater marks at Playa Lakes 27 and 26 (Leroy Elmore Park). Playa Lakes 27 and 26 were selected because the level of development in those watersheds in 1983 was almost fully urbanized. The elevations predicted by the model matched

fairly well with the elevations estimated from the photographs (± 0.5 feet).

No other rainfall/highwater mark data were available for calibration.

B. HYDRAULIC ANALYSES

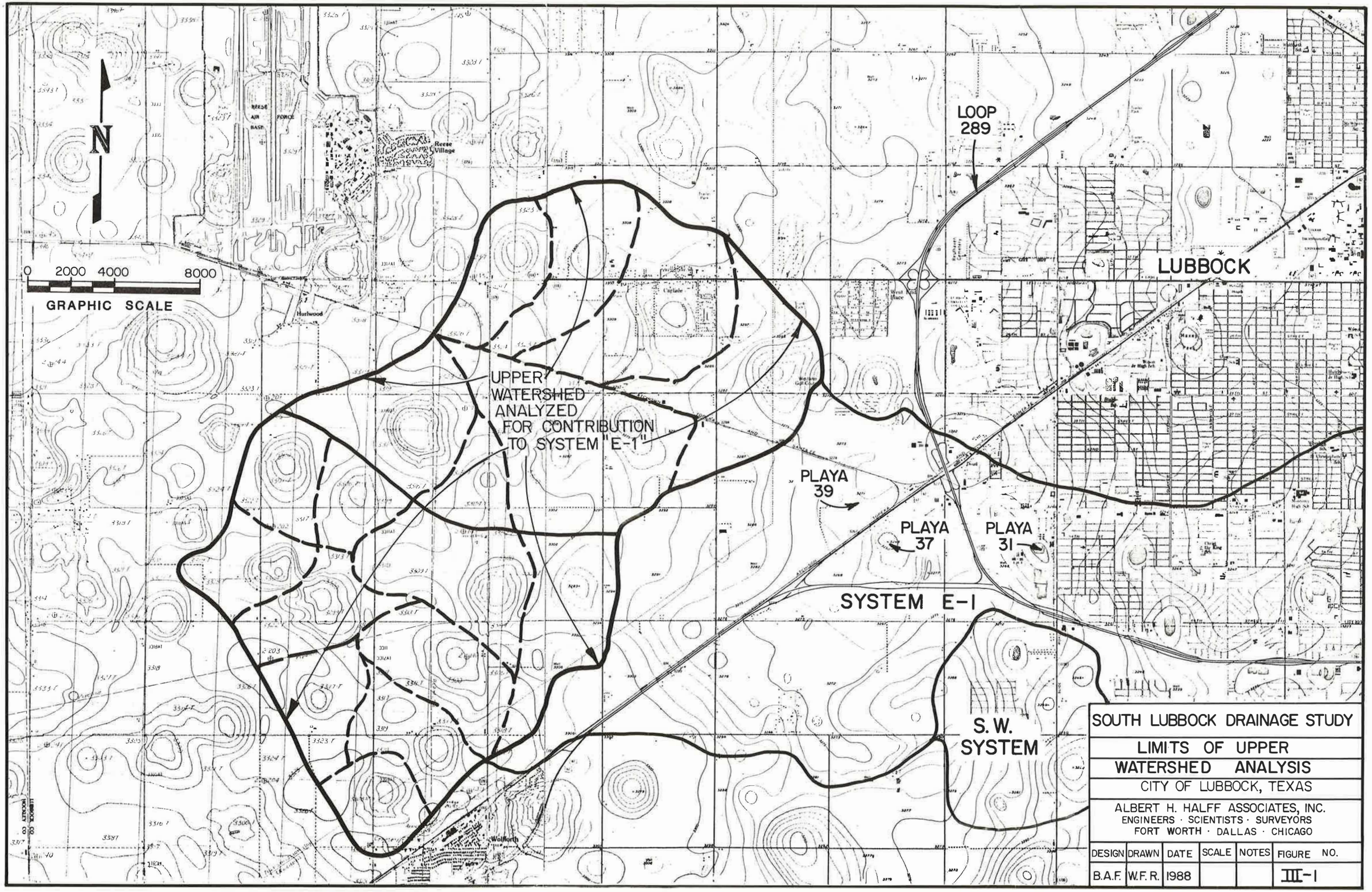
Models for flood flows along the overflow routes between playa lakes were developed, using the U.S. Army Corps of Engineers' backwater program HEC-2 (Reference 4). Cross-sections for the backwater analyses were taken from 1-foot contour interval city topographic maps. At certain locations, the topographic data was supplemented with field surveyed data and information from construction plans. Channel roughness factors (Manning's "n") for these computations were assigned on the basis of field inspections of the flood plain areas, photographs, and experience from past studies. For study purposes, it was assumed that culverts and equalizer pipes would not be obstructed. Significant changes in this premise, imposed by differing conditions of a future flood, could alter the estimated flood elevations and flood limits shown on the maps. All elevations are measured from National Geodetic Vertical Datum of 1929 (NGVD).

C. DESIGN CONSTRAINTS

The following design constraints were considered in the analysis of proposed improvements:

1. Restricted Right-of-Way

Based on site visits and examination of the city's topographic maps, unobstructed flow paths between playa lakes are often limited or non-existent. The majority of the overflow from playa lakes travels down and across streets, private lawns, and alleys. The existing land use within these overflow corridors reduces the available options for viable alternatives considerably, and



SOUTH LUBBOCK DRAINAGE STUDY

LIMITS OF UPPER WATERSHED ANALYSIS

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS · SCIENTISTS · SURVEYORS
FORT WORTH · DALLAS · CHICAGO

DESIGN	DRAWN	DATE	SCALE	NOTES	FIGURE NO.
B.A.F.	W.F.R.	1988			III-1

escalates the costs by requiring the replacement of streets, purchase of additional right-of-way, and possible purchase/relocation of residential or business structures.

2. Relatively Flat Terrain

The relatively flat slopes and terrain throughout the playa lake systems limits flood flow capacity for most gravity flow alternatives. This "flatness" tends to increase the relative size and corresponding costs of pipes.

3. Existing Water and Sewer Lines

Existing water, sewer, and other utilities dictate design elevations and alignment for some proposed improvements. Costs of relocations have an impact on the feasibility of various alternatives.

4. Existing Development

Houses and businesses are already close to the natural edges of many of the playa lakes. This limits possible modifications of existing playa lake storage capacities.

D. ECONOMIC ANALYSES

1. Estimated Project Costs

For each of the alternatives considered, a preliminary estimate of implementation costs was prepared. Those costs are based on preliminary quantities and unit prices from recent bid tabulations. No geotechnical borings were obtained for the study, and no detailed grading plans, utility relocation investigations, or right-of-way computations were prepared. The preliminary cost estimates for each alternative are shown in Appendix B.

2. Benefit-Cost Comparisons

a. Purpose and Scope - The principal purpose for making these economic analyses was to identify and quantify in dollars the extent of the flood problem and, on a comparable basis, evaluate solutions to reduce flood losses. Estimates of flood damages and benefits presented reflect 1988 prices and level of development. The current interest rate of 8.625 percent for Federal Water Resources Projects was applied to convert construction costs and benefits to average annual equivalent values. The Corps of Engineers' computer programs Structure Inventory for Flood Damage Analysis - SID (Reference 5) and Expected Annual Flood Damages Computations - EAD (Reference 6) were used in the economic analyses as described below. Benefit-cost calculations were made only for those areas in the playa systems that had significant flood damages. In some areas existing development is not subjected to frequent flooding (i.e. no flooding for less than 50- to 100-year floods), and the annualized flood damages are small.

b. Study Area - The economic analysis study area included all properties lying within the 500-year flood plain limits for each of the systems. City aerial photographs corresponding to the topographic maps dated 1978 and 1986 served as base maps to identify the flood-prone properties.

c. Flood Profiles and Delineations - The water surface profiles and playa lake elevations for 2-, 5-, 10-, 25-, 50-, 100-, and 500-year flood events based on existing playa lake conditions and fully developed watersheds were used for evaluating flood damages. These profiles aided in delineating the flood plain limits and in determining the relationship of damageable properties to both elevation and frequency of flood occurrence.

d. Reach Determination - The affected study areas were divided into reaches for economic accounting purposes. The reaches consisted of either individual playa lakes or the overflow routes between them.

e. Inventory of Structures - Finished floor elevations for all buildings in the 500-year flood plain in each playa lake system were compiled by using a CADD station to digitize overlays of the pertinent structures in the study area. Each structure was sequentially numbered and referenced to its corresponding city topographic sheet number. The structures were divided into four major landuse/damage categories as shown in Table III-1. The current market value of residential structures was estimated through the assistance of a local real estate company. The value of residential contents was estimated to be 50 percent of the structural value. In February 1988, an inventory was made of the existing commercial development in the flood plain. The type of business was identified, and building square footages were computed from the city's 1"=200' aerial photographs. Structure and content values for the commercial structures were then computed by multiplying the business' square footage times a dollar value per square foot. A list of typical businesses and their associated values per square foot was obtained from the Economics Section of the Corps of Engineers' Fort Worth District.

TABLE III-1
MAJOR DAMAGE CATEGORIES

Landuse/ Damage Category	Activity Description
Residential	Single Family Residential
Multifamily	Apartments, Duplexes, Quadruplexes
Commercial	Retail and Wholesale Businesses, Some Light Industrial
Public	Public and Quasi-Public Buildings

f. Benefits from Improvements - The primary benefit, to be derived from a proposed plan of improvement, is a reduction in flood damages. Social, environmental, and other intangible benefits are not quantified in monetary terms. Instead, intangible or non-monetary benefits can be assessed by performing a value analysis. Chapter VI contains a description of the value analysis and its results.

Average annual benefits were computed by subtracting the proposed conditions, average annual damages, from the baseline conditions average annual damages. Annual damages and benefits for certain reaches of the study area are contained in Chapter IV, BASELINE CONDITIONS and Chapter VI, EVALUATION of PROPOSED IMPROVEMENTS.

Benefit and cost accruals were made comparable by conversion to an equivalent annual basis using an interest rate of 8.625 percent. The average annual cost and benefits were calculated for a 50-year period of analysis.

The normal measure of economic feasibility, as used in Federal projects, is a benefit-cost ratio being greater than or equal to 1.0. Chapter VI on proposed alternatives details the overall benefit-cost ratio of each alternative considered.

IV. BASELINE CONDITIONS

IV. BASELINE CONDITIONS

Using the procedures detailed in Chapter III, baseline conditions were computed for existing playa lake storage/overflow configurations and a future, fully-urbanized watershed. This chapter summarizes the results of the hydrologic, hydraulic, and economic analysis.

A. GROUNDWATER ELEVATIONS

Groundwater elevations were estimated from a detailed, computer generated, groundwater contour map, using actual water depth measurements in 80 existing wells throughout the City. Table IV-1 shows the predicted groundwater elevations and playa lake pool elevations estimated from city topographic maps. The majority of the playa lakes in Table IV-1 were shown to have water in them on the City topographic maps, with no contours showing below the pool elevation.

B. HYDROLOGIC STUDY RESULTS

The baseline conditions hydrologic model computed the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year discharges and playa lake pool elevations for the study area. The hydrologic model was run with 2-inches of runoff added to Playa Lakes 39, 37, 30, and 25 for initial conditions, while all other playa lakes used the water surface elevation shown on the City topographic maps for starting conditions. Table IV-2 shows the 10-, 50-, 100-, and 500-year playa lake outflow discharges for the study area, as well as the comparable discharges from the 1982 Flood Insurance Study (FIS). Table IV-3 compares the 10-, 50-, 100-, and 500-year playa lake water surface elevations for this study with those for the 1982 FIS.

A comparison of the discharges in Table IV-2 shows an average 126% increase over the discharges published in the original FIS. A comparison of the elevations in Table IV-3 shows an average 0.9 foot

TABLE IV-1
ESTIMATED GROUNDWATER ELEVATIONS
AT PLAYA LAKES

SYSTEM	PLAYA LAKE NUMBER	ESTIMATED GROUNDWATER ELEVATION (1)	ESTIMATED PLAYA LAKE ELEVATION (2)
E-1	39	3185	3264.9
	37	3195	3250.5
	31	3198	3239
	27	3215	3233.2
	26	3220	3224.9
	25	3200	3200
	24	3205	3211.6
	23	3185-3190	3215.7-3212.6
	19	3175	3204.5
	20	3155	3207
	21	3160	3189.8
E-2	22	3200	3216.1
F	18	3113	3178.2
	17	3120	3150
	16	3137	3154.6
SOUTHWEST	30	3207	3255.2
	29	3205	3250.1
	28	3210	3241.5
	91	3195	3217.8

(1) ESTIMATED BY WATER RESOURCES CENTER, TEXAS TECH UNIV., FROM COMPUTER GENERATED GROUNDWATER CONTOUR MAP.

(2) ESTIMATED FROM CITY TOPOGRAPHIC MAPS, DATED 1986 AND 1978

TABLE IV-2

COMPARISON OF DISCHARGES
1988 STUDY VS. 1982 FLOOD INSURANCE STUDY

PLAYA #	10 YEAR DISCHARGE (CFS)			50 YEAR DISCHARGE (CFS)			100 YEAR DISCHARGE (CFS)			500 YEAR DISCHARGE (CFS)		
	1982 F.I.S.	1988 STUDY	% DIFF.	1982 F.I.S.	1988 STUDY	% DIFF.	1982 F.I.S.	1988 STUDY	% DIFF.	1982 F.I.S.	1988 STUDY	% DIFF.
SYSTEM E-1:												
39	145	650	348	400	980	145	500	1050	110	800	1350	69
37	0	100	N/A	0	170	N/A	0	210	N/A	115	400	248
31	0	120	N/A	75	280	273	135	540	300	310	980	216
27	300	450	50	620	960	55	840	1150	37	1415	1700	20
26	85	150	76	290	500	72	470	770	64	745	1350	81
25	0	110	N/A	125	390	212	160	670	319	335	1400	318
24	0	60	N/A	0	320	N/A	80	540	575	215	1250	481
23	55	50	-9	135	250	85	180	470	161	365	960	163
19	90	30	-67	210	190	-10	295	400	36	535	910	70
20	110	40	-64	255	180	-29	345	390	13	595	920	55
21	0	0	0	0	60	N/A	0	150	N/A	115	470	309
SYSTEM E-2:												
22	0	0	0	0	0	0	0	10	N/A	50	50	0
SOUTHWEST SYSTEM:												
30	---	50	N/A	---	140	N/A	---	210	N/A	---	350	N/A
29	---	470	N/A	---	670	N/A	---	830	N/A	---	1250	N/A
28	---	70	N/A	---	260	N/A	---	550	N/A	---	930	N/A
91	---	0	N/A	---	0	N/A	---	0	N/A	---	0	N/A
SYSTEM F:												
18	0	270	N/A	0	600	N/A	0	780	N/A	85	910	971
17	0	20	N/A	0	20	N/A	0	20	N/A	0	20	N/A
16	---	30	N/A	---	30	N/A	---	70	N/A	---	160	N/A

NOTES: 1. 1988 HYDROLOGIC MODEL WAS RUN WITH 2" RUNOFF IN PLAYA LAKES 39,37,30, AND 25 REMAINING PLAYA LAKES USED WATER SURFACE ELEVATION SHOWN ON CITY TOPOGRAPHIC MAPS FOR STARTING CONDITIONS.

2. A "---" SYMBOL UNDER THE "1982 F.I.S." COLUMN INDICATES THAT THE PLAYA LAKE WAS NOT STUDIED IN DETAIL FOR THE 1982 FLOOD INSURANCE STUDY.

TABLE IV-3

COMPARISON OF PLAYA LAKE WATER SURFACE ELEVATIONS
1988 STUDY VS. 1982 FLOOD INSURANCE STUDY

PLAYA #	10 YEAR ELEVATION (FT.)			50 YEAR ELEVATION (FT.)			100 YEAR ELEVATION (FT.)			500 YEAR ELEVATION (FT.)		
	1982 F.I.S.	1988 STUDY	DIFF. (FT.)	1982 F.I.S.	1988 STUDY	DIFF. (FT.)	1982 F.I.S.	1988 STUDY	DIFF. (FT.)	1982 F.I.S.	1988 STUDY	DIFF. (FT.)
SYSTEM E-1:												
39	3268.3	3268.8	0.50	3268.6	3269.0	0.40	3268.7	3269.0	0.30	3269.0	3269.1	0.10
37	3262.2	3265.5	3.30	3265.5	3266.7	1.20	3266.0	3267.4	1.40	3267.3	3268.5	1.20
31	3254.0	3254.6	0.60	3255.0	3255.0	0.00	3255.3	3255.4	0.10	3255.8	3256.0	0.20
27	3237.1	3238.1	1.00	3237.5	3239.0	1.50	3237.7	3239.2	1.50	3238.1	3240.0	1.90
26	3233.0	3231.8	-1.20	3233.3	3232.8	-0.50	3233.6	3233.3	-0.30	3234.0	3234.4	0.40
25	3227.1	3227.4	0.30	3227.7	3228.2	0.50	3227.8	3228.5	0.70	3228.2	3229.1	0.90
24	3223.6	3227.8	4.20	3227.0	3228.2	1.20	3227.4	3228.3	0.90	3227.9	3228.8	0.90
23	3221.4	3222.7	1.30	3221.9	3223.4	1.50	3222.0	3223.9	1.90	3222.5	3224.8	2.30
19	3214.7	3214.8	0.10	3215.1	3215.9	0.80	3215.3	3216.6	1.30	3215.6	3217.8	2.20
20	3212.8	3212.8	0.00	3213.0	3214.0	1.00	3213.1	3214.3	1.20	3213.4	3215.0	1.60
21	3199.8	3202.1	2.30	3204.7	3208.6	3.90	3207.0	3209.1	2.10	3209.7	3209.8	0.10
SYSTEM E-2:												
22	3223.5	3223.0	-0.50	3224.7	3224.6	-0.10	3224.8	3225.2	0.40	3225.0	3226.0	1.00
SOUTHWEST SYSTEM:												
30	---	3260.9	N/A	---	3261.2	N/A	---	3261.4	N/A	---	3261.8	N/A
29	---	3252.4	N/A	---	3252.6	N/A	---	3252.8	N/A	---	3253.0	N/A
28	---	3249.4	N/A	---	3249.8	N/A	---	3250.0	N/A	---	3250.3	N/A
91	---	3231.3	N/A	---	3235.4	N/A	---	3237.3	N/A	---	3240.0	N/A
SYSTEM F:												
18	3186.1	3187.0	0.90	3186.3	3187.5	1.20	3186.4	3187.7	1.30	3187.0	3187.8	0.80
17	3180.8	3181.7	0.90	3184.7	3184.3	-0.40	3185.4	3185.4	0.00	3187.0	3187.3	0.30
16	---	3178.7	N/A	---	3181.7	N/A	---	3182.4	N/A	---	3183.1	N/A

NOTES:
1. 1988 HYDROLOGIC MODEL WAS RUN WITH 2" RUNOFF IN PLAYA LAKES 39,37,30, AND 25 REMAINING PLAYA LAKES USED WATER SURFACE ELEVATION SHOWN ON CITY TOPOGRAPHIC MAPS FOR STARTING CONDITIONS.
2. A "---" SYMBOL UNDER THE "1982 F.I.S." COLUMN INDICATES THAT THE PLAYA LAKE WAS NOT STUDIED IN DETAIL FOR THE 1982 FLOOD INSURANCE STUDY.

increase over the elevations published in the original FIS. Tables IV-2 and IV-3 show that the 1982 FIS 100-year water surface elevation for Playa Lake 37 was above the baseline conditions overflow elevation (3266 vs. 3264) but that there was no overflow discharge. This is due to the fact that at the time the FIS was produced, an irrigation canal was blocking flow from Playa Lake 37 to Loop 289 and Playa Lake 31. The irrigation canal has since been removed.

The increases in discharges and elevations are due to the assumption of a future, fully-urbanized watershed, updated overflow backwater models, a change in assumed rainfall distribution, more detailed models, and other assumptions related to starting lake level conditions. See Appendix C (Separate Volume) for detailed computer printout of the hydrologic models.

C. HYDRAULICS STUDY RESULTS

The baseline condition flood discharges were input into the backwater models and executed to compute water surface profiles and hydraulic rating curves of the overland flow routes between the playa lakes in the study area.

The playa lake pool elevations, along with the water surface profiles, were used to delineate the 100-year flood plain for the study area. Sheets 1-35, located in Appendix A, show the 100-year flood plain, cross-sections, overflow water surface elevations, playa lake pool elevations, and affected buildings for the study area. The 100 year flood plain shown on the sheets is based on existing playa lake storage capacities and overflow routes, with a fully urbanized watershed.

Appendix C contains the summary HEC-2 printout of the hydraulic analyses. This appendix was not published with this report, but is available from the City of Lubbock or Albert H. Halff Associates.

D. ECONOMIC ANALYSES RESULTS

1. Structures and Investment in Flood Plain

A total of 1,223 structures were identified within the 500-year flood plain limits in the study area. Of the total, 1,156 structures (94.5% percent) are residential dwellings. The residential structures consist mainly of one story brick, brick-veneer, or frame homes built on concrete slabs. System E1 contains the heaviest concentration of flood plain properties (94.9 percent of the total). Estimates for the total flood plain investment (buildings and contents) within the 500-year flood plain limits totaled almost $154 million. Residential dwellings range in structural value between $20,000 to $142,000, with an average of about $63,800, excluding their land value and contents.

2. Summary of Flood Losses

It is estimated that a 500-year flood could potentially cause property damages of about $35.6 million. This would represent a loss of about 23 percent of the total investment in the affected study area. Comparatively, the 10-year event could produce losses of about $975,000. Estimates of flood losses for various single occurrence flood events, by system, are presented in Table IV-4.

TABLE IV-4

ESTIMATES OF SINGLE OCCURRENCE FLOOD LOSSES
BY PLAYA LAKE SYSTEM
(1988 Prices and Level of Development)
Values are in $1,000

System	500-Year	100-Year	50-Year	10-Year
E-1	33,595.5	15,152.5	9,902.6	931.8
E-2	297.4	52.2	22.7	0
Southwest	1,047.6	113.4	91.2	0
F	619.2	226.6	112.2	42.9
TOTAL	35,559.7	15,544.7	10,128.7	974.7

3. Average Annual Damages

Estimates of average annual damages (AAD) under baseline channel and flood plain conditions were calculated. The total existing average annual flood losses in the study area are estimated at near $749,000, based on 1988 prices. These damages include only buildings and contents and do not reflect damages to streets, bridges, utilities, etc. A breakdown of this information, by system, is contained in Table IV-5.

TABLE IV-5

EXISTING AVERAGE ANNUAL DAMAGES
BY PLAYA LAKE SYSTEM *

(March 1988 Prices and Level of Development)

System	Average Annual Damages
E-1	$721,150
E-2	2,530
Southwest	4,800
F	20,340
TOTAL	$748,820

* INCLUDES ONLY BUILDINGS AND CONTENTS WITHIN 500-YEAR FLOOD PLAIN

V. PLAN FORMULATION

V. PLAN FORMULATION

Alternative methods of mitigating flood damages considered for this are diagrammed in Figure V-1, and discussed below. The methods include No Action, Nonstructural Measures, Structural Measures, and Relief Measures.

A. NO ACTION

Taking no action is a non-structural measure that must always be considered. Taking no action towards the flooding problems identified would mean that the City would rely on its playa lake subdivision ordinance to handle all future development in the playa lakes, and on its Flood Insurance Program regulations to handle both future and existing development in the 100-year flood plain and floodway fringe. The interest and significant effort undertaken by the City in the production of this study indicated that Lubbock wishes to undertake some action towards alleviating flooding problems in the study area.

B. NON-STRUCTURAL MEASURES

Non-structural methods are the management and/or legislative measures used to decrease flooding and reduce flood damage to individual structures or to land in or around a community. Structures can be protected by elevating in place or specific areas of land can be regulated or acquired in fee or easement. Non-structural measures considered for this study were:

- o Land use zoning and subdivision regulations
- o On-site detention policy
- o Raising of finished floor elevations

1. Land Use Zoning and Subdivision Regulations

As non-structural measures, land use zoning and subdivision regulations allow a community to regulate development within the flood plain. The City currently has a comprehensive ordinance

regulating development within the design high water mark for the playa lakes. By participating in the National Flood Insurance Program, the City also has regulations governing the 100-year flood plain within and between the playa lakes.

2. On-Site Detention Policy

An on-site detention policy would help the City reduce the impact of urbanization on undeveloped portions of a watershed. Such a policy would require developers to provide temporary storage of stormwater within their subdivision. The basic objective of such a detention policy would be to minimize the increase in peak discharges and runoff volumes resulting from increased impervious cover due to development. Because of the flat terrain in the study area, construction of detention facilities would be expensive. Therefore, a general on-site detention policy appears to be impractical for the City of Lubbock.

A variation of the on-site detention policy would be the retention of stormwater by homeowners using underground cisterns on their lots. The water could be used by homeowners for irrigation of their lawns and gardens. Previous studies of the feasibility of this measure (Reference 7) have shown that the cost of a cistern retention system is too large to be offset by the reduced water use costs, and would require the city to offer incentives to cover the disparity.

3. Raising of Finished Floor Elevations

Another non-structural measure is the physical raising of structures affected by flooding. Such a measure requires the placement of the structure on a raised pier foundation, adjusting utilities and site aesthetics, and flood proofing utility connections. The types of structures ideally suited for raising are residential and light commercial structures with pier and beam foundations. Slab-on-grade structures are not normally feasible

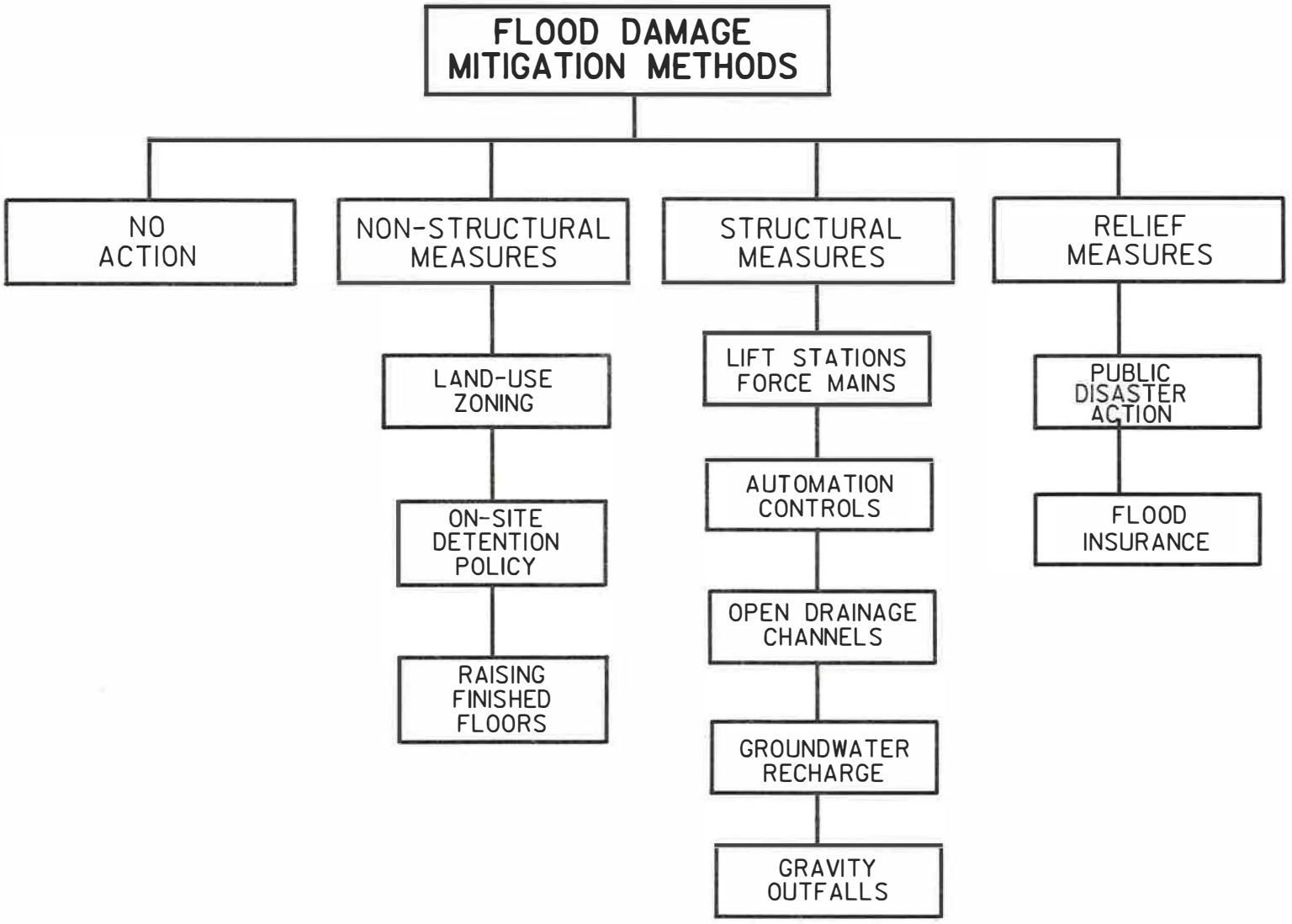


FIGURE V-I
FLOOD DAMAGE MITIGATION METHODS

AVO 9102
SOUTH LUBBOCK
DRAINAGE STUDY
1988

ALBERT H. HALFF ASSOCIATES, INC.

to raise. Federal studies (Reference 8) show that raising of structures is generally not cost-effective if the buildings are above the 10-year flood level. Within the study area, the majority of damages to structures was occurring above a 10-year flood, therefore making this alternative economically infeasible.

C. STRUCTURAL MEASURES

Structural measures are actions taken to alter sections of a watercourse within a watershed to prevent flood losses. Structural measures include dams, levees, diversion, dikes, channels, pump stations, and pipe systems. The structural measures considered for this study were:

- o Lift stations/force mains
- o Automation controls
- o Open drainage channels
- o Groundwater recharge
- o Gravity outfalls
- o Combination of two or more of the above

Any structural flood control measure for Lubbock's playa lake systems must address the interdependence of the individual lake storage capacities. This interdependence is a result of the playa lake systems being "closed" systems, i.e., there is no direct connection to Yellowhouse Canyon. Therefore, all runoff volumes must be contained by the playa lakes or spill out of the most downstream playa lake in the system, overland to Yellowhouse Canyon. Modification of one portion of the system will affect other protions.

1. Lift Stations and Force Mains

Lift stations/force mains would pump stormwater between playa lakes or to Yellowhouse Canyon. For a given design flood, pumping would lower playa lake elevations to prevent flooding of surrounding structures, as well as preventing overflow between

playa lakes. Because of the interdependence between playa lake storages, any lift station/force main flood control alternative would have to include pumping to Yellowhouse Canyon. Pumping between playa lakes without diversion to Yellowhouse Canyon would increase flood volumes in the downstream portion of the playa lake systems resulting in higher water surface elevations and increased flood damages.

The City's existing lift station at Clapp Park (Playa Lake 21) pumps into an existing storm sewer with numerous inlets. Pumping water out of Clapp Park can occur only when there is no danger of surcharging the storm sewer and causing localized flooding. This potential liability for the City limits the use of the existing lift station/storm sewer combination as a reliable flood control alternative, because pumping would be heavily dependent on hydraulic conditions in the downstream storm sewer.

To provide cost-effective flood control, lift station/force mains require large floodwater storage capacities in order to keep both the pump size and the pipe diameter small. The limited storage capacities of the playa lakes in the study area would significantly increase the pump size necessary to achieve the level of flood control provided by an uncontrolled gravity outfall. The construction and maintenance costs associated with a pump station would make a lift station/force main flood control alternative more expensive than an uncontrolled gravity outfall. For these reasons, lift stations/force mains as direct flood control alternatives were not considered further in this study.

2. Automation Controls

Automation controls are usually applied to lift stations/force main flood control alternatives. The controls serve to create an automatic response of the flood control system to specific rainfall amounts and water surface elevations within selected time periods. Because of the infeasibility of lift station/force

mains, automation controls were not considered further in this study.

3. Open Drainage Channels

Open drainage ways consisting of grass-lined channels would normally provide the most cost-effective type of flood control. However, the severe right-of-way constraints that exist within the study area would force an open channel alternative to include the purchase of homes and/or commercial structures, permanent closing of one or more residential streets, and major utility relocations. Neighborhood and community disruption would be extreme. With the contraints previously mentioned and predictable high costs, the implementation of open channel flood control measures is precluded.

4. Groundwater Recharge

Groundwater recharge from playa lakes has been studied extensively by the Water Resources Center at Texas Tech University (Reference 9). While the studies have shown that playa lakes are excellent candidates for groundwater recharge systems, there are two factors which rule out the use of groundwater recharge as a flood control measure for the study area: high existing groundwater elevations and relatively low recharge rates. Previous groundwater studies of the Ogallala Aquifer show a rising groundwater table underneath the City of Lubbock (Reference 10). In some areas, groundwater elevations are high enough that they prevent or inhibit recharge from the playa lakes into the groundwater. In some cases, groundwater elevations are above playa lake bottoms, and groundwater may be flowing into the lake itself. Without resumed pumping by the City or agricultural interests, the alternative of increasing the rate of groundwater recharge for flood control would only compound the rising groundwater problem. In addition, the rates of recharge, even under ideal conditions, are not large enough to provide flood control when compared with the volumes of

water that would have to be removed from a playa lake during a given design flood. For these reasons, groundwater recharge was not considered as a feasible flood control alternative.

5. Gravity Outfalls

Gravity outfalls to Yellowhouse Canyon, or between playa lakes could be viable flood control alternatives for the study area. Gravity outfalls between playa lakes are affected by relatively flat ground slopes, requiring larger pipe sizes to carry a design flood. Construction costs of gravity outfalls to Yellowhouse Canyon are affected by the large distance between the playa lakes in the study area and the canyon. These large distances result in large pipe lengths and deep cuts, resulting in increased construction costs. Several gravity alternatives were considered for the study area (See Chapter VI).

6. Combination of Alternatives

A combination of a lift station and gravity outfall could be used to provide an indirect means of flood control. A pump/gravity outfall system could be used to lower the playa lakes normal pool elevations. Lower normal pool elevations would provide additional storage capacity for flood events. After a flood event, the pump/gravity outfall system would drain the lakes down over a period of several days to return to a design normal pool level. This type of system is not a direct means of flood control because the system is designed to perform <u>after</u> a flood event occurs. A pump/gravity outfall system was evaluated for this study.

D. RELIEF MEASURES

1. Public Disaster Action

The City of Lubbock has procedures to be followed when flooding is anticipated at specific locations (such as the frontage roads on

Loop 289 near Quaker Avenue). City officials monitor areas that are likely to flood, and when flooding becomes imminent, personnel are dispatched to the areas to warn the residents, and to barricade dangerous roads. Portable pumps have been used to lower playa lake levels after heavy rainfall.

2. Flood Insurance

Flood insurance helps to alleviate the cost to individuals of flood destruction after flooding has occurred. It does not, however, prevent damaging floods, which remain burdensome to insurance institutions, property owners, and local and Federal Governments. Purchase of more flood insurance for property owners in the study area will offer some relief from expensive flood damages. The alternative may be advantageous in areas too infrequently flooded to justify any other flood damage mitigation measure. Lubbock is a participant in the National Flood Insurance Program (NFIP). As a condition to property owners purchasing flood insurance offered by the NFIP, the community has agreed to adopt and administer local flood plain management measures aimed at protecting lives and new construction from future flooding. The Federal Emergency Management Agency (FEMA), as part of this program, publishes Flood Insurance Rate Maps (Reference 1). In communities where a flood map has been published, section 102 of the Flood Disaster Protection Act of 1973, as amended, requires the purchase of flood insurance as a condition of Federal or Federally-related financial assistance for acquisition or construction of buildings in special flood hazard areas, as shown on the FIRMs. The act also requires local Governments to furnish the following:

a. Copies of land use and control measures,
b. Maps identifying jurisdictional limits and flood plain areas,
c. Estimates of buildings and populations in flood plains,
d. A local depository where flood-insurance and flood-hazard maps will be available for public inspection, and
e. A summary of the community's history of flooding.

VI. EVALUATION OF PROPOSED IMPROVEMENTS

VI. EVALUATION OF PROPOSED IMPROVEMENTS

This chapter is divided into two parts. The first part provides a description of each improvement, associated benefits, costs, and benefit-to-cost ratios. Preliminary cost estimates for the proposed improvements are in Appendix B. The second portion of the chapter discusses intangible or non-monetary benefits and shows the results of a non-monetary value analysis of the proposed improvements.

The alternatives discussed in this chapter are independent of each other. Each alternative is technically feasible and would not require the construction of another improvement to produce the benefits and benefit-cost ratio associated with the alternative.

A. DESCRIPTIONS OF ALTERNATIVE IMPROVEMENTS AND BENEFIT-COST ANALYSES

1. **Alternative 1** - Divert Flows from Playa 23 to Yellowhouse Canyon - 100-Year Design

The 100-year design flood would be carried from Playa Lake 23 at the south side of Loop 289 along the Highway Department right-of-way between the east bound lane and south frontage road. The flow would exit just west of Loop 289's intersection with Southeast Drive, and cross underneath the Slaton Highway and Atchison Topeka and Santa Fe (AT&SF) Railroad to empty into the Yellowhouse Canyon (See Figure VI-1).

The flow would be carried by two 72" diameter reinforced concrete pipes. The total length of pipe would be about 30,000 feet. Floods larger than a 100-year flood would split, with some flow diverted through the double 72" pipes, and the remainder passing on downstream to Playa Lake 19. The diversion of the 100-year flood would produce lower playa lake water surface elevations and reduced overflows for Playa Lakes 23, 19, 20, and 21. Table VI-1 compares the proposed and baseline conditions water surface elevations for Playa Lakes 23, 19, 20, and 21.

The benefits of Alternative 1 would total $461,320 in average annual damages reduced. The estimated construction cost is $12.21 million. Over a fifty (50) year project life, the average annual costs would be $1.07 million, yielding a benefit-to-cost ratio of 0.43 to 1.0.

TABLE VI-1

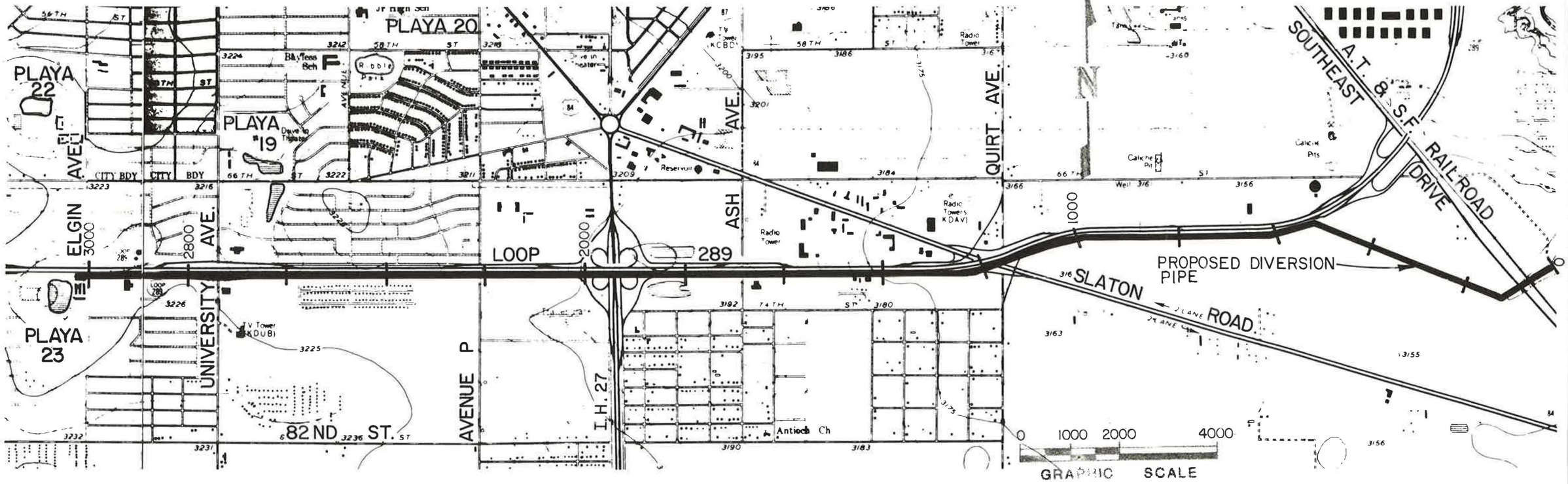
SYSTEM E-1
COMPARISON OF PLAYA LAKE WATER SURFACE ELEVATIONS
ALTERNATIVE 1
BASELINE CONDITIONS VS. DIVERT 100 YEAR FLOOD FROM PLAYA LAKE 23 TO YELLOWHOUSE CANYON

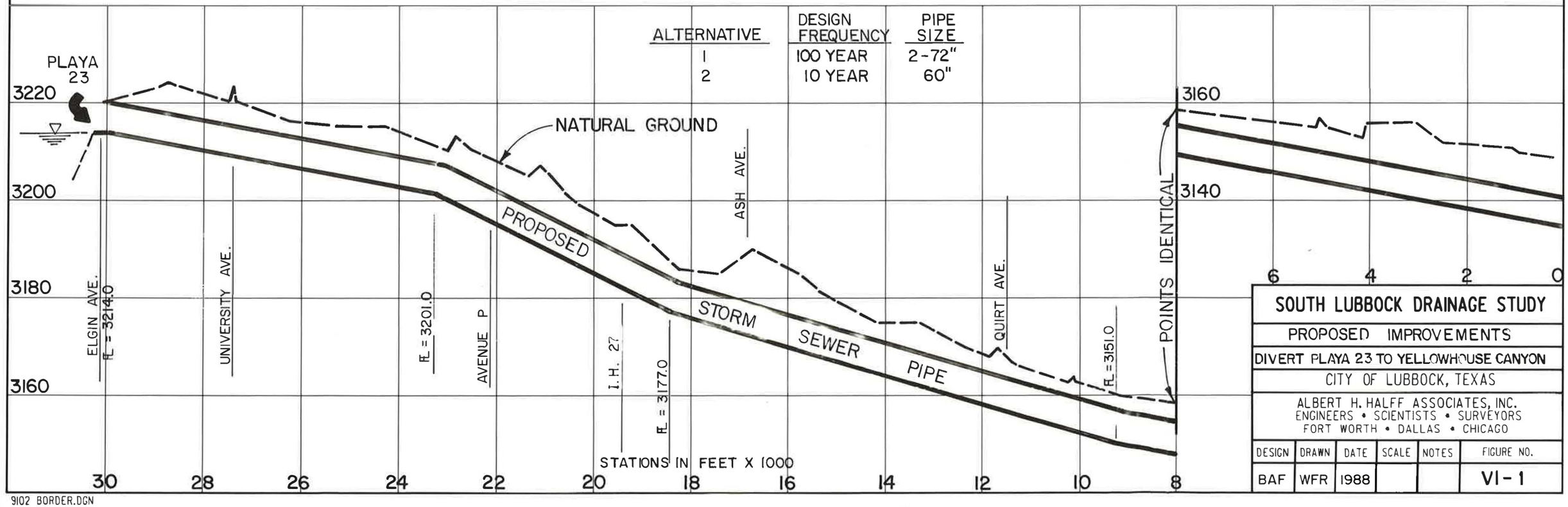
	10 YEAR ELEVATION (FT.)			50 YEAR ELEVATION (FT.)			100 YEAR ELEVATION (FT.)			500 YEAR ELEVATION (FT.)		
PLAYA #	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)
SYSTEM E-1:												
23	3222.7	3219.7	-3.00	3223.4	3221.2	-2.20	3223.9	3222.0	-1.90	3224.8	3224.1	-0.70
19	3214.8	3214.5	-0.30	3215.9	3215.1	-0.80	3216.6	3215.3	-1.30	3217.8	3216.8	-1.00
20	3212.8	3212.7	-0.10	3214.0	3213.5	-0.50	3214.3	3213.8	-0.50	3215.0	3214.4	-0.60
21	3202.1	3199.4	-2.70	3208.6	3202.2	-6.40	3209.1	3203.5	-5.60	3209.8	3208.2	-1.60

2. **Alternative** 2 - Divert Flows from Playa 23 to Yellowhouse Canyon - 10-Year Design

The 10-year design flood would be carried from Playa Lake 23 along the same route as described above for the 100-year design (See Figure VI-1).

The flow would be carried by one 60" diameter reinforced concrete pipe, with the total pipe length equal to that of the 100-year design. For floods larger than a 10-year frequency, some flow would be diverted through the 60" pipe, while the remainder would flow downstream to Playa Lake 19. The diversion of the 10-year flood would produce lower playa lake water surface elevations and





SOUTH LUBBOCK DRAINAGE STUDY

PROPOSED IMPROVEMENTS

DIVERT PLAYA 23 TO YELLOWHOUSE CANYON

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS • SCIENTISTS • SURVEYORS
FORT WORTH • DALLAS • CHICAGO

DESIGN	DRAWN	DATE	SCALE	NOTES	FIGURE NO.
BAF	WFR	1988			VI-1

9102 BORDER.DGN

reduced overflows for Playa Lakes 23, 19, 20, and 21. However, the magnitude of those reductions would be smaller than those achieved with the 100-year design. Table VI-2 compares the proposed and baseline conditions water surface elevations for Playa Lakes 23, 19, 20, and 21.

The benefits of Alternative 2 would be $361,240 in reduced average annual damages. The estimated construction cost is $5.91 million. Over a fifty (50) year project life, the average annual costs would be $518,100, yielding a benefit-to-cost ratio of 0.70 to 1.0.

TABLE VI-2

SYSTEM E-1
COMPARISON OF PLAYA LAKE WATER SURFACE ELEVATIONS
ALTERNATIVE 2
BASELINE CONDITIONS VS. DIVERT 10 YEAR FLOOD FROM PLAYA LAKE 23 TO YELLOWHOUSE CANYON

	10 YEAR ELEVATION (FT.)			50 YEAR ELEVATION (FT.)			100 YEAR ELEVATION (FT.)			500 YEAR ELEVATION (FT.)		
PLAYA #:	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)
SYSTEM E-1:												
23	3222.7	3221.0	-1.70	3223.4	3222.7	-0.70	3223.9	3223.6	-0.30	3224.8	3224.6	-0.20
19	3214.8	3214.5	-0.30	3215.9	3215.1	-0.80	3216.6	3216.0	-0.60	3217.8	3217.5	-0.30
20	3212.8	3212.7	-0.10	3214.0	3213.5	-0.50	3214.3	3214.0	-0.30	3215.0	3214.8	-0.20
21	3202.1	3199.4	-2.70	3208.6	3203.1	-5.50	3209.1	3206.8	-2.30	3209.8	3209.4	-0.40

3. **Alternative 3** - Divert Flows from Playa 21 to Yellowhouse Canyon - 100-Year Design

The 100-year design flood would be carried from Playa Lake 21 (Clapp Park) east along 42nd Street, crossing under Southeast Drive and the AT&SF Railroad to empty into the Yellowhouse Canyon (see Figure VI-2).

The flow would be carried by two 60" diameter reinforced concrete pipes. The total length of pipe would be about 22,000 feet. Floods larger than a 100-year flood would split, with flow diverted through the double 60" pipes, and the rest flowing overland from Playa Lake 21 east towards Southeast Drive and then southeast towards the intersection of Loop 289 and Southeast Drive. This alternative would remove the structures flooded by Playa Lake 21 from the flood plain. The proposed pipe alignment would allow the pipe to cross underneath the proposed depressed intersection of IH-27 and 42nd Street. A comparison of the proposed and baseline conditions water surface elevations for Playa Lake 21 is shown in Table VI-3.

The benefits of Alternative 3 would total $482,160 in reduced average annual damages. The estimated construction cost is $6.67 million. Over a fifty (50) year project life average annual costs would be $584,400, yielding a benefit-to-cost ratio of 0.83 to 1.0.

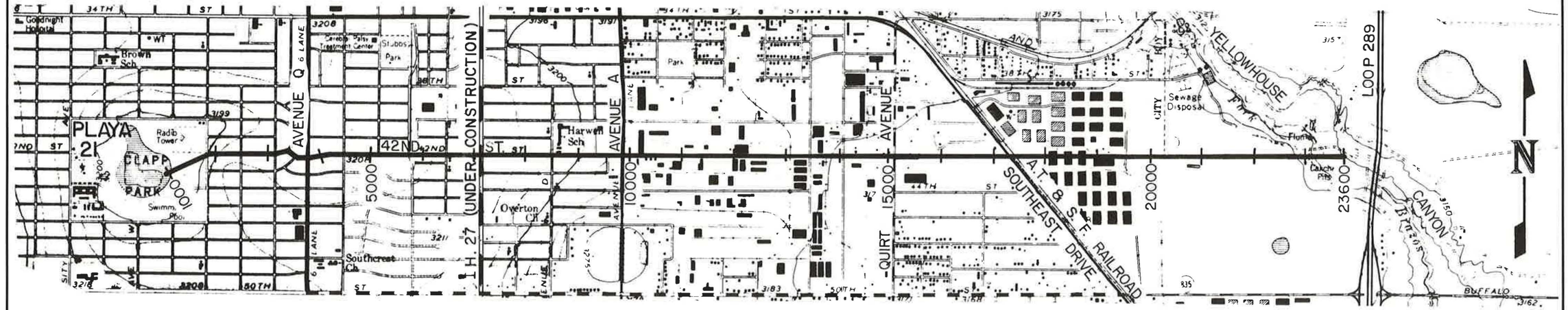
TABLE VI-3

SYSTEM E-1
COMPARISON OF PLAYA LAKE WATER SURFACE ELEVATIONS
ALTERNATIVE 3
BASELINE CONDITIONS VS. DIVERT 100 YEAR FLOOD FROM PLAYA LAKE 21 TO YELLOWHOUSE CANYON

	10 YEAR ELEVATION (FT.)			50 YEAR ELEVATION (FT.)			100 YEAR ELEVATION (FT.)			500 YEAR ELEVATION (FT.)		
PLAYA #:	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)
SYSTEM E-1:												
21	3202.1	3195.6	-6.50	3208.6	3197.7	-10.9	3209.1	3199.6	-9.50	3209.8	3207.7	-2.10

4. **Alternative 4** - Divert Flows from Playa 21 to Yellowhouse Canyon - 10-Year Design

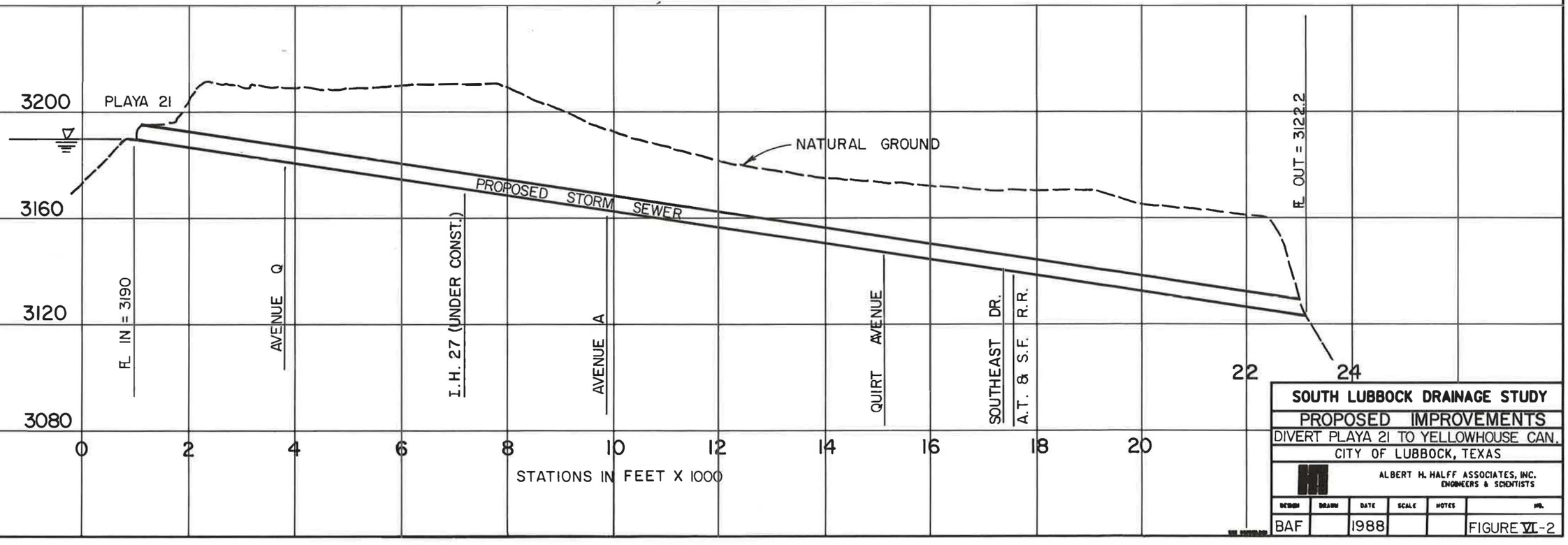
The 10-year design flood would be carried out of Playa Lake 21 along the same route as described above for the 100-year design (see Figure VI-2).



ALTERNATIVE	DESIGN FREQUENCY	PIPE SIZE
3	100-YEAR	2-60"
4	10-YEAR	36"

0 1000 2000 4000

GRAPHIC SCALE



SOUTH LUBBOCK DRAINAGE STUDY

PROPOSED IMPROVEMENTS

DIVERT PLAYA 21 TO YELLOWHOUSE CAN.

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	NO.
BAF		1988			FIGURE VI-2

The flow would be carried by one 36" diameter reinforced concrete pipe, with the total pipe length equal to that of the 100-year design. For floods larger than a 10-year frequency, Playa Lake 21 would have slightly lower pool elevations than baseline conditions, but would still overflow on the 100-year flood and flow overland to the intersection of Loop 289 and Southeast Drive. A comparison of proposed and baseline conditions water surface elevations for Playa Lake 21 is shown in Table VI-4.

The benefits of Alternative 4 would be $360,410 in reduced average annual damages. The estimated construction cost is $2.6 million. Over a fifty (50) year project life, average annual cost would be $228,200, yielding a benefit-to-cost ratio of 1.58 to 1.0.

TABLE VI-4

SYSTEM E-1
COMPARISON OF PLAYA LAKE WATER SURFACE ELEVATIONS
ALTERNATIVE 4
BASELINE CONDITIONS VS. DIVERT 10 YEAR FLOOD FROM PLAYA LAKE 21 TO YELLOWHOUSE CANYON

	10 YEAR ELEVATION (FT.)			50 YEAR ELEVATION (FT.)			100 YEAR ELEVATION (FT.)			500 YEAR ELEVATION (FT.)		
PLAYA #:	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)	BASE. COND.	PROP. DIV.	DIFF. (FT.)
SYSTEM E-1:												
21	3202.1	3197.8	-4.30	3208.6	3207.2	-1.40	3209.1	3208.8	-0.30	3209.8	3209.7	-0.10

5. **Alternative 5 -** Storm Drain System Playa Lakes 31, 27, 26, 25, & 24 - 10-Year Design

This proposed improvement would create a flood control system that would prevent Playa Lakes 31, 27, 26, 25, and 24 from incurring damages for the 10-year flood, while reducing overflow discharges

and playa lake pool elevations for higher frequency floods. Table VI-5 compares the baseline conditions playa lake water surface elevations with those that would result from this proposed improvement. The plan view of the proposed improvement is shown on Sheets 7-16, in Appendix A.

TABLE VI-5

SYSTEM E-1
COMPARISON OF PLAYA LAKE WATER SURFACE ELEVATIONS
ALTERNATIVE 5
BASELINE CONDITIONS VS. PROPOSED 10-YEAR STORM SEWER SYSTEM FOR PLAYAS 31,37,26,25,&24

	10 YEAR ELEVATION (FT.)			50 YEAR ELEVATION (FT.)			100 YEAR ELEVATION (FT.)			500 YEAR ELEVATION (FT.)		
PLAYA #:	BAS. COND.	PROP. COND.	DIFF. (FT.)	BAS. COND.	PROP. COND.	DIFF. (FT.)	BAS. COND.	PROP. COND.	DIFF. (FT.)	BAS. COND.	PROP. COND.	DIFF. (FT.)
SYSTEM E-1:												
31	3254.6	3253.8	-0.80	3255.0	3254.7	-0.30	3255.4	3255.2	-0.20	3256.0	3255.9	-0.10
27	3238.1	3236.3	-1.80	3239.0	3237.6	-1.40	3239.2	3238.1	-1.10	3240.0	3239.1	-0.90
26	3231.8	3230.3	-1.50	3232.8	3232.0	-0.80	3233.3	3232.7	-0.60	3234.4	3233.3	-1.10
25	3227.4	3227.2	-0.20	3228.2	3228.0	-0.20	3228.5	3228.3	-0.20	3229.1	3228.6	-0.50
24	3227.8	3227.2	-0.60	3228.2	3228.0	-0.20	3228.3	3228.3	0.00	3228.8	3228.6	-0.20

The Alternative 5 improvements would start at Playa Lake 31 (Sheet 7), with a 48" diameter reinforced concrete pipe connecting Playa Lakes 31 and 27. A 12' x 6' concrete box sewer would connect Playa Lakes 27 and 26 (Sheets 9-12). The overflow for Playa Lake 26 (Leroy Elmore Park) would be modified by placing two 5' x 4' concrete box culverts at both the north and south frontage roads of Loop 289 (Sheet 12). These boxes would be placed in alignment with the existing boxes under the Loop 289 main lanes, whose flowlines would be lowered by 2.0 feet. The 12 - 24" concrete pipes at the north and south frontage roads would remain in place. The frontage roads would maintain their present top-of-road elevations. The channel between Loop 289 and Playa Lake 25 would be deepened by 1.0 to 1.5 feet (Sheets 12-13) to accommodate the improvements at Loop 289. Two 60" diameter reinforced concrete

pipes would connect Playa Lakes 25 and 24, with major excavation to occur in Playa Lake 24 (Sheets 12 and 13) to accommodate the increased volume of water moving between the playa lakes caused by the improvements. The cut slopes for excavation of Playa Lake 24 would be 4H:1V, in conflict with the City's subdivision ordinance requiring excavated slopes no steeper than 7H:1V. However, the 4H:1V sideslope is necessary to accommodate the increased volume to Playa Lake 24 under this proposed improvement.

The benefits of Alternative 5 would be $71,520 in reduced average annual damages. The estimated construction cost is $3.49 million. Over a fifty (50) year project life, average annual costs would be $305,700, yielding a benefit-to-cost ratio of 0.23 to 1.0.

6. **Alternative 6** - Storm Drain System Playa Lakes 19, 20, and 21 - 10-Year Design

This proposed improvement would create a flood control system that would prevent Playa Lakes 19, 20, and 21 from incurring damages for the 10-year flood, while reducing overflow discharges and playa lake pool elevations for higher frequency floods. Table VI-6 shows a comparison of the baseline and proposed conditions playa lake water surface elevations for this proposed improvement. The plan view schematic of the proposed improvement is shown on Sheets 18-21, in Appendix A.

TABLE VI-6

SYSTEM E-1
COMPARISON OF PLAYA LAKE WATER SURFACE ELEVATIONS
ALTERNATIVE 6
BASELINE CONDITIONS VS. PROPOSED 10-YEAR STORM DRAIN SYSTEM FOR PLAYAS 19,20,&21

	10 YEAR ELEVATION (FT.)			50 YEAR ELEVATION (FT.)			100 YEAR ELEVATION (FT.)			500 YEAR ELEVATION (FT.)		
PLAYA #	BASE. COND.	PROP. COND.	DIFF. (FT.)	BASE. COND.	PROP. COND.	DIFF. (FT.)	BASE. COND.	PROP. COND.	DIFF. (FT.)	BASE. COND.	PROP. COND.	DIFF. (FT.)
SYSTEM E-1:												
19	3214.8	3210.5	-4.30	3215.9	3215.4	-0.50	3216.6	3216.2	-0.40	3217.8	3217.6	-0.20
20	3212.8	3208.1	-4.70	3214.0	3210.0	-4.00	3214.3	3212.8	-1.50	3215.0	3214.2	-0.80
21	3202.1	3199.3	-2.80	3208.6	3208.2	-0.40	3209.1	3209.1	0.00	3209.8	3209.5	-0.30

The improvements would start at Playa Lake 19 with major excavation of the lake to provide increased flood storage capacity (Sheet 18). Playa Lake 19 would then be connected to Playa Lake 21 (Sheets 18-21) by a 48" diameter reinforced concrete pipe. Playa Lake 20 (Sheet 18), would also be excavated for flood storage capacity, and would be connected to Playa Lake 21 by a 48" diameter reinforced concrete pipe. The 48" line between Playa Lakes 19 and 21, and the 48" line between Playa Lake 20 and 21 would not be connected together, to prevent back flow into Playa Lake 20 that might occur from the pipe connecting 19 and 21. Playa Lake 21 itself, would be excavated (Sheets 20-21), to accommodate the increased volume of water from both 48" lines.

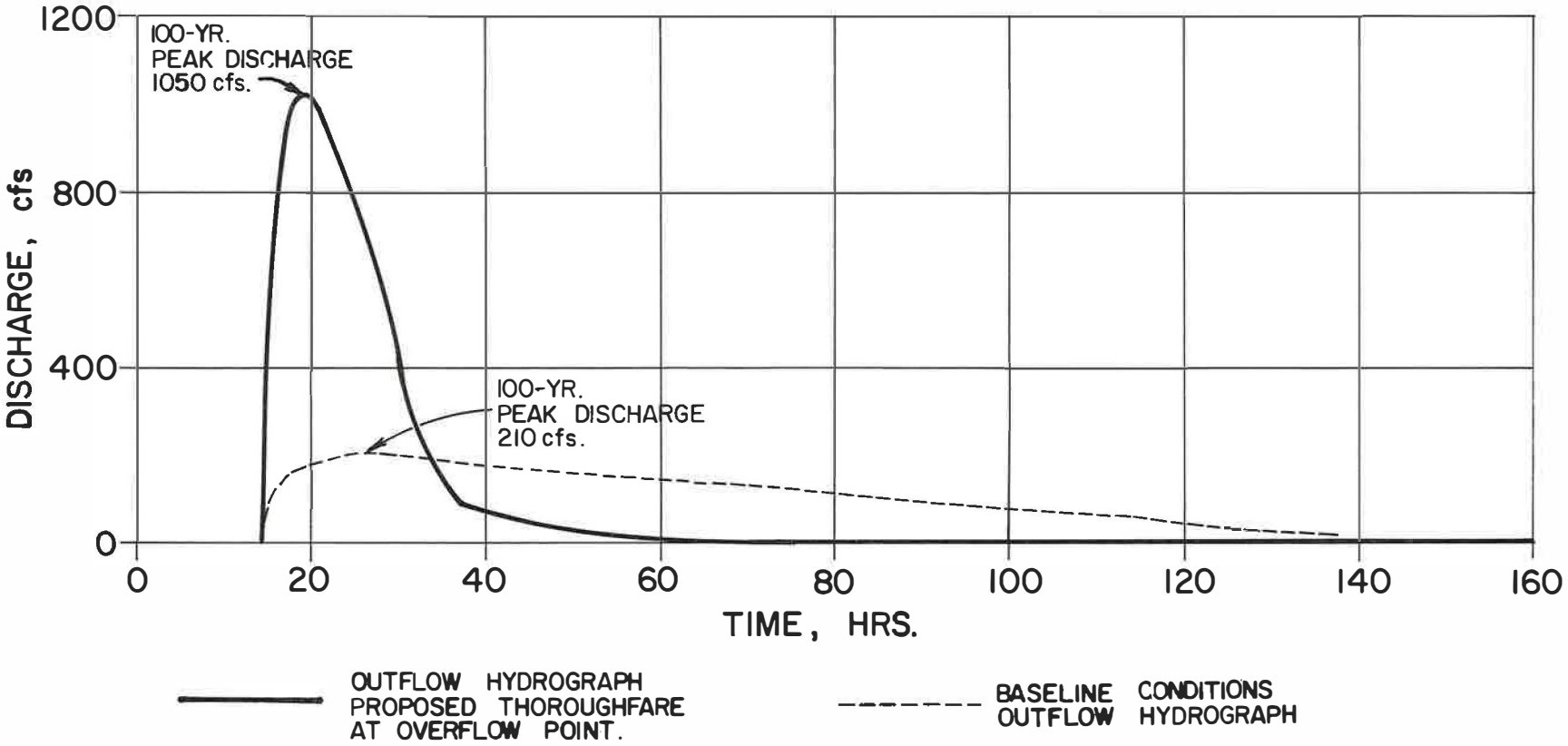
The benefits of Alternative 6 would be $232,800 in reduced damages. The estimated construction cost is $3.62 million. Over a fifty (50) year project life, average annual costs would be $317,300, yielding a benefit-to-cost ratio of 0.73 to 1.0.

7. **Alternative 7 -** Flood Control Plan for Playa Lake 37

The area surrounding Playa Lake 37 (Bill McAlister Park), in west Lubbock, is experiencing rapid development. City conceptual plans show a possible thoroughfare alignment that would cross Loop 289 at the current overflow point of Playa Lake 37, and extend into Bill McAlister Park. The Loop 289 main lanes are proposed to be redesigned as an overpass at the intersection with the proposed thoroughfare. The proposed thoroughfare alignment would create a substantially larger overflow opening than the current configuration.

An analysis was made to determine the hydrologic effect of creating a larger overflow opening for Playa Lake 37 based upon the proposed 110-foot right-of-way thoroughfare. The larger opening resulted in a substantial increase in peak outflow discharge from Playa Lake 37. Figure VI-3 shows the comparison of both baseline and proposed conditions outflow hydrographs for

FIGURE VI-3



COMPARISON OF 100 YEAR FLOOD OUTFLOW HYDROGRAPHS PLAYA LAKE 37 (BILL Mc ALISTER PARK)

Playa Lake 37. The peak 100-year discharge increases dramatically from 210 cfs to 1050 cfs (+500%). Tables VI-7 and VI-8 show the resulting increases in peak outflow and water surface elevations for System E-1 due to the increased outflow from Playa Lake 37. The downstream System E1 playa lake outflow discharges for the 100-year flood would increase an average of 137%. The 100-year water surface elevations in the playa lakes would average almost 0.7-feet higher than the baseline conditions. The 100-year peak discharge and water surface elevation for Playa Lake 27 is unaffected by the proposed opening because the peak flow is from local runoff which occurs before the spill of Playa Lake 37.

The results of the above analysis show that the existing Loop 289 overflow configuration for the Playa Lake 37 serves as an effective flood control/detention outlet structure. Any enlargement of the overflow opening, such as the proposed thoroughfare, without downstream improvements, would be detrimental to the rest of System E-1, causing increased discharges, water-surface elevations, and damages. Therefore, it is recommended that the City leave the restriction in place. In addition, any modifications to Loop 289 that would increase the outflow from Playa Lake 37 should be offset by increasing the storage capacity of the lake.

Figure VI-4 is an example of the type of excavation that would be necessary if the proposed thoroughfare were built. The figure shows an excavation plan that would encompass almost the entire park area. The plan calls for excavating from elevation 3265.0 down to 3240.0. The total excavation amount would be about 4.1 million cubic yards of material. The proposed excavation plan for Playa Lake 37 was modelled hydrologically, using the baseline condition 2-inch runoff criteria to establish a starting water surface elevation. The results show that the excavation plan completely contains the 100-year flood without overflow. Tables VI-9 and VI-10 show the effects of the excavation plan on the downstream playa lakes. Containing the 100-year flood at Playa

TABLE VI-7

SYSTEM E-1
COMPARISON OF DISCHARGES
BASELINE CONDITIONS VS. PROPOSED OPENING OF PLAYA LAKE 37

PLAYA #	10 YEAR DISCHARGE (CFS)			50 YEAR DISCHARGE (CFS)			100 YEAR DISCHARGE (CFS)			500 YEAR DISCHARGE (CFS)		
	BASE. COND.	PROP. OPEN.	% DIFF.	BASE. COND.	PROP. OPEN.	% DIFF.	BASE. COND.	PROP. OPEN.	% DIFF.	BASE. COND.	PROP. OPEN.	% DIFF.
SYSTEM E-1:												
39	650	650	0	980	980	0	1050	1050	0	1350	1350	0
37	100	280	180	170	750	341	210	1050	400	400	1550	288
31	120	310	158	280	800	186	540	1100	104	980	1650	68
27	450	430	-4	960	900	-6	1150	1150	0	1700	1750	3
26	150	300	100	500	860	72	770	1150	49	1350	1650	22
25	110	240	118	390	880	126	670	1200	79	1400	1750	25
24	60	110	83	320	880	175	540	1200	122	1250	1750	40
23	50	80	60	250	740	196	470	1100	134	960	1700	77
19	30	60	100	190	640	237	400	990	148	910	1650	81
20	40	50	25	180	630	250	390	980	151	920	1650	79
21	0	0	0	60	80	33	150	430	187	470	1350	187

NOTES: 1. 1988 HYDROLOGIC MODEL WAS RUN WITH 2" RUNOFF IN PLAYA LAKES 39,37, AND 25. ALL REMAINING PLAYA LAKES USED WATER SURFACE ELEVATION SHOWN ON CITY TOPOGRAPHIC MAPS FOR STARTING CONDITIONS.
2. "PROP. OPEN." CONDITIONS BASED ON REVISED RATING FOR PLAYA 37, WITH A 110' WIDE OPENING CORRESPONDING TO PROPOSED STREET R.O.W. AT PRESENT OVERFLOW ELEVATION.

TABLE VI-8

SYSTEM E-1
COMPARISON OF PLAYA LAKE WATER SURFACE ELEVATIONS
BASELINE CONDITIONS VS. PROPOSED OPENING OF PLAYA LAKE 37

PLAYA #	10 YEAR ELEVATION (FT.)			50 YEAR ELEVATION (FT.)			100 YEAR ELEVATION (FT.)			500 YEAR ELEVATION (FT.)		
	BASE. COND.	PROP. OPEN.	DIFF. (FT.)	BASE. COND.	PROP. OPEN.	DIFF. (FT.)	BASE. COND.	PROP. OPEN.	DIFF. (FT.)	BASE. COND.	PROP. OPEN.	DIFF. (FT.)
SYSTEM E-1:												
39	3268.8	3268.8	0.00	3269.0	3269.0	0.00	3269.0	3269.0	0.00	3269.1	3269.1	0.00
37	3265.5	3265.2	-0.30	3266.7	3265.9	-0.80	3267.4	3266.3	-1.10	3268.5	3267.1	-1.40
31	3254.6	3255.0	0.40	3255.0	3255.7	0.70	3255.4	3256.1	0.70	3256.0	3256.7	0.70
27	3238.1	3238.1	0.00	3239.0	3238.9	-0.10	3239.2	3239.2	0.00	3240.0	3240.0	0.00
26	3231.8	3232.5	0.70	3232.8	3233.5	0.70	3233.3	3234.0	0.70	3234.4	3235.2	0.80
25	3227.4	3227.9	0.50	3228.2	3228.8	0.60	3228.5	3229.0	0.50	3229.1	3229.3	0.20
24	3227.8	3227.9	0.10	3228.2	3228.5	0.30	3228.3	3228.7	0.40	3228.8	3229.1	0.30
23	3222.7	3222.9	0.20	3223.4	3224.4	1.00	3223.9	3225.0	1.10	3224.8	3225.9	1.10
19	3214.8	3215.1	0.30	3215.9	3217.2	1.30	3216.6	3218.0	1.40	3217.8	3219.1	1.30
20	3212.8	3213.1	0.30	3214.0	3214.6	0.60	3214.3	3215.1	0.80	3215.0	3216.1	1.10
21	3202.1	3202.2	0.10	3208.6	3208.8	0.20	3209.1	3209.8	0.70	3209.8	3211.2	1.40

NOTES:
1. 1988 HYDROLOGIC MODEL WAS RUN WITH 2" RUNOFF IN PLAYA LAKES 39,37, AND 25. ALL REMAINING PLAYA LAKES USED WATER SURFACE ELEVATION SHOWN ON CITY TOPOGRAPHIC MAPS FOR STARTING CONDITIONS.
2. "PROP. OPEN." CONDITIONS BASED ON REVISED RATING FOR PLAYA 37 , WITH A 110' WIDE OPENING CORRESPONDING TO PROPOSED STREET R.O.W. AT PRESENT OVERFLOW ELEVATION.

TABLE VI-9

SYSTEM E-1
COMPARISON OF DISCHARGES
ALTERNATIVE 7
BASELINE CONDITIONS VS. PROPOSED EXCAVATION OF PLAYA LAKE 37

PLAYA #	10 YEAR DISCHARGE (CFS)			50 YEAR DISCHARGE (CFS)			100 YEAR DISCHARGE (CFS)			500 YEAR DISCHARGE (CFS)		
	BASE. COND.	PROP. EXCAV.	% DIFF.	BASE. COND.	PROP. EXCAV.	% DIFF.	BASE. COND.	PROP. EXCAV.	% DIFF.	BASE. COND.	PROP. EXCAV.	% DIFF.
SYSTEM E-1:												
39	650	650	0	980	980	0	1050	1050	0	1350	1350	0
37	100	0	-100	170	0	-100	210	0	-100	400	0	-100
31	120	50	-58	280	290	4	540	540	0	980	980	0
27	450	430	-4	960	900	-6	1150	1150	0	1700	1700	0
26	150	130	-13	500	500	0	770	770	0	1350	1350	0
25	110	20	-82	390	320	-18	670	650	-3	1400	1400	0
24	60	0	-100	320	180	-44	540	440	-19	1250	1250	0
23	50	30	-40	250	140	-44	470	360	-23	960	920	-4
19	30	30	0	190	110	-42	400	300	-25	910	840	-8
20	40	30	-25	180	120	-33	390	300	-23	920	850	-8
21	0	0	0	60	0	-100	150	0	-100	470	250	-47

NOTES: 1. 1988 HYDROLOGIC MODEL WAS RUN WITH 2" RUNOFF IN PLAYA LAKES 39,37, AND 25. ALL REMAINING PLAYA LAKES USED WATER SURFACE ELEVATION SHOWN ON CITY TOPOGRAPHIC MAPS FOR STARTING CONDITIONS.
2. "PROP. EXCAV." CONDITIONS BASED ON REVISED RATING FOR PLAYA LAKE 37, NO OUTFLOW FROM PLAYA LAKE 37 UP TO 500 YEAR FLOOD, DUE TO EXCAVATION OF ADDITIONAL STORAGE.

JOIN SHEET 26

E642,000 E643,000 E644,000 E645,000 E646,000 E647,000

ATCHISON TOPEKA & SANTA FE RAILROAD

BROWNFIELD ROAD

U.S. HWY. 62 BROWNFIELD RD.

U.S. HWY 62 BROWNFIELD RD.

HOMESTEAD AVE

50TH ST

N

0 200 400 800

GRAPHIC SCALE

PLAYA LAKE 37

BILL McALISTER PARK

8:1

8:1

3240

3265

SLOPE = 8:1

3265

3240

CITY PROPERTY LIMITS

SPUR 327

SPUR 327

SOUTH LUBBOCK DRAINAGE STUDY

ALTERNATIVE 7

EXCAVATION PLAN FOR PLAYA LAKE 37

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS • SCIENTISTS • SURVEYORS
FORT WORTH • DALLAS • CHICAGO

DESIGN	DRAWN	DATE	SCALE	NOTES	FIGURE NO.
BAF		1988			FIGURE VI-4

TABLE VI-10

SYSTEM E-1
COMPARISON OF PLAYA LAKE WATER SURFACE ELEVATIONS
ALTERNATIVE 7
BASELINE CONDITIONS VS. PROPOSED EXCAVATION OF PLAYA LAKE 37

	10 YEAR ELEVATION (FT.)			50 YEAR ELEVATION (FT.)			100 YEAR ELEVATION (FT.)			500 YEAR ELEVATION (FT.)		
PLAYA #:	BASE. COND.	PROP. EXCAV.	DIFF. (FT.)	BASE. COND.	PROP. EXCAV.	DIFF. (FT.)	BASE. COND.	PROP. EXCAV.	DIFF. (FT.)	BASE. COND.	PROP. EXCAV.	DIFF. (FT.)
SYSTEM E-1:												
39	3268.8	3268.8	0.00	3269.0	3269.0	0.00	3269.0	3269.0	0.00	3269.1	3269.1	0.00
37	3265.5	3251.8	-13.7	3266.7	3255.3	-11.4	3267.4	3257.3	-10.1	3268.5	3261.5	-7.00
31	3254.6	3254.3	-0.30	3255.0	3255.0	0.00	3255.4	3255.4	0.00	3256.0	3256.0	0.00
27	3238.1	3238.1	0.00	3239.0	3238.9	-0.10	3239.2	3239.2	0.00	3240.0	3240.0	0.00
26	3231.8	3231.7	-0.10	3232.8	3232.8	0.00	3233.3	3233.3	0.00	3234.4	3234.4	0.00
25	3227.4	3227.1	-0.30	3228.2	3228.1	-0.10	3228.5	3228.5	0.00	3229.1	3229.1	0.00
24	3227.8	3222.0	-5.80	3228.2	3228.1	-0.10	3228.3	3228.2	-0.10	3228.8	3228.8	0.00
23	3222.7	3222.5	-0.20	3223.4	3223.1	-0.30	3223.9	3223.7	-0.20	3224.8	3224.7	-0.10
19	3214.8	3214.8	0.00	3215.9	3215.4	-0.50	3216.6	3216.3	-0.30	3217.8	3217.6	-0.20
20	3212.8	3212.7	-0.10	3214.0	3213.8	-0.20	3214.3	3214.1	-0.20	3215.0	3214.9	-0.10
21	3202.1	3199.8	-2.30	3208.6	3204.9	-3.70	3209.1	3207.3	-1.80	3209.8	3209.3	-0.50

NOTES:
1. 1988 HYDROLOGIC MODEL WAS RUN WITH 2" RUNOFF IN PLAYA LAKES 39,37, AND 25. ALL REMAINING PLAYA LAKES USED WATER SURFACE ELEVATION SHOWN ON CITY TOPOGRAPHIC MAPS FOR STARTING CONDITIONS.
2. "PROP. EXCAV." CONDITIONS BASED ON REVISED RATING FOR PLAYA LAKE 37, NO OUTFLOW FROM PLAYA LAKE 37 UP TO 500 YEAR FLOOD, DUE TO EXCAVATION OF ADDITIONAL STORAGE.

Lake 37 would decrease downstream 100-year outflow discharges an average of 29%, and lower 100-year water surface elevations an average of 0.3-feet.

The analysis of the excavation plan assumes that in the future the playa lake would have a normal pool elevation corresponding to 2-inches of runoff for a future-fully urbanized watershed, as was assumed in baseline conditions. After a flood event, the playa lake would drain back to normal pool via the same groundwater recharge and evaporation mechanisms affecting the other playa lakes.

The benefits of the excavation plan (Alternative 7) would be $284,800 in reduced damages downstream of Playa Lake 37. The estimated construction costs would be $7.26 million. Annual operation and maintenance costs would be $11,000. Over a fifty (50) year project life, average annual costs would be $636,400, yielding a benefit-to-cost ratio of 0.44 to 1.0.

8. **Alternatives 8, 9a, and 9b** - Lower Normal Pool of Playa Lakes for Additional Storage

The creation of additional storage capacity for the playa lakes in System E-1 would lower their normal pool elevations and increase the flood volumes retained by the playa lakes. The additional storage capacity would reduce playa lake flooding and overflow flooding between playa lakes.

An analysis was prepared to evaluate the effects that increased storage capacity would have on System E-1 flooding. The additional storage for each playa lake would be obtained by lowering the playa lake's normal pool elevation. City topographic maps were used to take cross-sections across each playa lake in System E-1, and the bank slopes were extrapolated below the lake water surface elevation to estimate playa lake depths. The majority of the playa lakes were assumed to be 10-feet deep, with

no playa lake estimated deeper than 11-feet. The available storage below the playa lakes' normal water surface was calculated and added in the System E-1 hydrologic model to each playa lake's baseline conditions elevation-storage-discharge curve.

The hydrologic model was then executed for three scenarios:

1) 100% Drawdown: The entire estimated depth (maximum 11.0-feet) below the playa lakes water surface elevations could be used for additional storage.

2) 50% Drawdown: Only half of the estimated depth could be used.

3) 25% Drawdown: Only one quarter of the estimated depth could be used.

The corresponding water surface elevations and overflow discharges for the three scenarios were used to compute average annual damages for each scenario. Figure VI-5 graphically shows the reduction in average annual damages corresponding to the three levels of drawdown. The graph shows significant reduction in damages if the 100% drawdown scenario could be realized. The reduction in damages shown if Figure VI-5 is contingent upon the actual storage available below the playa lakes current normal pool elevation and the technical feasibility of lowering the normal pool levels.

The proposed drawdowns could be accomplished by two different methods:

1) Pumping from the groundwater table along Loop 289 to lower groundwater elevations and increase recharge rates for the nearby playa lakes (See Alternative 8).

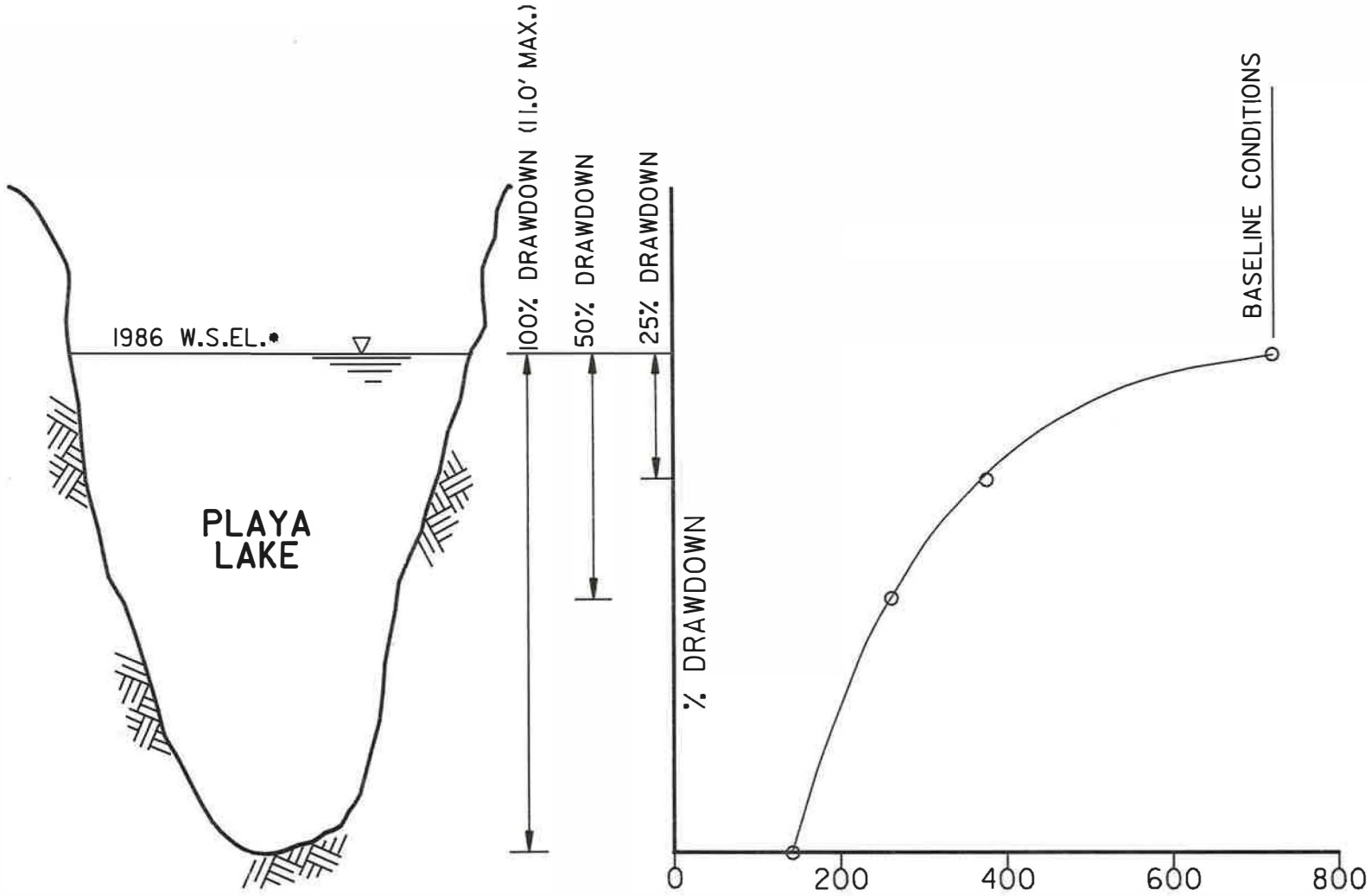
2) Construct a gravity outfall/lift station combination that would help drain the lakes over an extended period of time (See Alternative 9a and 9b).

a. **Alternative 8 -** Groundwater Pumping

Pumping from the groundwater table along Loop 289 would help reverse the trend of rising groundwater elevations in the study area. The stabilization and eventual lowering of the groundwater table due to pumping would increase the recharge rates of nearby playa lakes, lower playa lake normal pool elevations and create additional storage capacity. The process of lowering groundwater elevations by pumping in the study area would be a long one, taking at least one year to reach equilibrium and produce any noticeable changes in playa lake water surface elevations. After a flood event, the playa lakes would drain via enhanced groundwater recharge and evaporation.

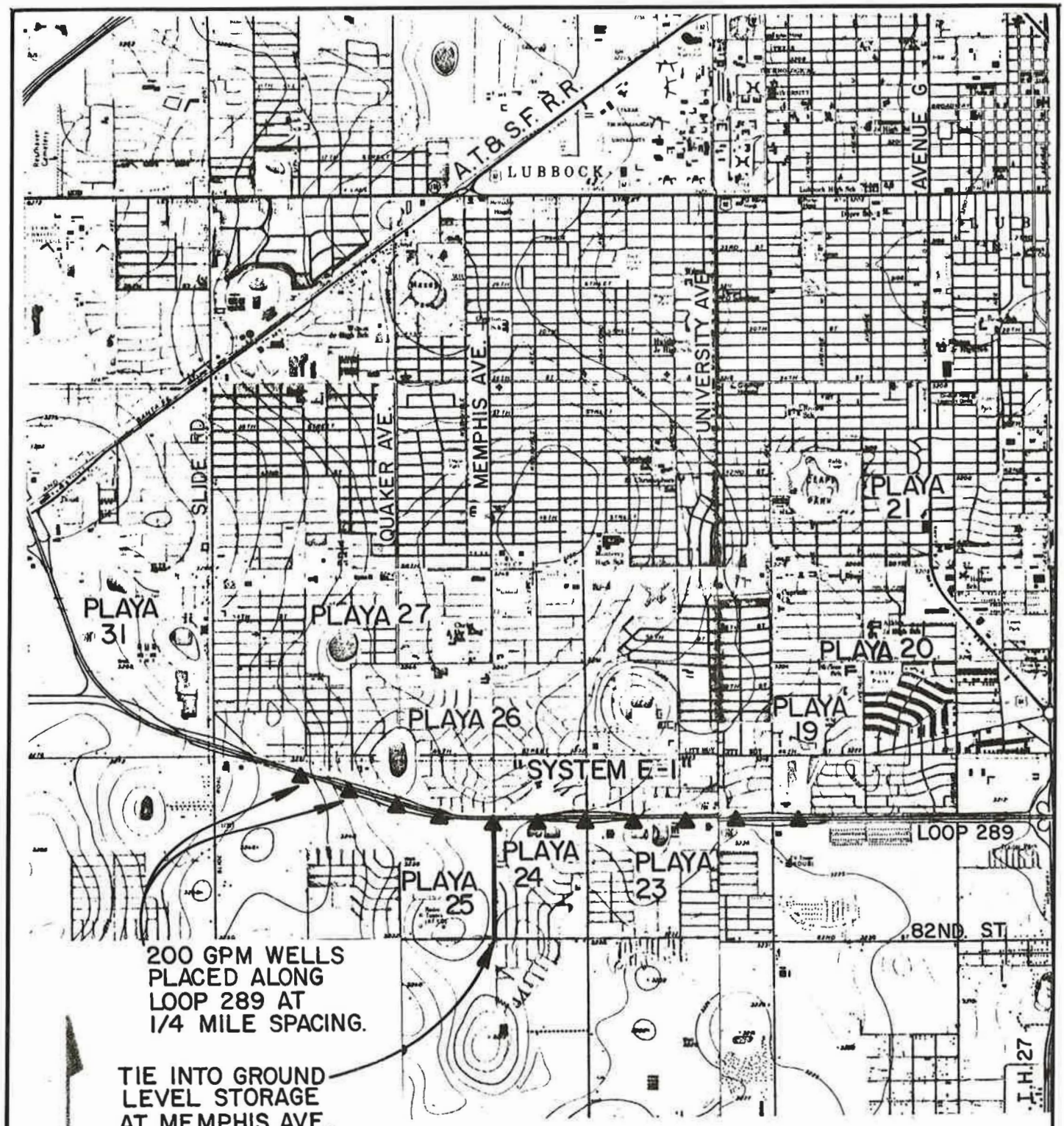
One proposed pumping configuration would consist of eleven 200 gallon per minute (gpm) wells as shown in Figure VI-6. The wells would be spaced at one-quarter mile intervals, and well depths would reach down to the bottom of the aquifer. The water pumped from the wells would be piped to the City's ground level storage tank at Memphis and 82nd Street. Previous preliminary investigations (Reference 11) of the groundwater quality in the southern portion of the City have indicated that the groundwater, with some chlorination, could potentially be used as a potable water supply. The investigations were based on preliminary testing of the groundwater, and the full range of quality tests were not performed.

The pumping system shown in Figure VI-6 would have an estimated construction cost of $507,600, with annual operation and maintenance costs of $42,100. The benefits



* 1986 W.S.EL. BASED ON WATER SURFACE ELEVATIONS SHOWN ON THE 1986 CITY TOPOGRAPHIC MAPS USED FOR THIS STUDY.

FIGURE VI-5
EFFECTS OF PLAYA LAKE DRAWDOWN ON AVERAGE ANNUAL DAMAGES
SYSTEM E - 1



SOUTH LUBBOCK DRAINAGE STUDY
PROPOSED IMPROVEMENTS
ALTERNATIVE 8
PUMP GROUNDWATER ALTERNATIVE
CITY OF LUBBOCK, TEXAS

Albert H. Halff Assoc., Inc.

DATE 1988	AVO 9102
SCALE	SHEET FIG. VI-6

from this alternative would be in the form of additional water supplies for the City and in flood control from the increased storage of the playa lakes. The flood control benefits from the pumping system would be dependent on the ultimate drawdowns achieved at each individual playa lake. Average annual costs would be $86,600. If 25% of the possible drawdown were achieved in all of the playa lakes of System E-1, The average annual benefits would be $347,170, and this alternative would have a benefit-to-cost ratio of 4.0 to 1.0.

b. **Alternative 9a** - Pump/Gravity Outfall Combination with Total of 14 Day Drawdown.

An alternative to the pumping system would be a pump/gravity outfall combination that would drain most of the lakes after a flood event and carry the lake volumes down Loop 289 to Yellowhouse Canyon. A possible pump/gravity outfall system is shown in Figure VI-7.

The pump/gravity outfall system would consist of a main gravity outfall trunk line extending from just west of Frankford Road along Spur 327 east along to Loop 289 and Southeast Drive. The trunk line would be a 60-inch diameter reinforced concrete pipe. Each playa lake in System E-1, excluding Playa 21 (Clapp Park), would have a pump station and pressure line tying into the gravity outfall. For Clapp Park, the existing pumps would be used to achieve the drawdown in Playa Lake 21.

The pump/gravity outfall system design assumes, as a worst case, that all the playa lakes in System E-1 would be full up to their outflow elevation. The pumping would be done in two stages. The first stage, consisting of the pumps at Playa Lakes 31, 27, 26, 25, 24, 23, 19, 20, and 21, and the second stage consisting of the pumps at Playa Lake 37. The majority

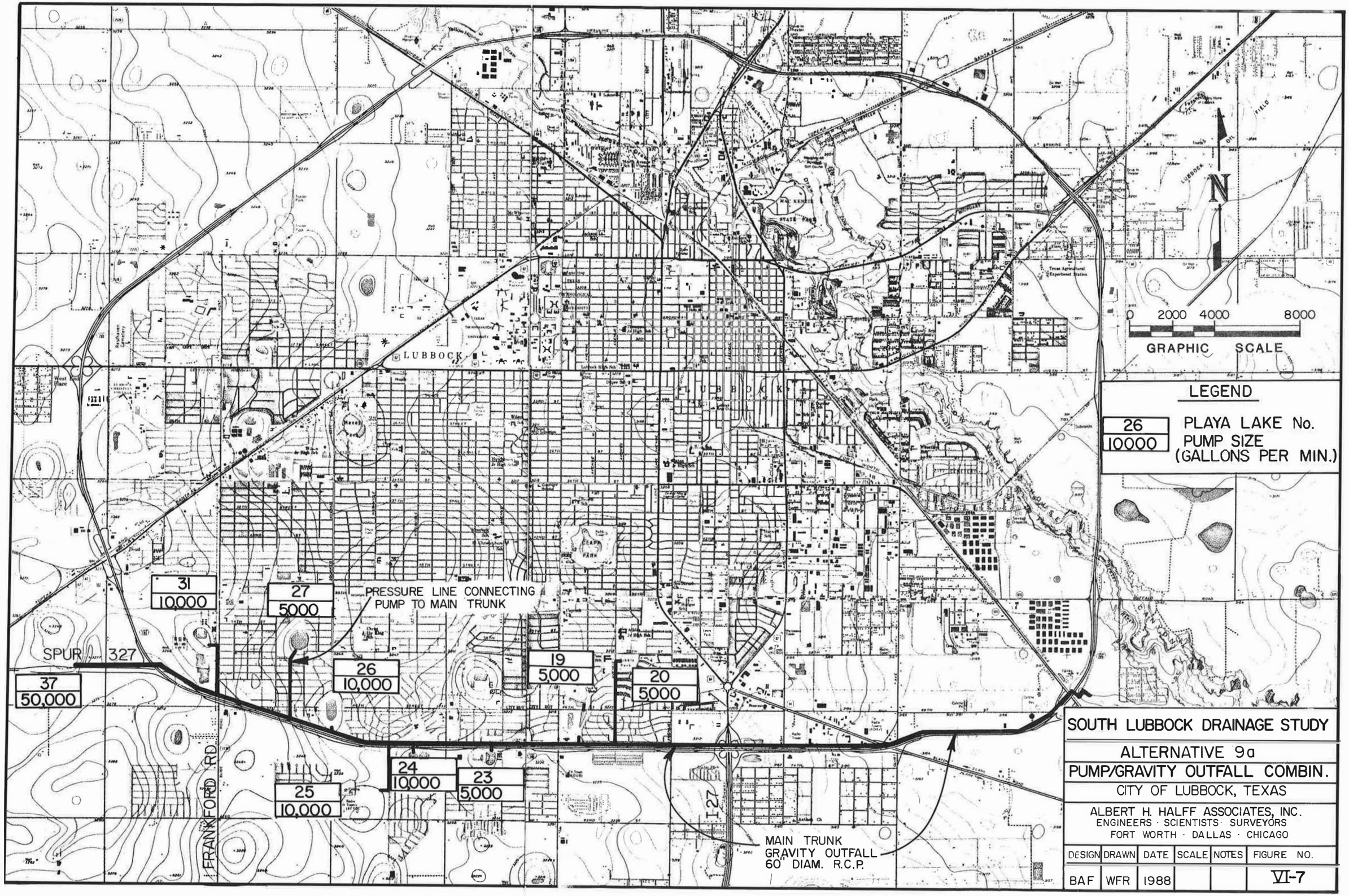
of the playa lakes would be drained in 7 days, and both pumping stages would be completed in 14 days or less.

The pump/gravity outfall system shown in Figure VI-7 would have an estimated construction cost of $11.30 million. Over a fifty (50) year project life, average annual costs would be $990,500, excluding power and maintenance costs to operate the pump system. The benefits from the system would be $581,760 in the form of reduced average annual damages. The benefit-to-cost ratio would be 0.59 to 1.0.

c. **Alternative 9b -** Pump/Gravity Outfall Conbination with Total of 28 Day Drawdown

The pump/gravity outfall design is dependent upon the time frame specified for draining down the playa lakes: the longer the time frame allowed, the smaller the pumps and trunk line. For example, Alternative 9b would extend the average time period for draining a playa lake from 7 days to 14 days, the trunk line size would be reduced from a 60-inch diameter to a 48-inch diameter concrete pipe. The required pump sizes shown in Figure VI-7 would be reduced by an average of 50%. The pumping would still be done in two stages, with the majority of the playa lakes being drained in 14 days, and both stages being completed in 28 days.

For the 14 day drain time period (Alternative 9b), the pump/gravity outfall system would have an estimated construction cost of $8.58 million. Over a fifty (50) year project life, average annual costs would be $751,690, not including annual power and maintenance costs of the pumps. The benefits from the system would be $581,760 in the form of reduced average annual damages. The benefit-to-cost ratio would be 0.77 to 1.0.



SOUTH LUBBOCK DRAINAGE STUDY

ALTERNATIVE 9a

PUMP/GRAVITY OUTFALL COMBIN.

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS · SCIENTISTS · SURVEYORS
FORT WORTH · DALLAS · CHICAGO

DESIGN	DRAWN	DATE	SCALE	NOTES	FIGURE NO.
BAF	WFR	1988			VI-7

An estimated $2.51 million could be saved by extending the drain time period for a playa lake from 7 to 14 days, i.e. by implementation of Alternative 9b. However, it is unlikely that a further extension of the drain time would produce significant reductions in construction costs, because the pumping rates necessary to reduce the size of the gravity outfall trunkline would more than double the 14 day drain time period.

B. NON-MONETARY OR INTANGIBLE BENEFITS

Each plan proposed in this Chapter would, if implemented, have either immediate or future effects on the citizens and environment of the South Lubbock Playa Lake systems. An attempt has been made to evaluate each plan to determine its intangible (non-monetary) value.

A matrix has been devised to rate the proposed plans, in terms of four difficult-to-quantify categories of environmental and intangible factors that have been assessed for each alternative:

1. Degree of Safety from Flooding,

2. Environmental Quality,

3. Neighborhood Enhancement, and

4. Aesthetics.

The first category, Degree of Safety from Flooding, encompasses each plan's effectiveness in preventing loss of life and minimizing property damage. Some factors considered for this category are: (1) Reduction in the number of buildings that will be damaged by floods; (2) Development of land uses that are compatible with flooding; (3) Reclamation of land from the flood plain; and (4) Reduction of flood hazards along the roads affected by the playa drainage system.

The second category, Environmental Quality, includes each plan's physical and chemical effects on the land and water, on the biota or the natural habitats, and the diversity of life forms. Factors that have been evaluated under this category include: (1) Increases in the populations of flora; (2) Increases in the populations of fauna; and (3) Increases in the extent of the natural habitat.

The third category, Neighborhood Enhancement, focuses on the improvement of neighborhood livability and the well-being of local residents. Factors that have been considered under this category are: (1) Improvement of neighborhood and community pride; (2) Provision of individual and family peace of mind through reduction of the threat of flooding; and (3) Provision of new or improved recreational opportunities.

The fourth category, Aesthetics, measures each plan's effect on the appearance of the water, land, biota, and neighborhood. Five factors are included in this category: (1) Reduction in water turbidity and algal growth; (2) Preservation of open space areas; (3) Preservation of natural playas; (4) Preservation of biota; and (5) Beautification of neighborhood due to added open space.

The matrix shown in Table VI-11 offers a convenient means of calculating the relative merits of alternative plans. Each of the four categories of intangible factors is given a weighing factor (WF) commensurate with its importance. Each plan is then given a quality rating (R), ranging from -5 to +5, for each category, depending on the value of its anticipated effects. A rating of +5 indicates the most favorable effect, while -5 indicates the most unfavorable effect. A rating of zero indicates that the plan has either no effect in relationship to the specific category or that its benefits and drawbacks offset each other. Multiplication of the weighting factor times the rating yields a rating factor (RF) for each plan's relative value in terms of each weighted category. Each plan's total intangible value rating is calculated by adding its four rating factors.

TABLE VI-II
ENVIRONMENTAL AND INTANGIBLE VALUE ANALYSIS
OF THE PLANS FOR THE SOUTH LUBBOCK DRAINAGE STUDY

ALTERNATIVE / CATAGORY	WF*	① DIVERT PLAYA 23 TO YELLOWHOUSE CANYON 100 YEAR FLOOD	R*/ RF*	② DIVERT PLAYA 23 TO YELLOWHOUSE CANYON 10 YEAR FLOOD	R*/ RF*	③ DIVERT PLAYA 21 TO YELLOWHOUSE CANYON 100 YEAR FLOOD	R*/ RF*	④ DIVERT PLAYA 21 TO YELLOWHOUSE CANYON 10 YEAR FLOOD	R*/ RF*	⑤ PLAYA LAKES 31,27,26,25,& 24. 10 YEAR STORM SEWER	R*/ RF*
DEGREE OF SAFETY FROM FLOOD A. BUILDING B. ROADS & THOUROUGHFARES	0.35	o REMOVES 537 STRUCTURES FROM THE 100 YEAR FLOOD BETWEEN PLAYA 23 AND PLAYA 21.	2.5/ 0.88	o REMOVES 335 STRUCTURES FROM THE 100 YEAR FLOOD BETWEEN PLAYA 23 AND PLAYA 21.	2.2/ 0.77	o REMOVES 478 STRUCTURES FROM THE 100 YEAR FLOOD PLAIN. o REMOVES ROADS FROM THE 100 YEAR FLOOD PLAIN AT PLAYA 21 AND DOWNSTREAM.	4.0/ 1.40	o REMOVES 171 STRUCTURES FROM THE 10 YEAR FLOOD PLAIN AT PLAYA 21. o REMOVES ROADS AROUND PLAYA 21 FROM 10 YEAR FLOOD.	3.0/ 1.05	o REMOVES ALL BUILDINGS FROM THE 10 YEAR FLOOD PLAIN BETWEEN PLAYAS 31 AND 24. o REMOVES ALL ROADS FROM THE 10 YEAR FLOOD PLAIN BETWEEN PLAYAS 31 AND 24.	3.2/ 1.12
ENVIRONMENTAL QUALITY A. WATER B. LAND C. FLORA D. FAUNA E. NATURAL HABITAT	0.25	o POSSIBLE POINT SOURCE POLLUTION PROBLEM AT YELLOWHOUSE CANYON. o POSSIBLE DESTRUCTION OF HABITAT DUE TO LOWER NORMAL POOL ELEVATION FOR PLAYA 23. o POSSIBLE LOSS OF FLORA AND FAUNA.	-1.7/ -0.43	o POSSIBLE POINT SOURCE POLLUTION PROBLEM AT YELLOWHOUSE CANYON. o POSSIBLE DESTRUCTION OF HABITAT DUE TO LOWER NORMAL POOL ELEVATION FOR PLAYA 23. o POSSIBLE LOSS OF FLORA AND FAUNA.	-1.0/ -0.25	o POSSIBLE POINT SOURCE POLLUTION PROBLEM AT YELLOWHOUSE CANYON. o POSSIBLE DESTRUCTION OF HABITAT DUE TO LOWER NORMAL POOL ELEVATION FOR PLAYA 23. o POSSIBLE LOSS OF FLORA AND FAUNA.	-0.8/ -0.2	o POSSIBLE POINT SOURCE POLLUTION PROBLEM AT YELLOWHOUSE CANYON. o POSSIBLE DESTRUCTION OF HABITAT DUE TO LOWER NORMAL POOL ELEVATION FOR PLAYA 23. o POSSIBLE LOSS OF FLORA AND FAUNA.	-1.2/ -0.3	o SIGNIFICANT DESTRUCTION OF HABITAT FROM EXCAVATION OF PLAYA 24. o POSSIBLE DESTRUCTION OF HABITAT DUE TO LOWER NORMAL POOL ELEVATIONS FOR PLAYA LAKES. o LOSS OF FLORA AND FAUNA.	-1.5/ -0.38
NEIGHBORHOOD ENHANCEMENT A. COMMUNITY PRIDE B. INDIVIDUAL PEACE OF MIND C. RECREATION D. RELOCATIONS	0.25	o ELIMINATES THREAT OF FLOODING FOR SOME BUILDINGS. o NO ADDED RECREATIONAL AREAS. o LOSS OF LAKE AREA FOR RECREATION. o NO BUILDING RELOCATIONS REQUIRED.	0.3/ 0.08	o ELIMINATES THREAT OF FLOODING FOR SOME BUILDINGS. o NO ADDED RECREATIONAL AREAS. o LOSS OF LAKE AREA FOR RECREATION. o NO BUILDING RELOCATIONS REQUIRED.	0.2/ 0.05	o ELIMINATES THREAT OF FLOODING OF BUILDINGS AROUND PLAYA 21. o SECURITY-LAKE WON'T RISE AS BEFORE. o NO ADDITIONAL RECREATIONAL AREAS. o NO BUILDING RELOCATIONS REQUIRED.	2.5/ 0.63	o ELIMINATES THREAT OF FLOODING OF BUILDINGS AROUND PLAYA 21. o SECURITY-LAKE WON'T RISE AS BEFORE. o NO ADDITIONAL RECREATIONAL AREAS. o NO BUILDING RELOCATIONS REQUIRED.	2.4/ 0.60	o ELIMINATES THREAT OF 10 YEAR FLOOD. o DESTRUCTION OF PLAYA LAKE 24 AS A RECREATIONAL AREA. o NO BUILDING RELOCATIONS REQUIRED.	-0.7/ -0.18
AESTHETICS A. WATER B. LAND C. BIOTA D. NEIGHBORHOOD	0.15	o ENHANCES NEIGHBORHOOD AESTHETICS. o MAY DEGRADE AESTHETICS AROUND EXISTING LAKE. LOSS OF "LAKESIDE" HOUSES.	-1.3/ -0.20	o ENHANCES NEIGHBORHOOD AESTHETICS. o MAY DEGRADE AESTHETICS AROUND EXISTING LAKE. LOSS OF "LAKESIDE" HOUSES.	-1.2/ -0.18	o ENHANCES NEIGHBORHOOD AESTHETICS	0.2/ 0.03	o ENHANCES NEIGHBORHOOD AESTHETICS	0.6/ 0.09	o ENHANCES NEIGHBORHOOD AESTHETICS FOR PLAYA LAKES 31,27,26,& 25. o REDUCES AESTHETICS FOR PLAYA LAKE 24.	-0.2/ -0.03
INTANGIBLE VALUE RATING			0.33		0.39		1.86		1.44		0.53

* WF - WEIGHING FACTOR INDICATES THE RELATIVE IMPORTANCE OF THE CATEGORIES OF ENVIRONMENTAL AND INTANGIBLE FACTORS.

R - RATING INDICATES EACH PLANS' EFFECT.
RF - RATING FACTOR IS THE PRODUCT OF THE WEIGHING FACTOR AND THE RATING.

TABLE VI-II (CONT.)
ENVIRONMENTAL AND INTANGIBLE VALUE ANALYSIS
OF THE PLANS FOR THE SOUTH LUBBOCK DRAINAGE STUDY

ALTERNATIVE / CATAGORY	WF*	⑥ PLAYA LAKES 19,20 & 21 10 YEAR STORM SEWER	R*/ RF*	⑦ EXCAVATION OF PLAYA LAKE 37	R*/ RF*	⑧ PUMP GROUNDWATER FOR ADDITIONAL STORAGE	R*/ RF*	⑨ PUMP/GRAVITY OUTFALL	R*/ RF*	⑩ NO ACTION	R*/ RF*
DEGREE OF SAFETY FROM FLOOD A. BUILDING B. ROADS & THOUROUGHFARES	0.35	o REMOVES ALL BUILDINGS FROM THE 10 YEAR FLOOD PLAIN BETWEEN PLAYAS 19 AND 21. o REMOVES ALL ROADS FROM THE 10 YEAR FLOOD PLAIN BETWEEN PLAYAS 19 AND 21.	2.8/ 0.98	o REMOVES ALL FUTURE ADJACENT DEVELOPMENT FROM 100 YEAR FLOOD PLAIN. o REMOVES ADJACENT ROADS FROM 100 YR. FLOOD PLAIN. o NO CONTRIBUTION FROM PLAYA 37 TO DOWNSTREAM 100 YEAR FLOOD.	3.5/ 1.23	o REDUCED FLOODING OF BUILDINGS AND ROADS IN THE STUDY AREA. o LONG TIME PERIODS BETWEEN FLOOD EVENT AND PLAYA LAKE DRAWDOWN. o UNPREDICTABLE AMOUNT OF AVAILABLE STORAGE IN PLAYA LAKES.	1.8/ 0.63	o REDUCED FLOODING OF BUILDINGS AND ROADS IN THE STUDY AREA.	3.0/ 1.05	o LEAVES EXISTING STRUCTURES IN 100 YEAR FLOOD PLAIN. o LEAVES NUMEROUS ROADS IN 100 YEAR FLOOD PLAIN.	-3.3/ -1.16
ENVIRONMENTAL QUALITY A. WATER B. LAND C. FLORA D. FAUNA E. NATURAL HABITAT	0.25	o SIGNIFICANT DESTRUCTION OF HABITAT FROM EXCAVATION OF PLAYA LAKES 19,20 & 21. o LOSS OF FLORA AND FAUNA.	-1.5/ -0.38	o SIGNIFICANT DESTRUCTION OF HABITAT DUE TO EXCAVATION. o LOSS OF FLORA AND FAUNA.	-2.0/ -0.90	o CHANGES IN HABITAT, FLORA, AND FAUNA DUE TO LOWER GROUNDWATER TABLE AND NORMAL POOL ELEVATIONS.	-0.5/ -0.13	o CHANGES IN HABITAT, FLORA, AND FAUNA DUE TO LOWER NORMAL POOL ELEVATIONS.	-0.7/ -0.18	o IN UNDEVELOPED AREAS, MAY ALLOW REDUCTION IN HABITAT AND POPULATION OF FLORA AND FAUNA. o MAY REDUCE SPECIES DIVERSITY.	-0.5/ -0.13
NEIGHBORHOOD ENHANCEMENT A. COMMUNITY PRIDE B. INDIVIDUAL PEACE OF MIND C. RECREATION D. RELOCATIONS	0.25	o ELIMINATES THREAT OF 10 YEAR FLOOD. o DESTRUCTION OF PLAYA LAKE 20 AS A RECREATIONAL AREA. o NO BUILDING RELOCATIONS REQUIRED.	-1.2/ -0.30	o ELIMINATES THREAT OF FLOODING. o EXCAVATION USES MOST OF RECREATIONAL AREA. o NO BUILDING RELOCATIONS REQUIRED.	-0.7/ -0.18	o ENHANCED COMMUNITY PRIDE FROM REDUCED FLOODING, AND REDUCED THREAT OF RISING GROUNDWATER. o NO RELOCATIONS REQUIRED.	2.2/ 0.55	o ENHANCED COMMUNITY PRIDE FROM REDUCED FLOODING. o REDUCED THREAT OF RISING GROUNDWATER o NO RELOCATIONS REQUIRED.	2.2/ 0.55	o CONTINUING THREAT OF FLOODING. o NO ADDED RECREATIONAL AREAS. o NO BUILDING RELOCATIONS REQUIRED. o NEGATIVE PUBLIC NOTION THAT NOTHING IS BEING DONE.	-3.3/ -0.83
AESTHETICS A. WATER B. LAND C. BIOTA D. NEIGHBORHOOD	0.15	o ENHANCES NEIGHBORHOOD AESTHETICS FOR PLAYA LAKE 19. o REDUCES AESTHETICS FOR PLAYA LAKES 20 & 21. o INCREASED LAKE SURFACE AREA MAY ENHANCE AESTHETICS.	-1.0/ -0.15	o REDUCES AESTHETICS OF ADJACENT AREA.	-1.3/ -0.20	o ENHANCED WATER SUPPLY. o ENHANCES NEIGHBORHOOD AESTHETICS. o ENHANCEMENT OF RECREATIONAL AREAS.	2.0/ 0.30	o ENHANCES NEIGHBORHOOD AESTHETICS. o ENHANCEMENT OF RECREATIONAL AREAS.	1.3/ 0.20	o ALLOWS CONTINUED DEGRADATION OF NEIGHBORHOOD FACILITIES DUE TO FLOODING.	-1.3/ -0.20
INTANGIBLE VALUE RATING			0.15		0.35		1.35		1.62		-2.32

* WF - WEIGHING FACTOR INDICATES THE RELATIVE IMPORTANCE OF THE CATEGORIES OF ENVIRONMENTAL AND INTANGIBLE FACTORS.

R - RATING INDICATES EACH PLANS' EFFECT.
RF - RATING FACTOR IS THE PRODUCT OF THE WEIGHING FACTOR AND THE RATING.

For example, a plan with a quality rating of +3 for a category that is considered important, and therefore, assigned with a weighing factor of 0.4, will receive a rating factor of +1.2 for that category. This rating factor reflects both the relative importance of the category to the basin and the specific plan's relative merit under this category.

The evaluation of intangible or non-monetary effects is highly subjective. The values assigned to the weighing factors and to each alternative's quality ratings depend largely upon the individual's viewpoint. The weighing factors used in Table VI-11 represents a consensus of the opinions of six study team members who are most familiar with the South Lubbock Drainage Study Area.

The sum of each alternative's rating factors, that is, its overall environmental and intangible value rating, may be used to compare the alternatives with each other.

C. SUMMARY OF ALTERNATIVES

All but two of the major alternatives evaluated in this chapter have benefit-cost ratios that are less than 1.0, which is the usual dividing point between economically feasible and infeasible projects. Therefore, only two of these proposed alternatives can be justified solely by the tangible value analysis. Several plans provide significant nonquantifiable benefits to residents of the area and to the environment. These intangible benefits are of enough importance to the City of Lubbock and its residents that a positive plan of action can be recommended. These and other relevant factors are summarized in Table VI-12.

The recommendations that follow in Chapter VII have been formulated after careful consideration of the environmental and intangible-value ratings, as well as scrutiny of the quantifiable costs and benefits of the alternatives.

TABLE VI-12

SUMMARY OF ALTERNATIVES

No.	Alternative Description	Average Annual Damages Prevented (Benefits)	Estimated Construction Cost [1]	Benefit to Cost Ratio	Technical Reliability of Alternative to Reduce Flooding	Intangible Value Rating (-5 to +5)[2]	Playa Areas to be Benefitted [3]
1	Divert 100-Year Flood from Playa Lake 23 to Yellowhouse Canyon	$461,320	$12,206,700	0.43:1	High	0.33	23,19,20,21
2	Divert 10-Year Flood from Playa Lake 23 to Yellowhouse Canyon	$361,240	$ 5,910,500	0.70:1	Medium	0.39	23,19,20,21
3	Divert 100-Year Flood from Playa Lake 21 to Yellowhouse Canyon	$482,160	$ 6,666,500	0.83:1	High	1.86	21
4	Divert 10-Year Flood from Playa Lake 21 to Yellowhouse Canyon	$360,410	$ 2,603,500	1.58:1	Medium	1.44	21
5	10-Year Design Storm Sewer System Connecting Playa Lakes 31, 27, 26, 25, 24	$ 71,520	$ 3,486,900	0.23:1	Medium	0.53	31,27,26,25,24
6	10-Year Design Storm Sewer System Connecting Playa Lakes 19, 20, 21	$232,800	$ 3,620,000	0.73:1	Medium	0.15	19,20,21
7	Excavation of Playa Lake 37	$284,800	$ 7,260,000	0.44:1	Medium	0.35	37
8	Lower System E-1 Playa Lakes Normal Pool Elevations by Pumping Groundwater Table	$347,170	$ 507,600	4.00:1	Low	1.35	31,27,26,25,24, 23,19
9a	Lower System E-1 Playa Lakes Normal Pool Elevations by Pump/ Gravity Outfall System (7-day average drain time)	$581,760	$11,300,500	0.59:1	Low	1.62	All E-1 except 39
9b	Lower System E-1 Playa Lakes Normal Pool Elevations by Pump/ Gravity Outfall System (14-day average drain time)	$581,760	$ 8,580,000	0.77:1	Low	1.62	All E-1 except 39

[1] See Appendix B - Cost Estimates
[2] See Table VI-11 for Rating Details
[3] See Figure I-1

VII. RECOMMENDATIONS

VII. RECOMMENDATIONS

The recommendations to reduce flooding potential in the study area have been selected based on Chapter V, Plan Formulation, and Chapter VI, Evaluation of Proposed Alternatives. Halff Associates recommends that the City of Lubbock consider the following alternatives for implementation:

A. ALTERNATIVE 8 - Pump Groundwater along Loop 289 for Additional Playa Lake Storage.

Alternative 8 is the construction of a system that would pump ground water from eleven proposed wells along Loop 289, to the city ground level storage tank at Memphis Avenue and 82nd Street. The pumping of the eleven wells would create groundwater drawdowns that would eventually result in lower normal pool elevations for the System E-1 playa lakes located along Loop 289. It is estimated that it would take approximately one year for the effects of the groundwater pumping to impact the playa lake normal pool elevations. (See Chapter VI for a more detailed description).

This alternative will require testing of the groundwater quality to determine if the water can be pumped into the City water supply with minimal treatment. The estimated construction cost of the eleven wells system is $507,600. Annual operation and maintenance costs are estimated at $42,100. The benefit-to-cost ratio could reach 4.0 to 1.0, depending upon the actual drawdowns achieved. Note that this B/C ratio does not include the significant benefit of water being provided to the City's system. The intangible value rating for Alternative 8 is 1.35 on a scale of -5 to +5. Possible negative impacts would be reduced water-related recreation activities.

B. ALTERNATIVE 4 - Divert 10-Year Flood from Playa Lake 21 to Yellowhouse Canyon

Alternative 4 is the construction of a 36" diameter reinforced concrete pipe gravity outfall that would divert the 10-year design flood from Playa Lake 21 to Yellowhouse Canyon. The gravity outfall system would remove all structures and roads surrounding Playa Lake 21 (Clapp Park) from the 10-year flood, and would lower flood elevations for higher frequency floods. (See Chapter VI for a more detailed description). The estimated construction cost of the 36" gravity outfall is $2,603,500. The benefit-to-cost ratio is 1.58 to 1.0. The intangible value rating for Alternative 4 is 1.44 on a scale of -5 to +5.

C. ALTERNATIVE 7 - Flood Control Plan For Playa Lake 37

The City should not allow a proposed thoroughfare to intersect Loop 289, with a larger opening at the overflow point for Playa Lake 37. Construction of the thoroughfare opening along that alignment would alter the overflow configuration for Playa Lake 37, increasing discharges and flood elevations downstream. (See Chapter VI for a more detailed description of impacts and possible improvements).

Should the position of not allowing the thoroughfare alignment to cross Playa Lake 37's overflow point become an untenable one, additional compensatory storage should be required within Playa Lake 37. The estimated construction cost for excavating Playa Lake 37 to contain the future, fully-urbanized 100-year flood is $7,260,000. This cost is based on the excavation of approximately 4.1 million cubic yards of material with a unit price of $1.50 per cubic yard. The benefits of the excavation plan are $284,800 in the form of reduced damages downstream from Playa Lake 37. The benefit-to-cost ratio is 0.44 to 1.0, and the intangible value rating is 0.35 on a scale of -5 to +5.

The City could phase the excavation of Playa Lake 37 material, based on watershed urbanization. Under the first phase, the City would need to excavate approximately 2.56 million cubic yards of material in order to contain the 100-year flood, assuming that the Playa Lake 39 and 37 watersheds at 50% urbanized. As the Playa Lake 39 and 37 watersheds approach 100% urbanization, the City could complete a final phase, excavating approximately 1.55 million cubic yards to complete the excavation plan.

The City could designate Playa Lake 37 as a borrow site, allowing excavation of fill material in selected areas. By designating Playa Lake 37 as a borrow site, the City could achieve an ultimate excavation plan, such as the example shown in Figure VI-4, while saving money on excavation and hauling costs.

D. PHASING OF RECOMMENDED STRUCTURAL PLANS

The construction of these recommended alternatives could be divided into two phases. The first phase would involve the construction of Alternative 8, the groundwater pumping system. The second phase would involve the construction of Alternative 4, the 10-year gravity outfall from Playa Lake 21 to Yellowhouse Canyon.

In Phase I, the City should initially construct the wells in the problem area along Loop 289 and Playa Lake 26 (Leroy Elmore Park), tie into the City ground level storage tank, and then add the remaining wells to the system as funding becomes available.

The construction of the 10-year gravity outfall in Phase II would have to be constructed in its entirety, and funding will probably have to be obtained through a future City capital improvements bond issue.

E. IMPLEMENTATION OF EXISTING REGULATIONS AND ORDINANCES (NON-STRUCTURAL)

Halff Associates recommends that citizens living within the 100-year flood plain, should consider the purchase of federal flood insurance.

The City should continue enforcing its playa lake subdivision ordinances. In order to properly address the effects of future urbanization, the City should adopt the 100-year flood elevations produced by this study as the designated highwater marks for establishing finished floor elevations and determining necessary storage in accordance with the City's subdivisions ordinances governing playa lakes.

VIII. FUTURE PLANS OR ACTIONS FOR CONSIDERATION

VIII. FUTURE PLANS OR ACTIONS FOR CONSIDERATION

This study was undertaken by the City because of its concern for the flooding potential of its playa lake systems. As the City of Lubbock expands over time, new development will occur in previously undeveloped playa lake systems.

The results of this study highlight the problems the City can encounter in the playa lake systems as contributing watersheds urbanize, development surrounds a playa lake, and the overflow "paths" between playa lakes are developed. The conclusion of this study leads to the following recommendations to the City for addressing flood control in playa lake systems targeted for future development:

1. The City should continue to prepare similar comprehensive drainage studies for those playa lake systems that are either currently undeveloped but targeted for development in the near future, or are currently undeveloped, and in the process of urbanization. These comprehensive drainage studies should identify, for future, fully-urbanized conditions, playa lake 100-year flood limits, and the 100-year flood plain between playa lakes. Funding for these comprehensive studies could be accomplished by the City setting aside funds annually for flood plain management investigations. Another source could be the Texas Water Development Board funds for Flood Protection Studies.

2. Revise the City's subdivision regulations to provide for the preservation of all of the undeveloped lake area within a future, fully-developed 100-year flood plain. This revised policy would allow the City to have more land to modify a playa lake's storage capacity if it was necessary at a later date.

3. Purchase or require the dedication of the overflow paths between playa lakes as public open space and floodway, up to the 100-year flood inundation limit. The preservation of this open space would help create a greenbelt or park system winding its way from playa

lake to playa lake. With careful planning, the greenbelt could become a major community and environmental enhancement for the City.

Implementation of the above recommendations by the City in areas such as the playa lakes that are located south of the study area would create publicly owned and dedicated flood control systems consisting of playa lakes and their natural overflow paths. These greenbelt/floodway systems would provide the surrounding community with flood protection from the 100-year flood, reduce the significant costs of future drainage/flood control improvements, and also create a parks and recreation system that would be environmentally beneficial and a source of pride for the citizens of Lubbock.

IX. REFERENCES

IX. REFERENCES

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[2] TR-20, Project Formulation - Hydrology (1982 version) Technical Release Number 20, U.S. Department of Agriculture, Soil Conservation Service, Hydrology Unit, Lanham, Maryland, May 1982.

[3] Soil Survey of Lubbock County, Texas, U.S. Department of Agriculture, Soil Conservation Service, April 1979.

[4] HEC-2 Water Surface Profiles, U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis California, May 1984.

[5] SID, Structure Inventory for Damage Analysis, U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis California, January 1982.

[6] Expected Annual Flood Damage Computation - EAD, U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California, February 1984.

[7] Satisfying Urban Lawn Water Requirements from On-Site Retention, Masters Thesis by J. Clinton Walker, Department of Civil Engineering, Texas Tech University, 1986.

[8] Physical and Economic Feasibility of Non-Structural Flood Plain Management Measures, U.S. Army Corps of Engineers, Hydrologic Engineering Center, March 1978.

[9] Aquifer Recharge Utilizing Playa Lake Water and Filter Underdrains, Phase IV, Lloyd V. Urban, B.J. Claborn, R.H. Ramsey, Texas Tech University, Water Resources Center, January 1988.

[10] Quantity and Quality of Recharge to the Ogallala Aquifer from Urban Runoff, C. Stecker, K.A. Rainwater. Presented at Focus Conference on Southwestern Ground Water Issues, Association of Ground Water Scientists and Engineers, Albuquerque, New Mexico, March 1988.

[11] Economic Potential for Development of Increasing Groundwater Storage Beneath a High Plains Municipality, Yu-Chi Chen, K.A. Rainwater, R.H. Ramsey, M.J. Dvoracek, Texas Tech University, Water Resources Center, January 1988.

APPENDIX A

FLOOD PLAIN DELINEATION SHEETS

LEGEND

- SYSTEM BOUNDARIES
- SUBBASINS
- MAJOR THOROUGHFARES
- RAILROADS
- STREAMS

LEGEND

15 — CITY OF LUBBOCK TOPOGRAPHIC MAP NUMBER

FLOOD PLAIN DELINEATION SHEET THIS STUDY

N

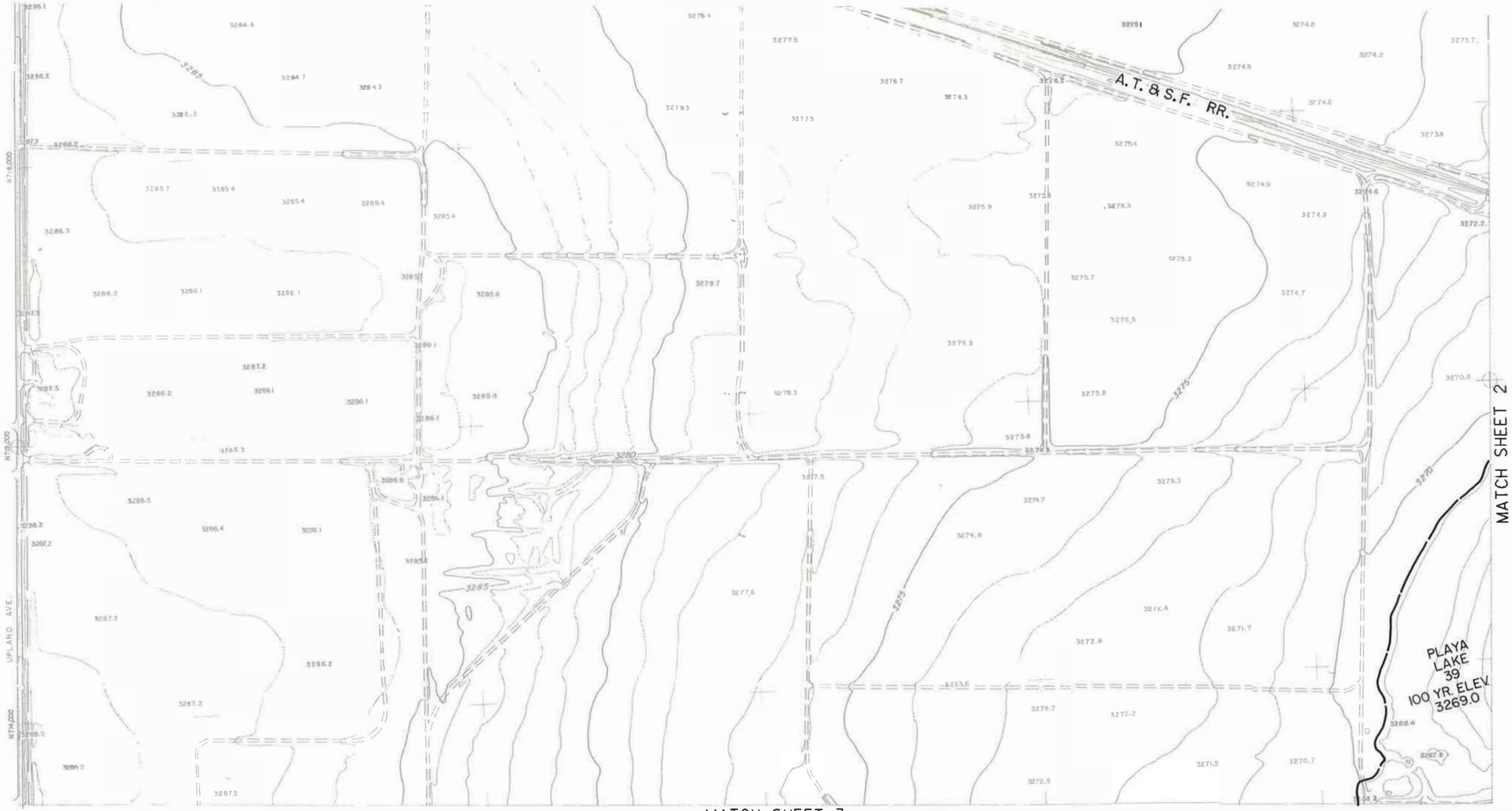
NOT TO SCALE

CLOVIS RD. (84)
YELLOW HOUSE DRAW
HWY. 27 (87)
U.S.HWY. 62-82
LOOP 289
F.M. 2255
4TH. ST.
PARKWAY
U.S.HWY. 82
DR.
S.H. 116
A.T. & S.F. RAILROAD
U.S. HWY. 62
U.S.HWY. 62 & 82)
BROWNFIELD HIGHWAY
UNIVERSITY AVE.
AVE. Q (84)
AVE. H
AVE. A
34TH. STREET
SLIDE RD.
QUAKER AVE.
NO. FORK, DOUBLE MTN. FORK BRAZOS RIVER
A.T. & S.F. RAILROAD
SOUTHEAST DR.
50TH. ST.
66TH. STREET
SLATON HWY.
82ND. STREET
U.S.HWY. 87
SYSTEM "E1"
SYSTEM "E2"
SYSTEM "SOUTHWEST"
SYSTEM "F"

INDEX MAP
OF FLOOD PLAIN DELINEATION SHEETS
SOUTH LUBBOCK DRAINAGE STUDY
CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.	
DATE 1988	
DESIGN BAF / DRAWN BD,CADD	FIGURE A-1

AVO 9102



LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

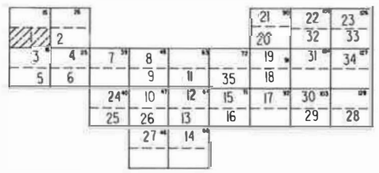
3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•

CROSS-SECTION

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

PROPOSED IMPROVEMENTS

• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986), ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
AJJL	RD,CADD	12/88		1982 BORDER.DGN

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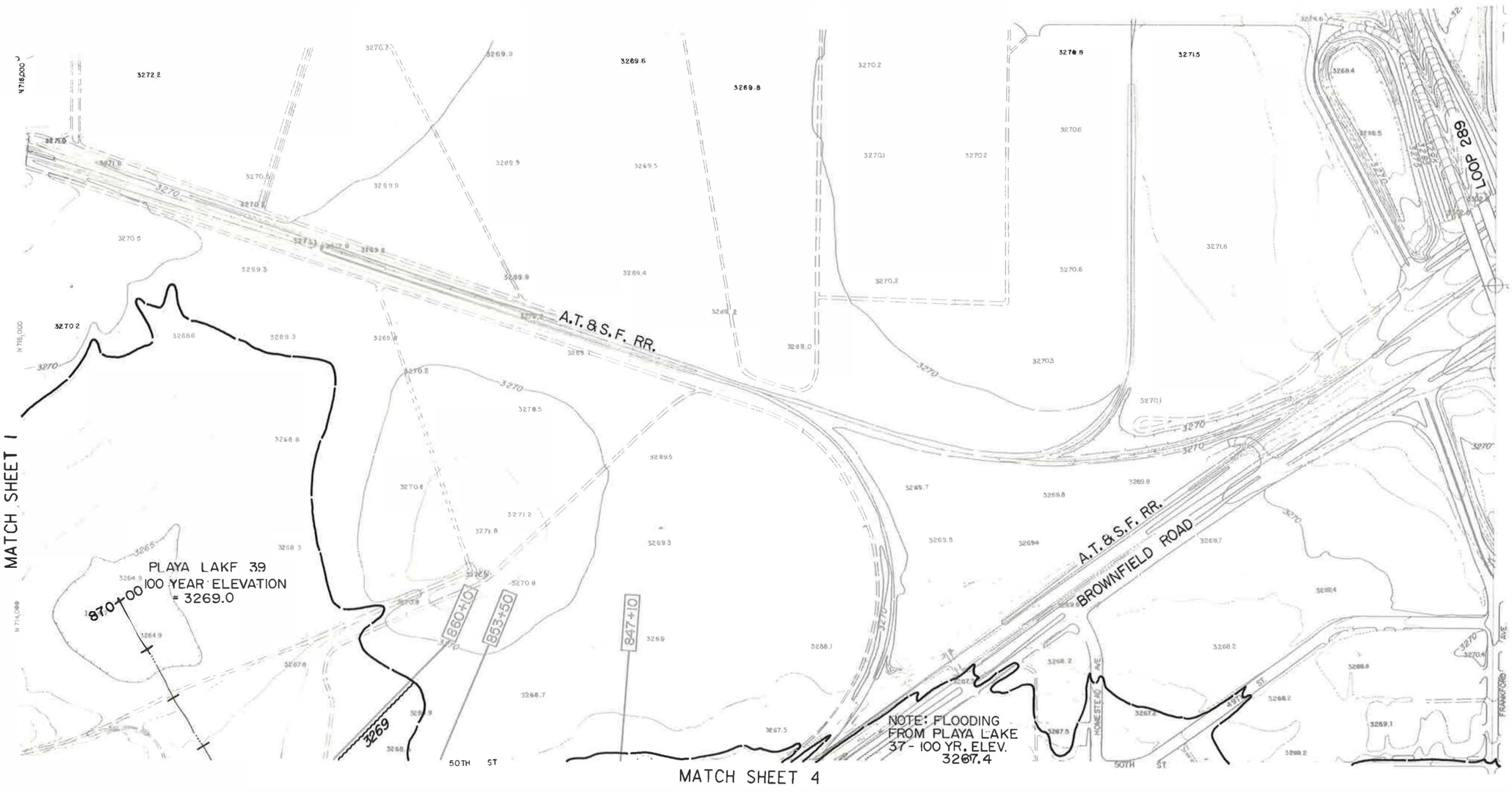
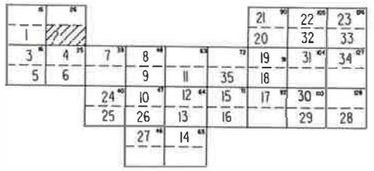


LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*
- 20+00 — SYSTEM CENTERLINE AND STATIONS (FEET)
- 576+00 — CROSS-SECTION

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV., 1978 & FEB., 1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986), ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
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A.H.H.	BD.CADD	12/88		902 BORDER.DGN	SHEET 2

902 • BV • • BORDER.DGN

MATCH SHEET 1

NOTE: FLOODING FROM PLAYA LAKE 39-100 YR. ELEV. 3269.0

MATCH SHEET 4

MATCH SHEET 5

AT&SF RR.

BROWNFIELD ROAD

N

0 200 400 600

SCALE IN FEET

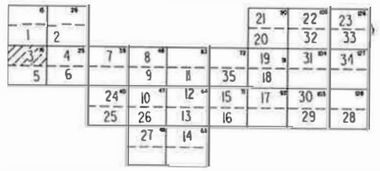
LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

200 SYSTEM CENTERLINE AND STATIONS (FEET)

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
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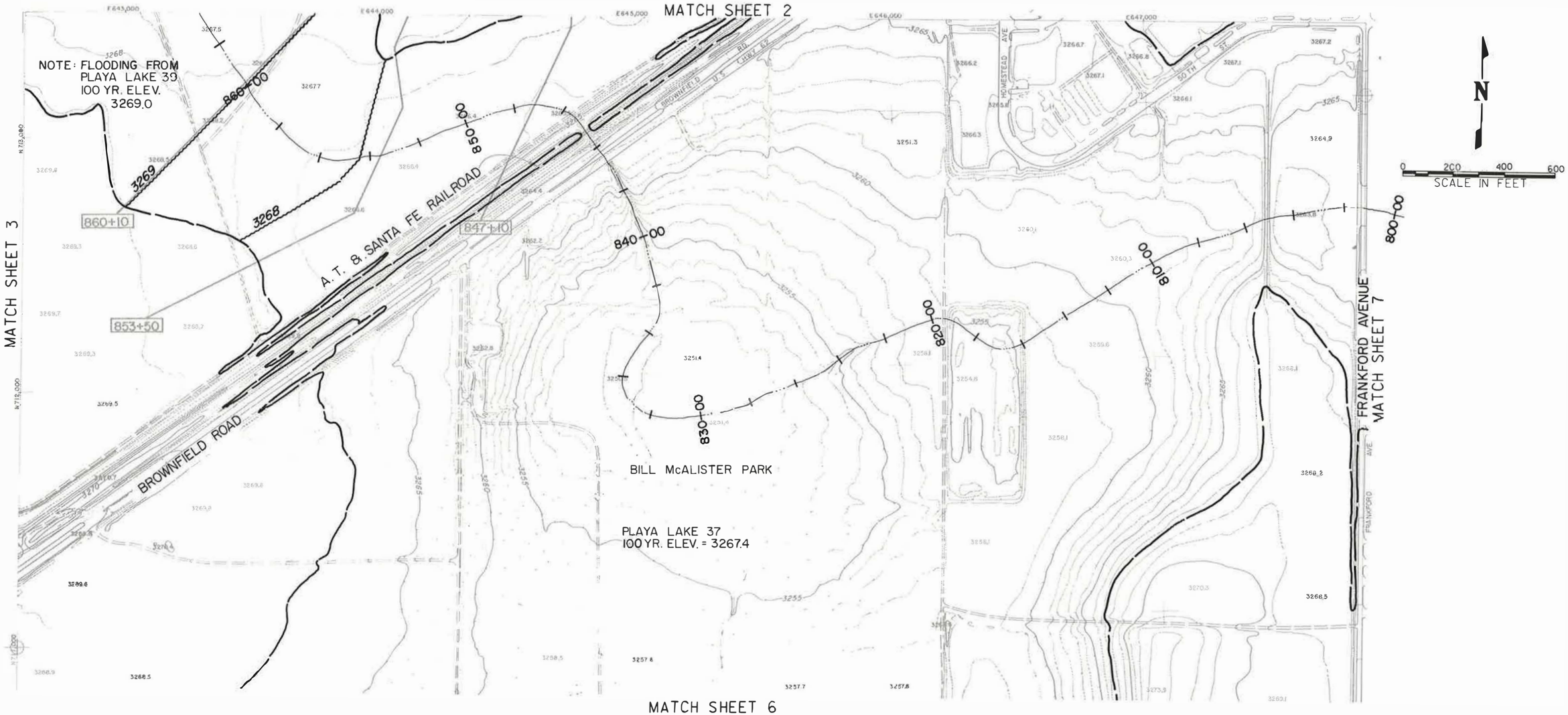
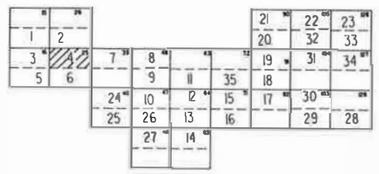


LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*
- 20+00 — SYSTEM CENTERLINE AND STATIONS (FEET)
- 576+00 — CROSS-SECTION

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

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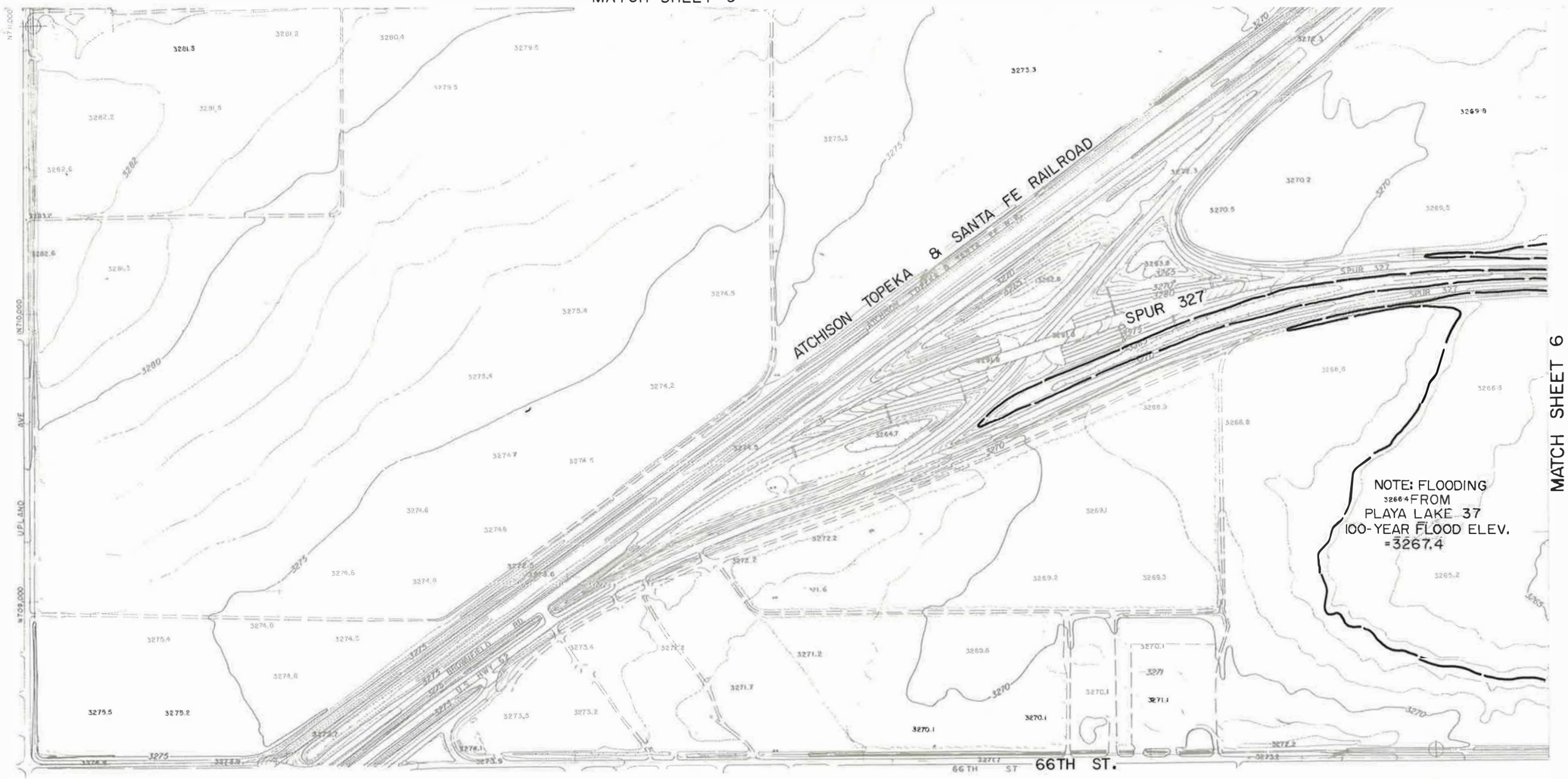

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0 200 400 600
SCALE IN FEET

LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*
- 20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986), ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
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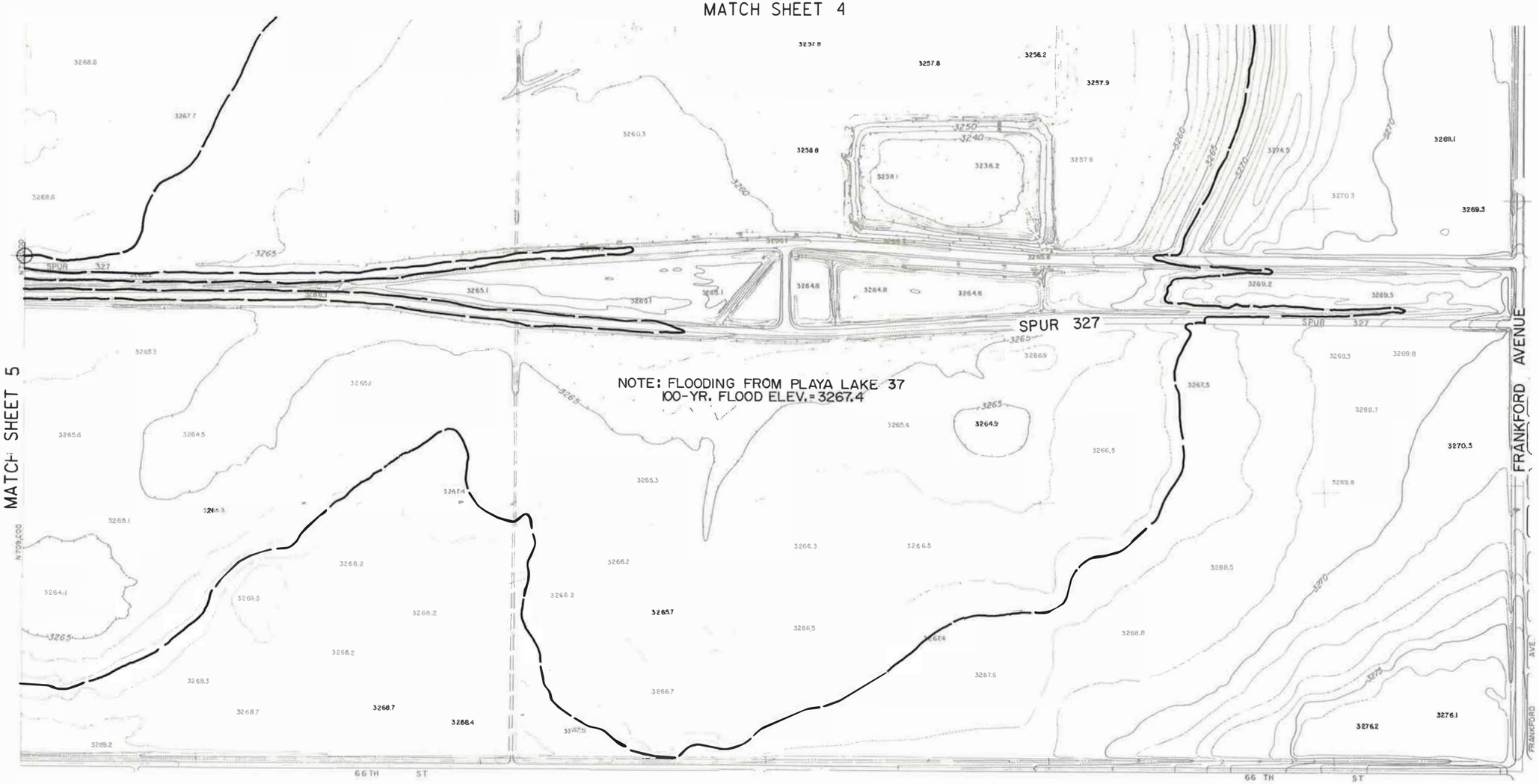
A.H.H.	BR.CADD	12/88		9102 BORDER.DGN	

MATCH SHEET 4

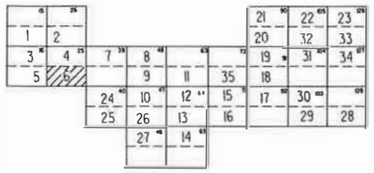


MATCH SHEET 5

LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*
- 20+00 — SYSTEM CENTERLINE AND STATIONS (FEET)

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.H.H.	BD.CADD	12/88		9102 BORDER.DGN

SHEET 6

NOTE: FLOODING FROM PLAYA LAKE 37 - 100 YR. ELEV. = 3267.4

PLAYA LAKE 31
100 YR. ELEV. = 3255.4

BUSTER LONG PARK

10-YEAR DESIGN ALTERNATIVE 5
SINGLE 48" PIPE
BETWEEN PLAYA LAKES 31 & 27

FRANKFORD AVENUE

LOOP 289

CHICAGO

ALBANY

ABERDEEN

BANGOR

MATCH SHEET 4

MATCH SHEET 8

0 200 400 600
SCALE IN FEET

N

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

576+00 CROSS-SECTION

• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

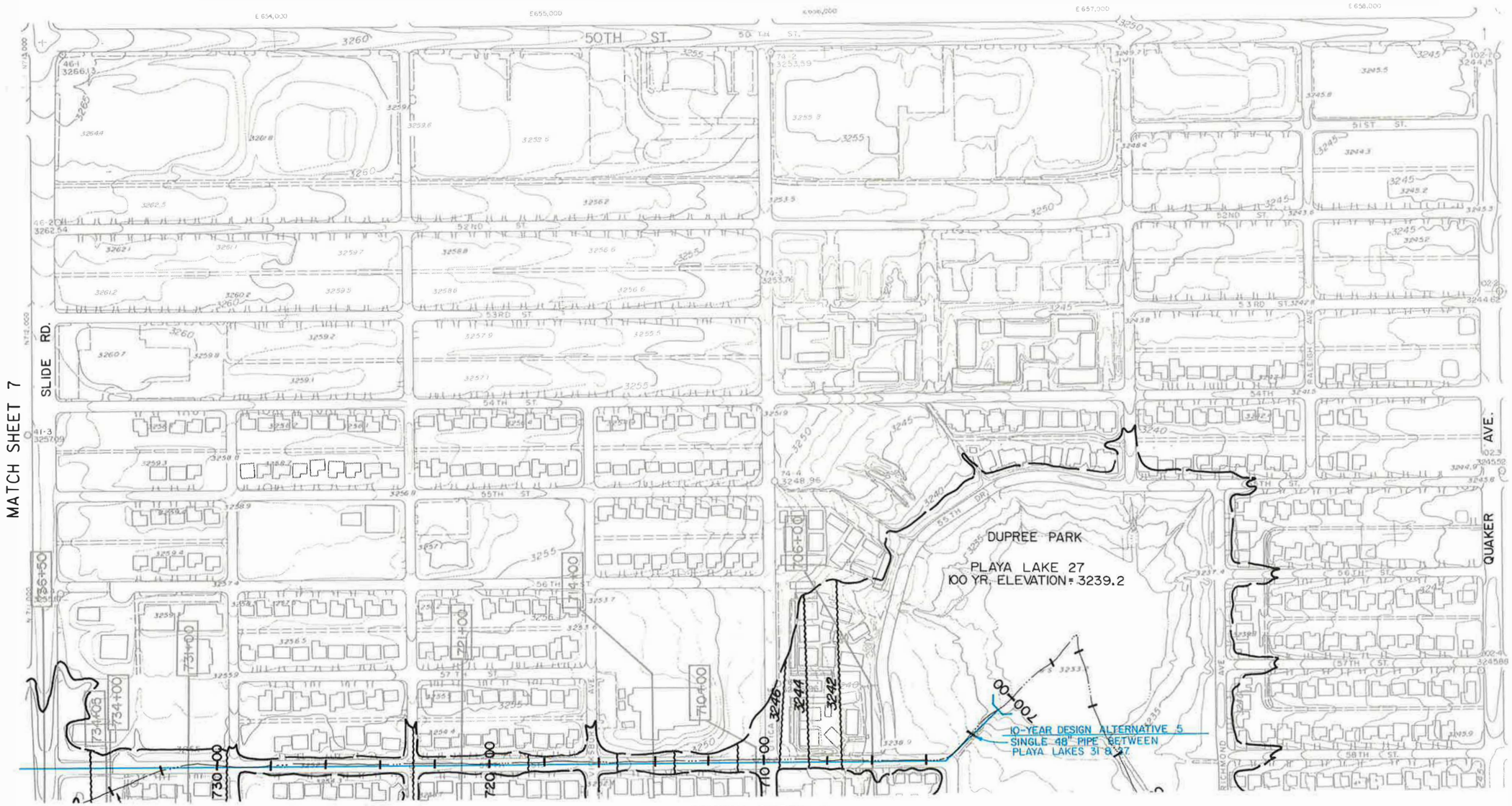
100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	SHEET 7
A.H.H.	BD,CADD	12/88		902 BORDER.DGN	

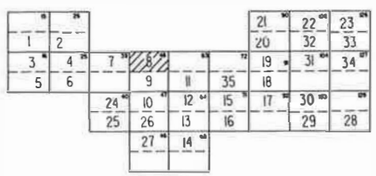


NOTE: FLOODING FROM PLAYA LAKE 31
100 YEAR ELEVATION = 3255.4

LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*
- 20+00 — SYSTEM CENTERLINE AND STATIONS (FEET)
- 576+00 — CROSS-SECTION

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

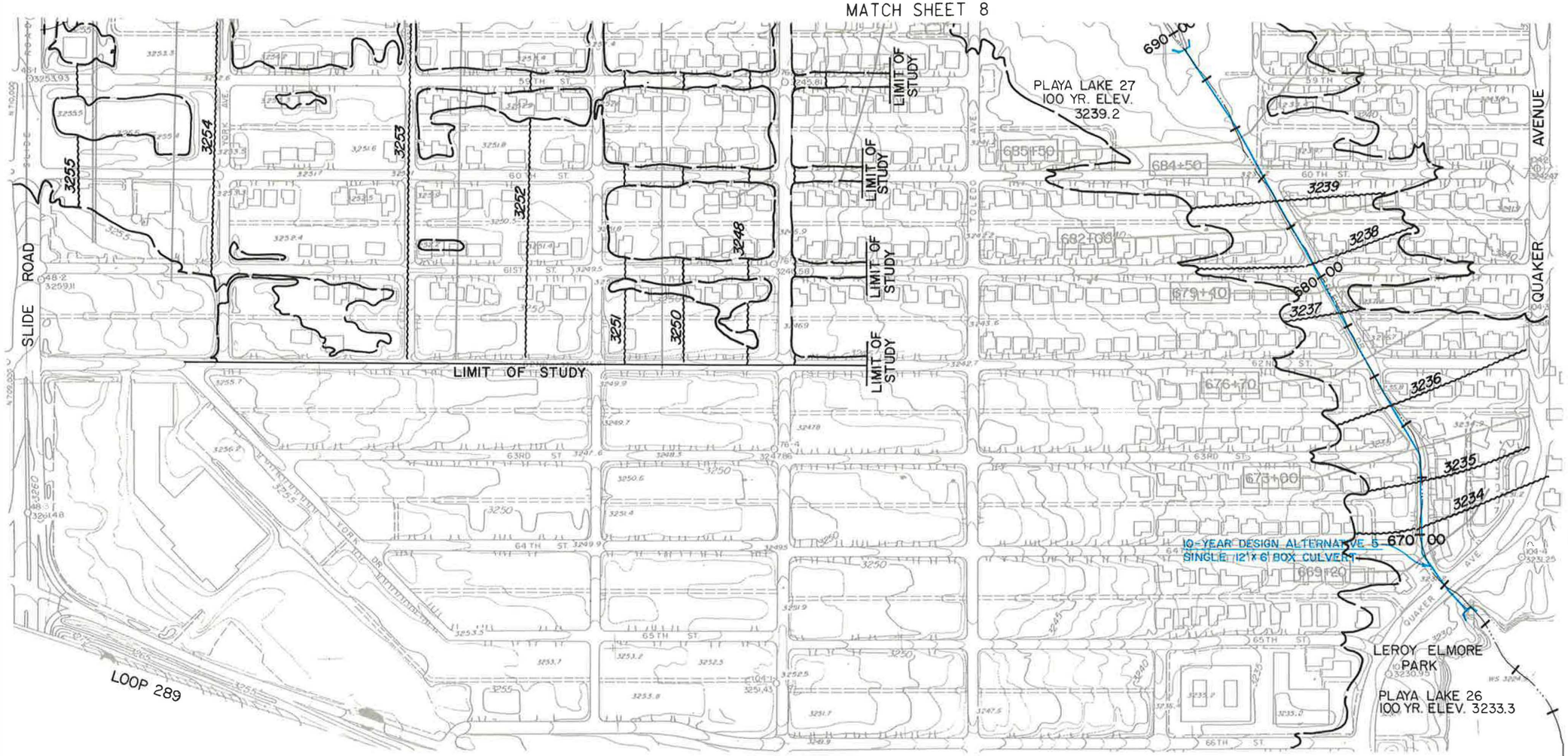
SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	
A.H.H.	BD,CADD	12/88		9N9 BORDER.DGN	SHEET 8

MATCH SHEET 8



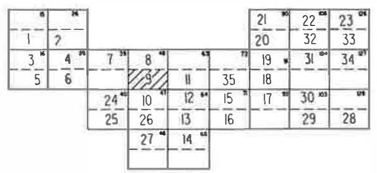
MATCH SHEET 10

MATCH SHEET II

LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*
- 20+00 — SYSTEM CENTERLINE AND STATIONS (FEET)
- 576+00 — CROSS-SECTION

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	
AJLJL	GD,CADD	12/88		9102 BORDER.DGN	SHEET 9

902 * 8½ * BORDER.DGN

MATCH SHEET 9

MATCH SHEET 24

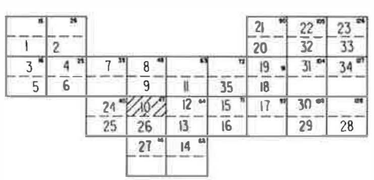
MATCH SHEET 12

MATCH SHEET 26

LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•
- 20+00 — SYSTEM CENTERLINE AND STATIONS (FEET)

• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.M.M.	BD.CADD	12/88		902 BORDER.DGN

SHEET 10

MATCH SHEET 9

MATCH SHEET 35

MATCH SHEET 12

QUAKER AVENUE

MEMPHIS AVENUE

58TH ST.

59TH ST.

60TH ST.

61ST ST.

62ND ST.

63RD ST.

64TH ST.

65TH ST.

66TH ST.

LEROY ELMORE PARK

PLAYA LAKE 26
100 YR. ELEV.
3233.3

0 200 400 600
SCALE IN FEET

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986), ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	SHEET 11
A.M.M.	BB,CADD	12/00		1902 BORDER.DGN	

MATCH SHEET II

660+00

PLAYA LAKE 26
100 YR. ELEV. = 3233.3

LEROY ELMORE PARK

650+00

10-YEAR DESIGN ALTERNATIVE 5
TWO DBL. 5'x4' BOXES AND LOWER FLOWLINE OF EXISTING BOXES

MATCH SHEET 10

646+46

645+80

640+00

10-YEAR DESIGN ALTERNATIVE 5
RE-GRADE CHANNEL
LOWER FLOWLINE

643+00

641+30

639+16

638+40

636+10

631+90

629+60

3232

630+00

LOOP 289

590+90

NOTE: FLOODING FROM PLAYA LAKE 24 - 100 YR. ELEV = 3228.3

KASTMAN PARK

554+60

MATCH SHEET 15

PLAYA LAKE 24
100 YR. ELEV. 3228.3

BILL MILLER PARK

570+00

10-YEAR DESIGN ALTERNATIVE 5
EXCAVATE FROM ELEV. 3227 TO ELEV. 3210, 4:1 I.V SIDE SLOPES

560+00

3228

MATCH SHEET 13

N

0 200 400 600
SCALE IN FEET

LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*
- 20+00 — SYSTEM CENTERLINE AND STATIONS (FEET)
- 576+00 — CROSS-SECTION
- PROPOSED IMPROVEMENTS

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986), ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.H.H.	WD,CADD	12/88		902 BORDER.DGN

SHEET 12

MATCH SHEET 12

MATCH SHEET 26

MATCH SHEET 16

MATCH SHEET 14

628+50

620+30

620+00

3231

3230

3229

EXISTING SPOIL AREA FROM PLAYA EXCAVATION PLANS

10-YEAR DESIGN ALTERNATIVE 5
RE-GRADE CHANNEL LOWER FLOWLINE.

10-YEAR DESIGN ALTERNATIVE 5
TWO 60" PIPES CONNECTING PLAYA LAKES 25 AND 24

PLAYA LAKE 25
1000 YR. ELEV. = 3228.5

LIMITS OF ULTIMATE PLAYA EXCAVATION PER DEVELOPMENT PLANS

PLAYA LAKE 24
100 YR. ELEV. 3228.3

BILL MILLER PARK

10 YR. DESIGN ALTERNATIVE 5
EXCAVATE FROM ELEV. 3227 TO ELEV. 3210 ON 4H:1V SIDESLOPES

580+00

590+00

600+00

610+00

585+20

556+50

554+60

AVENUE

QUAKER

MEMPHIS AVE

82ND ST.

74TH ST.

75TH ST.

76TH ST.

78TH ST.

79TH ST.

81ST ST.

INDIANA DR.

JOLIET AVE.

KENOSHA AVE.

LOUISVILLE AVE.

LYNNHAVEN AVE.

N

0 200 400 600
SCALE IN FEET

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

576+00 CROSS-SECTION

PROPOSED IMPROVEMENTS

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV., 1978 & FEB., 1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.H.H.	BD.CADD	12/88		9102 BORDER.DGN

SHEET 13

MATCH SHEET 13

MATCH SHEET 27

QUAKER AVE.

82ND ST.

NOTE: FLOODING FROM PLAYA 25
100 YR. ELEV. = 3228.5

LIMITS OF EXCAVATION PER DEVELOPMENT PLAN

N

0 200 400 600
SCALE IN FEET

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986), ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY
100 YEAR FLOOD PLAIN DELINEATION
SYSTEMS E1, E2, F, & SOUTHWEST
CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.H.H.	BD,CADD	12/88		

SHEET 14

MATCH SHEET 35

MATCH SHEET 12

MATCH SHEET 17

MATCH SHEET 16

PLAYA LAKE 23 - 100 YR. ELEV.=3223.9

PLAYA LAKE 23 - 100 YR. ELEV. = 3223.9

LOOP 289

INDIANA AVE.

HARTFORD AVE.

GARY AVE.

CANTON AVE.

UNIVERSITY AVE.

66TH ST.

67TH ST.

68TH ST.

74TH ST.

16+00

10+00

8+00

490+00

499+70

504+40

506+50

492+60

494+80

500+00

510+00

518+00

520+00

530+00

540+00

550+00

3225

3217

3218

3219

3220

3221

3222

3223

3226

3227

3228

N

0 200 400 600

SCALE IN FEET

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

576+00 CROSS-SECTION

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.H.H.	BD.CADD	12/88		BD2 BORDER.DGN

SHEET 15

BD2 • RF1 • BORDER.DGN

MATCH SHEET 15

MATCH SHEET 13

PLAYA LAKE 23-100 YR.
ELEV. = 3223.9

554+60
553+00
546+60
541+80
550+00

74TH ST.
75TH ST.
76TH ST.
77TH ST.
78TH ST.
79TH ST.
80TH ST.
81ST ST.
82ND ST.

INDIANA AVE.
GARFORD AVE.
GARY AVE.
DETROIT AVE.
DIXON AVE.
CANTON AVE.
ELGIN AVE.
AKRON AVE.
UNIVERSITY
GENEVA AVE.
FREMONT AVE.
ELKRIDGE AVE.
BOSTON AVE.

N

0 200 400 600
SCALE IN FEET

LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*
- 20+00 — SYSTEM CENTERLINE AND STATIONS (FEET)
- 576+00 — CROSS-SECTION

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION SYSTEMS E1, E2, F, & SOUTHWEST CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
AJLH	BD,DADD	12/00		BD2 BORDER.DGN

SHEET 16

MATCH SHEET 18

MATCH SHEET 15

MATCH SHEET 30

NOTE: FLOODING FROM PLAYA LAKE 19 - 100 YR. ELEV. = 3216.6

DAVID CASEY PARK

LIMIT OF STUDY

UNIVERSITY AVENUE

LOOP 289

66TH ST

67TH ST

69TH ST

70TH AVE

71ST ST

73RD ST

74TH ST

TEMPLE AVENUE

SHERMAN AVENUE

ANDERSON AVENUE

485+20

490+00

492+60

494+60

3217

3218

N 707,000

N 706,000

N 705,000

E 669,000

E 670,000

E 671,000

E 672,000

E 673,000

E 674,000

0 200 400 600

SCALE IN FEET

N

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

576+00 CROSS-SECTION

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986), ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.H.H.	BD,CADD	12/88		902 BORDER.DGN

SHEET 17

MATCH SHEET 19

MATCH SHEET 35

10-YEAR DESIGN ALTERNATIVE 6
SINGLE 48" PIPE TO CONNECT TO CLAPP PARK (PLAYA LAKE 21)

10 YR. DESIGN ALTERNATIVE 6
EXCAVATE RIBBLE PARK (PLAYA LAKE 20)
10H:1V SIDE SLOPES

PLAYA LAKE 20
100 YR. ELEV.
3214.3

10-YEAR DESIGN ALTERNATIVE 6
EXCAVATE PLAYA LAKE 19,
SIDE SLOPES VARY FROM
10H:1V TO 4H:1V.

PLAYA LAKE 19
100 YR. ELEV. = 3216.6

10-YEAR DESIGN ALTERNATIVE 6
SINGLE 48" PIPE TO CONNECT
TO PLAYA LAKE 2 *

UNIVERSITY AVE.

AVENUE U

62 ND ST

66TH. ST.

455+20

460+00

470+00

480+00

450+00

443+90

450+50

3215

3216

MATCH SHEET 17

N

0 200 400 600
SCALE IN FEET

* NOTE : ALTERNATIVE 6 DOES NOT INCLUDE A PIPE CONNECTION BETWEEN PLAYA LAKES 19 TO 20.

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

676+00 CROSS-SECTION

PROPOSED IMPROVEMENTS

• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION
SYSTEMS E1, E2, F, & SOUTHWEST
CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	
AJJL	BD,CADD	12/88		802 BORDER.DGN	SHEET 18

MATCH SHEET 20

50TH. ST.

AVENUE

UNIVERSITY

AVENUE

3210

3211

410+00

3212

414+60

3213

418+85

420+00

422+00

3214

425+10

430+70

430+00

434+20

443+90

10-YEAR DESIGN ALTERNATIVE 6
48" PIPE FROM PLAYA LAKE 19 TO PLAYA LAKE 21

10-YEAR DESIGN ALTERNATIVE 6
48" PIPE FROM PLAYA LAKE 20 TO PLAYA LAKE 21

LIMIT OF STUDY
SHALLOW FLOW-LESS THAN 6"

MATCH SHEET 31

MATCH SHEET 18

N

0 200 400 600
SCALE IN FEET

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

575+00 CROSS-SECTION

PROPOSED IMPROVEMENTS

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986), ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

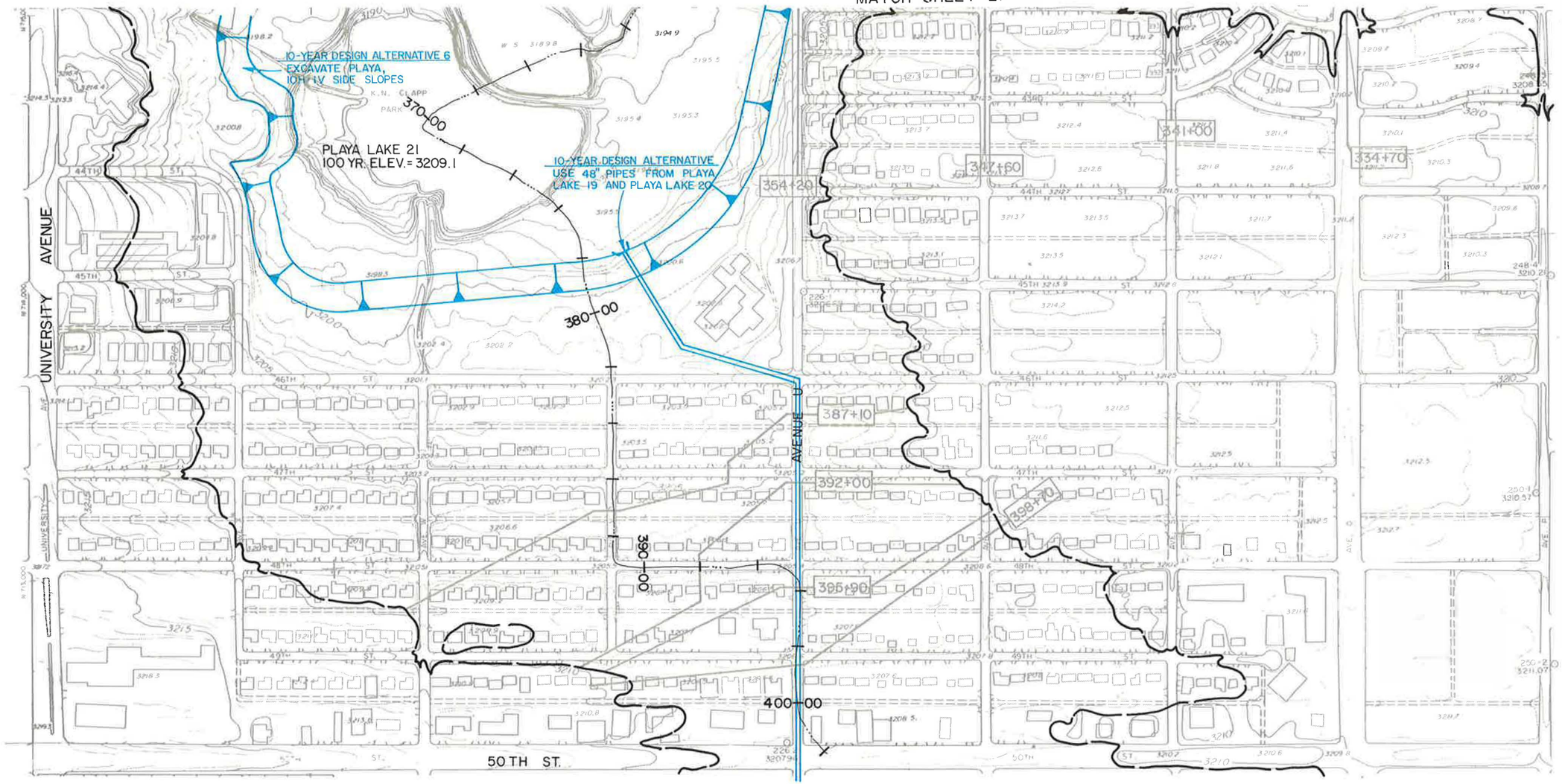
CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.M.M.	BG,CADD	12/88		2802 BORDER.DGN

SHEET 19

MATCH SHEET 21



MATCH SHEET 32

MATCH SHEET 19

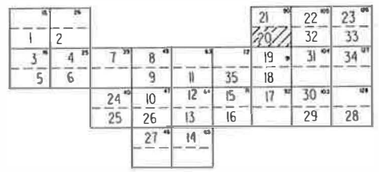
N

0 200 400 600
SCALE IN FEET

LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•
- 20+00 — SYSTEM CENTERLINE AND STATIONS (FEET)
- 576+00 — CROSS-SECTION
- PROPOSED IMPROVEMENTS

• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.H.H.	BD,CADD	12/88		3102 BORDER.DGN

SHEET 20

34TH. ST.

10-YEAR DESIGN ALTERNATIVE 6
EXCAVATE PLAYA LAKE 21
10H:1V SIDE SLOPES

PLAYA LAKE 21
100 YR. ELEV. 3209.1

CLAPP PARK

AVE. U

AVE. Q

UNIVERSITY AVE.

MATCH SHEET 22

MATCH SHEET 20

N

0 200 400 600
SCALE IN FEET

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION▪

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

576+00 CROSS-SECTION

PROPOSED IMPROVEMENTS

▪ 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

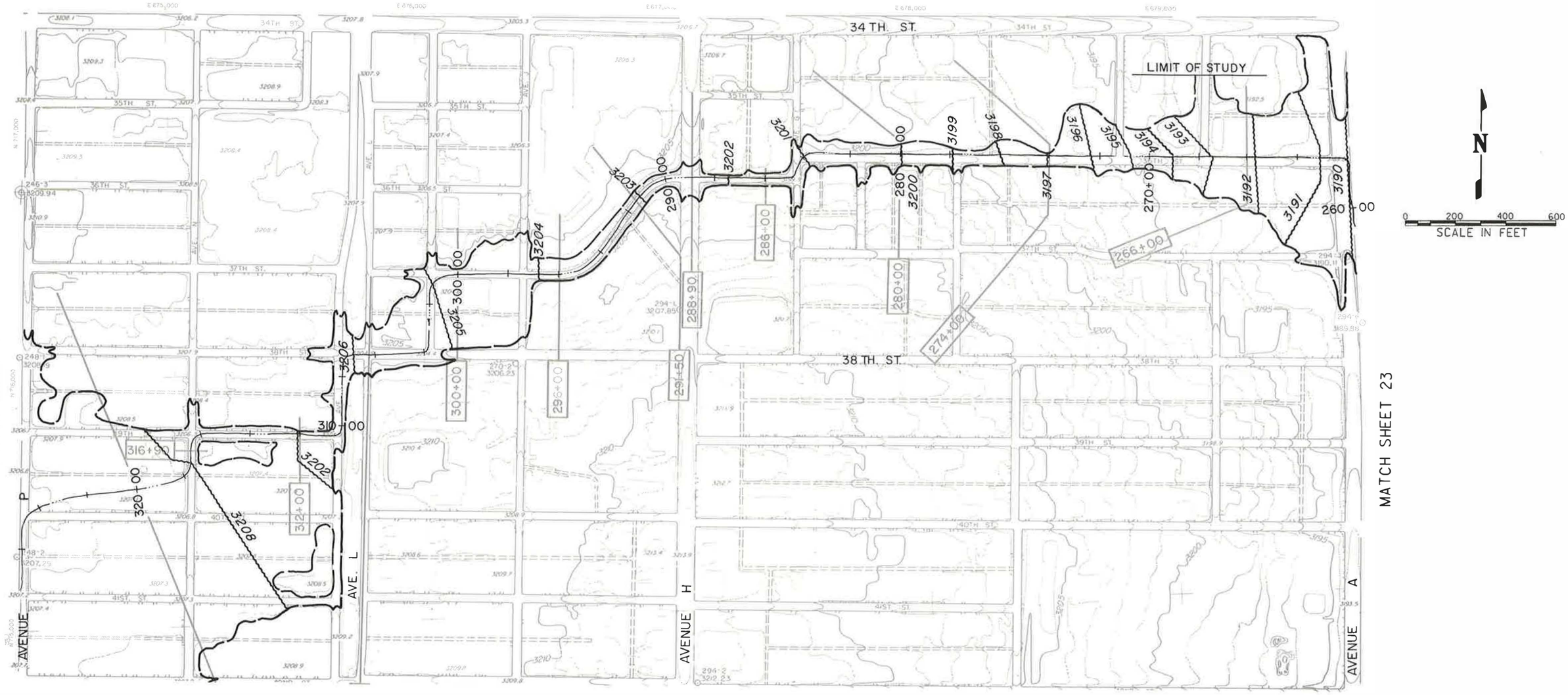
SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.H.H.	BD.CADD	12/88		902 BORDER.DGN

SHEET 21



LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*
- 20+00 — SYSTEM CENTERLINE AND STATIONS (FEET)
- 576+00 — CROSS-SECTION

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

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SOUTH LUBBOCK DRAINAGE STUDY

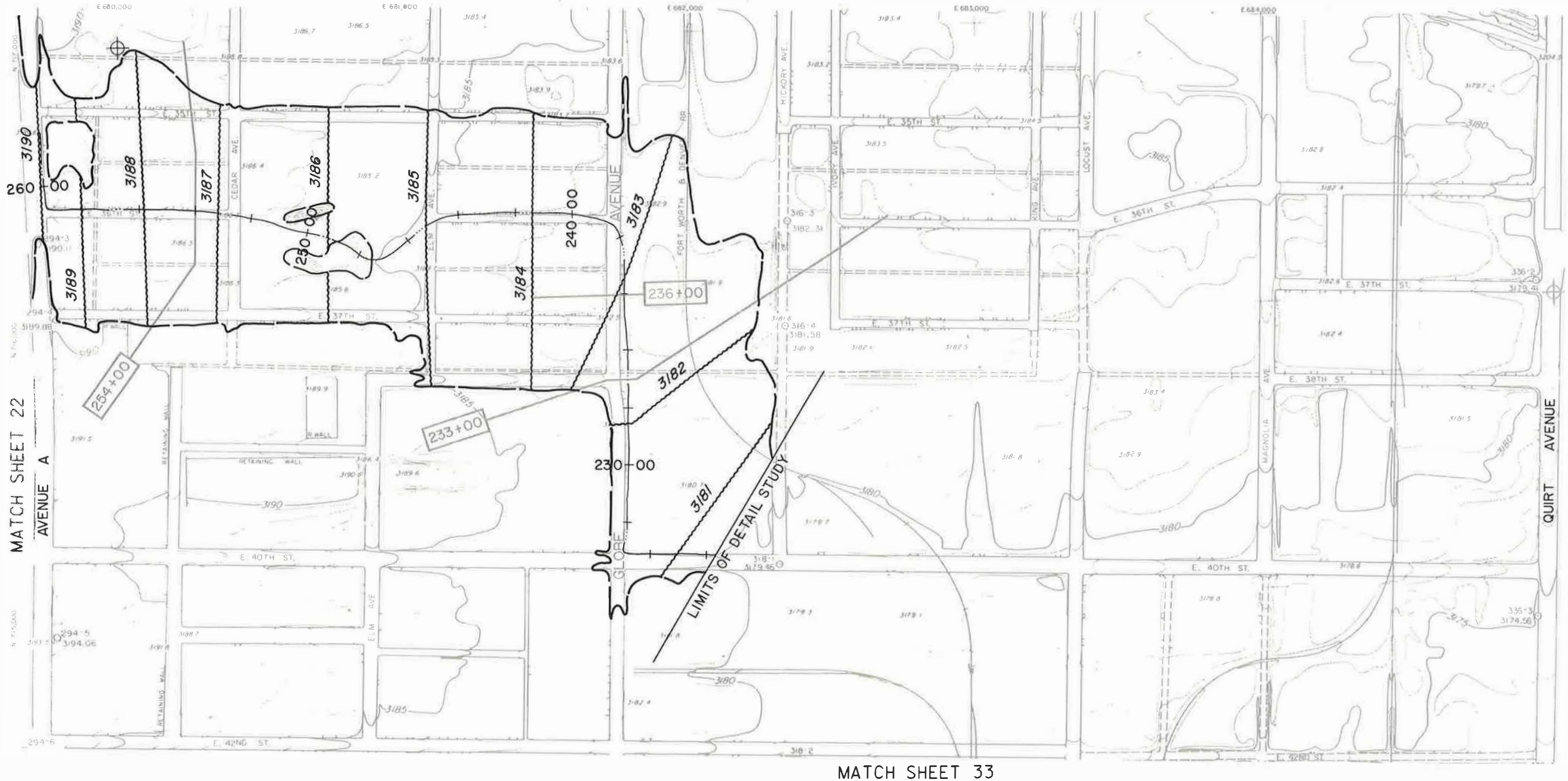
100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

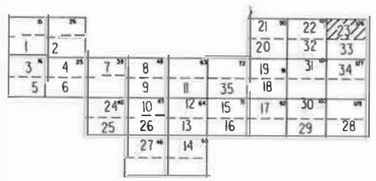
DESIGN	DRAWN	DATE	SCALE	NOTES	SHEET 22
A.H.H.	RR,CANN	12/88		1902 BORDER.DGN	



LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•
- 20+00 — SYSTEM CENTERLINE AND STATIONS (FEET)
- 576+00 — CROSS-SECTION

• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

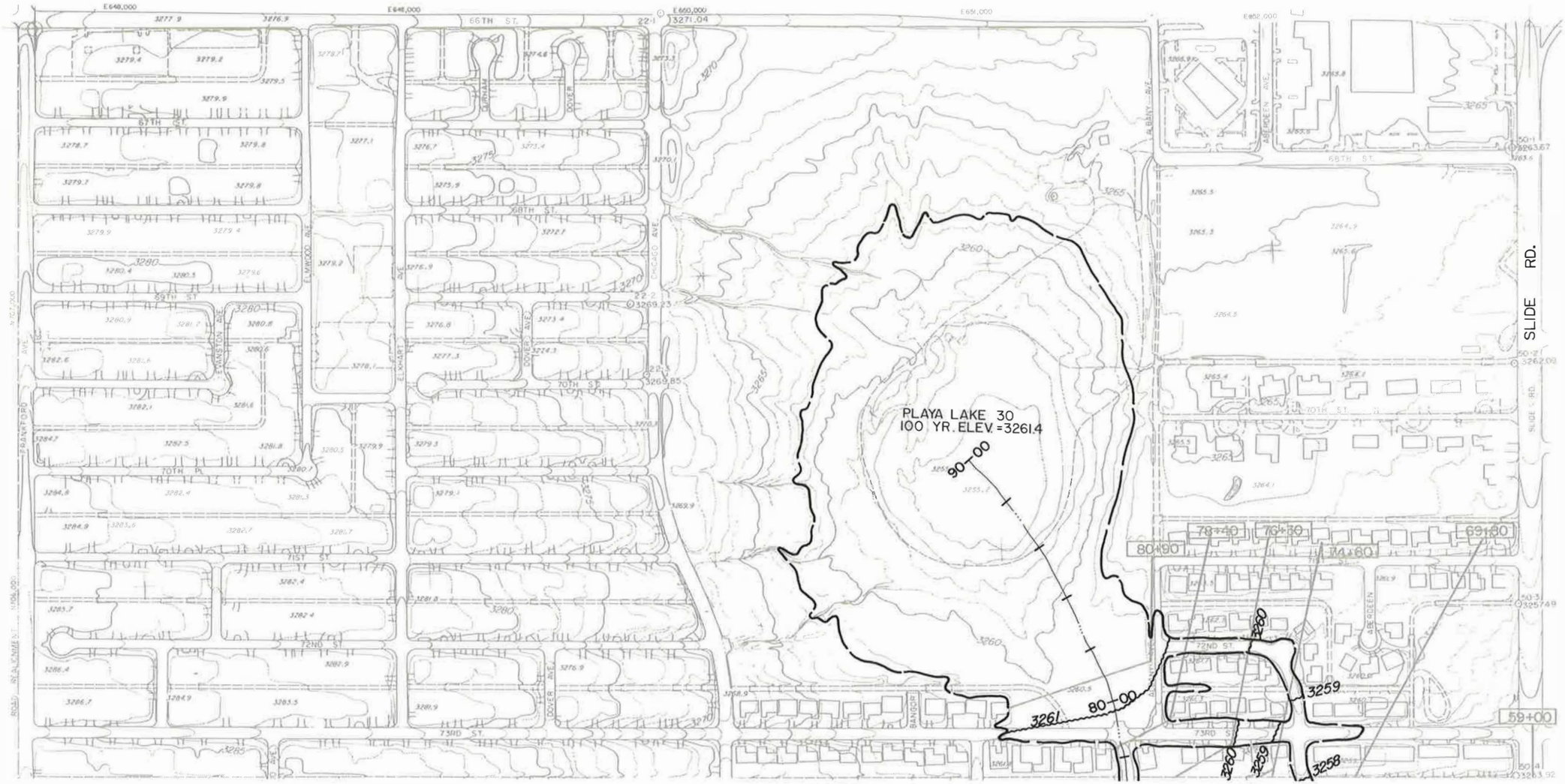
CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
AJJ,JL	BS,CADD	12/88		902 BORDER.DGN

SHEET 23

902 • MF • BORDER.DGN



MATCH SHEET 10

MATCH SHEET 25

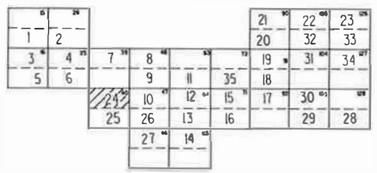
N

0 200 400 600
SCALE IN FEET

LEGEND

- LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)
- 3300 — BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*
- 20-00 — SYSTEM CENTERLINE AND STATIONS (FEET)
- 576+00 — CROSS-SECTION

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.H.H.	BD,CADD	12/88		9in2 BORDER.DGN

SHEET 24

MATCH SHEET 24

MATCH SHEET 26

PLAYA LAKE 29
100 YR. ELEV.=3252.8

JACK STEVENS PARK

74+80
71+20
69+80
70+00
60+00
59+00

3260
3259
3258

82 ND ST.

SLIDE RD.

N

0 200 400 600
SCALE IN FEET

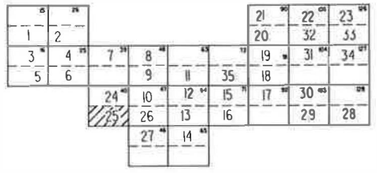
LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	
A.H.H.	BD,CADD	12/88		30C BORDER.DGN	SHEET 25

MATCH SHEET 10

MATCH SHEET 25

MATCH SHEET 13

MATCH SHEET 27

PLAYA LAKE 28
100 YR. EL. 3250.0

50-00

40-00

50+00

3252

3251

3250

3249

30-00

3248

3247

3246

3245

3244

20-00

3243

3242

54+00

52+80

58+50

28+30

24+20

20+00

17+00

SLIDE RD.

76TH ST.

77TH ST.

78TH ST.

79TH ST.

80TH ST.

81ST ST.

82ND ST.

YORK AVE.

VICKSBURG AVE.

UTICA AVE.

TOLEDO AVE.

SALEM AVE.

RICHMOND AVE.

RALEIGH AVE.

QUINTON AVE.

QUAKER AVENUE

74TH ST.

75TH DR.

0 200 400 600
SCALE IN FEET

N

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

576+00 CROSS-SECTION

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV., 1978 & FEB., 1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	SHEET 26
A.H.H.	BD,CADD	12/88		BD2 BORDER.DGN	

MATCH SHEET 26

82ND ST.

MATCH SHEET 14

QUAKER AVENUE

SLIDE RD.

PLAYA LAKE 91
100 YR. ELEV. 3237.3

13+20
3241
3240
3239
3238
10+00
0+00

N

0 200 400 600
SCALE IN FEET

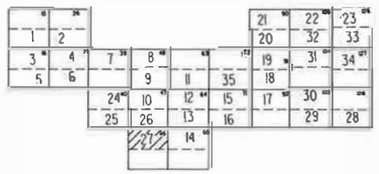
LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

576+00 CROSS-SECTION



• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	
A.H.H.	BD,CADD	12/88		992 BORDER.DGN	SHEET 27

992 - RF - - BORDER.DGN

MATCH SHEET 29 N703,000

PLAYA LAKE 18
100 YR. ELEV.= 3187.7

LIMITS OF STUDY

82ND ST

N

0 200 400 600
SCALE IN FEET

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

20-100 SYSTEM CENTERLINE AND STATIONS (FEET)

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
AJHH	BD,CADD	12/88		902 BORDER.DGN

SHEET 28

MATCH SHEET 30

PLAYA LAKE 17
100 YR. ELEV. 3185.4

I. H. 27

20+00

21+00

23+40

26+00

27+00

30+00

3186

3187

MATCH SHEET 28

ASH AVENUE

N

0 200 400 600
SCALE IN FEET

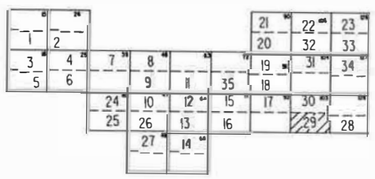
LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

576+00 CROSS-SECTION



* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	
A.H.H.	BD.CADD	12/88		9in2 BORDER.DGN	SHEET 29

MATCH SHEET 17

66TH ST

AVENUE P

I. H. 27

ASH AVE.

LOOP 289

LIMIT OF STUDY

PLAYA LAKE 17
100 YR. ELEV. = 3185.4

0+00

10+00

N

0 200 400 600
SCALE IN FEET

MATCH SHEET 29

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
AJLH	DD,CADD	12/88		902 BORDER.DGN

SHEET 30

MATCH SHEET 32

MATCH SHEET 19

MATCH SHEET 34

NOTE: FLOODING FROM PLAYA 16 100 YR. ELEV. 3182.4

N

0 200 400 600 800 1200
SCALE IN FEET

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION*

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

* 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

																		21	22	23			
1	2																	20	32	33			
3	4		7		8													19			34		
5	6				9		11		35		18												
			24		10		12		15		17		30										
			25		26		13		16				29		28								
					27		14																

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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

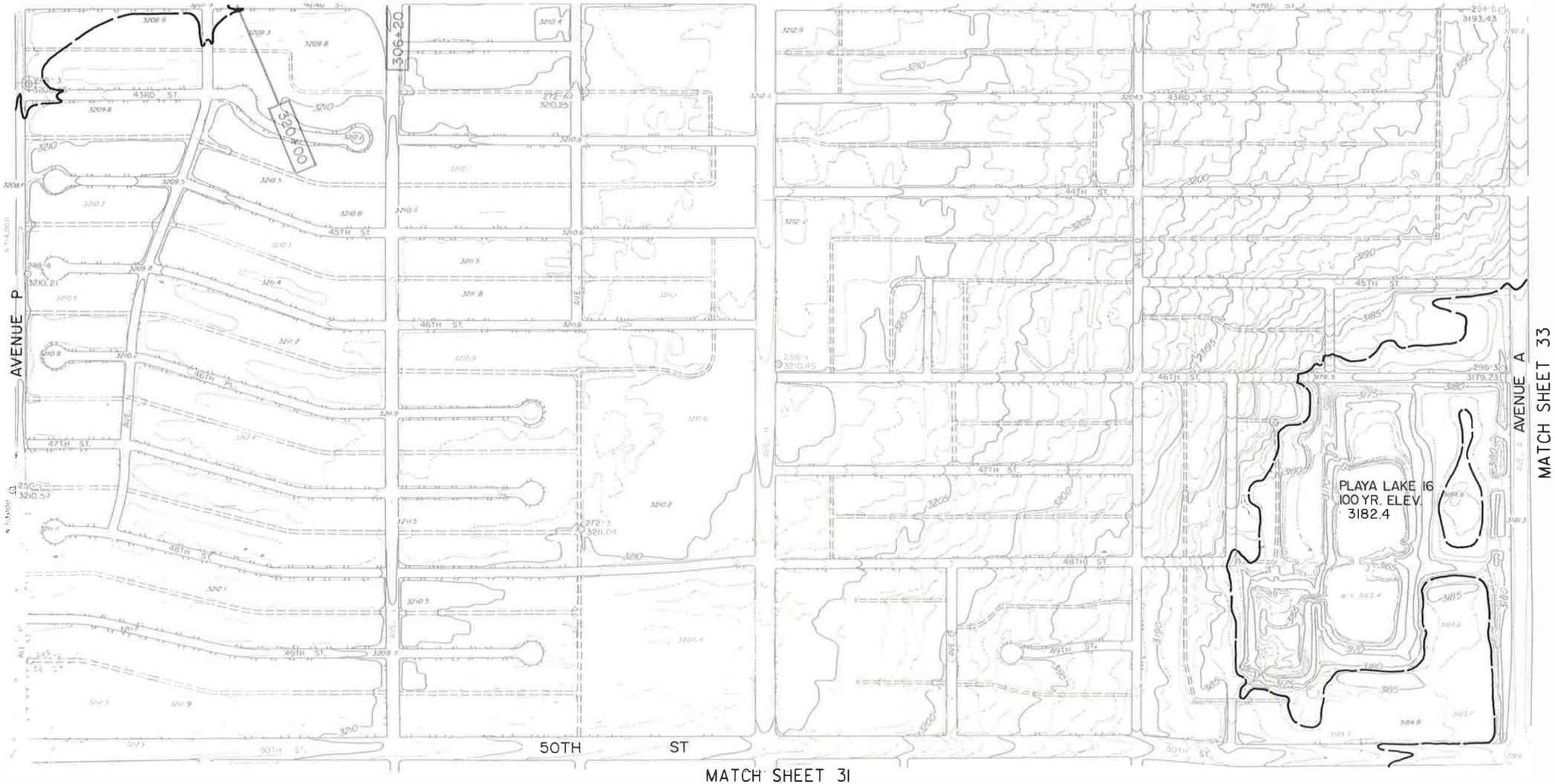
ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	SHEET
AHH	BR,DARD	12/88		1902 WORDER.DGN	31

MATCH SHEET 22

MATCH SHEET 20

MATCH SHEET 33



N

0 200 400 600
SCALE IN FEET

MATCH SHEET 31

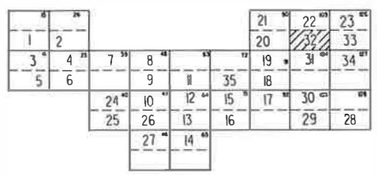
LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F. & SOUTHWEST

CITY OF LUBBOCK, TEXAS

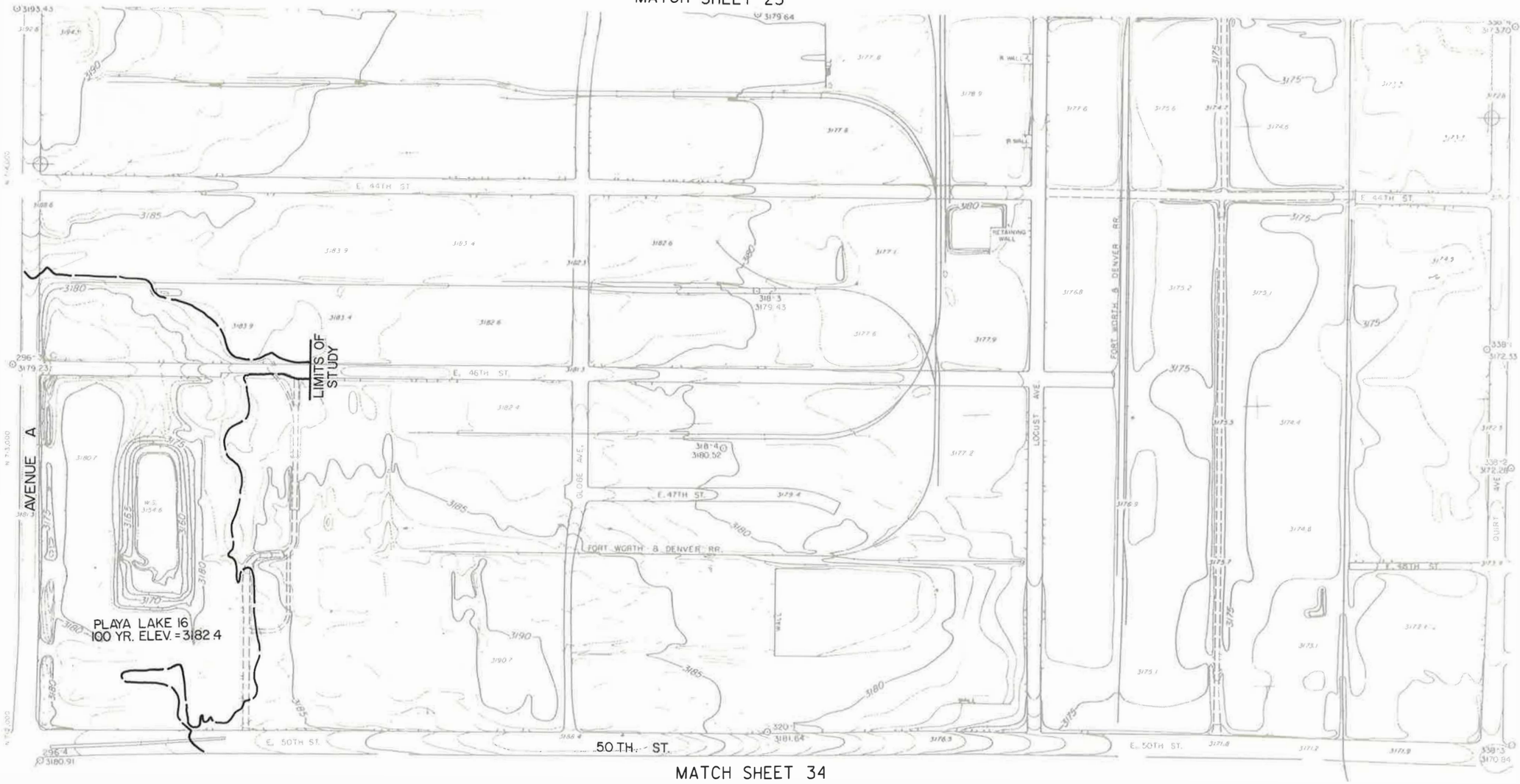
ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES	
A.H.H.	BD.CADD	12/88		9N2 BORDER.DGN	SHEET 32

MATCH SHEET 23

MATCH SHEET 32

MATCH SHEET 34



N

0 200 400 600
SCALE IN FEET

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•

• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

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SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

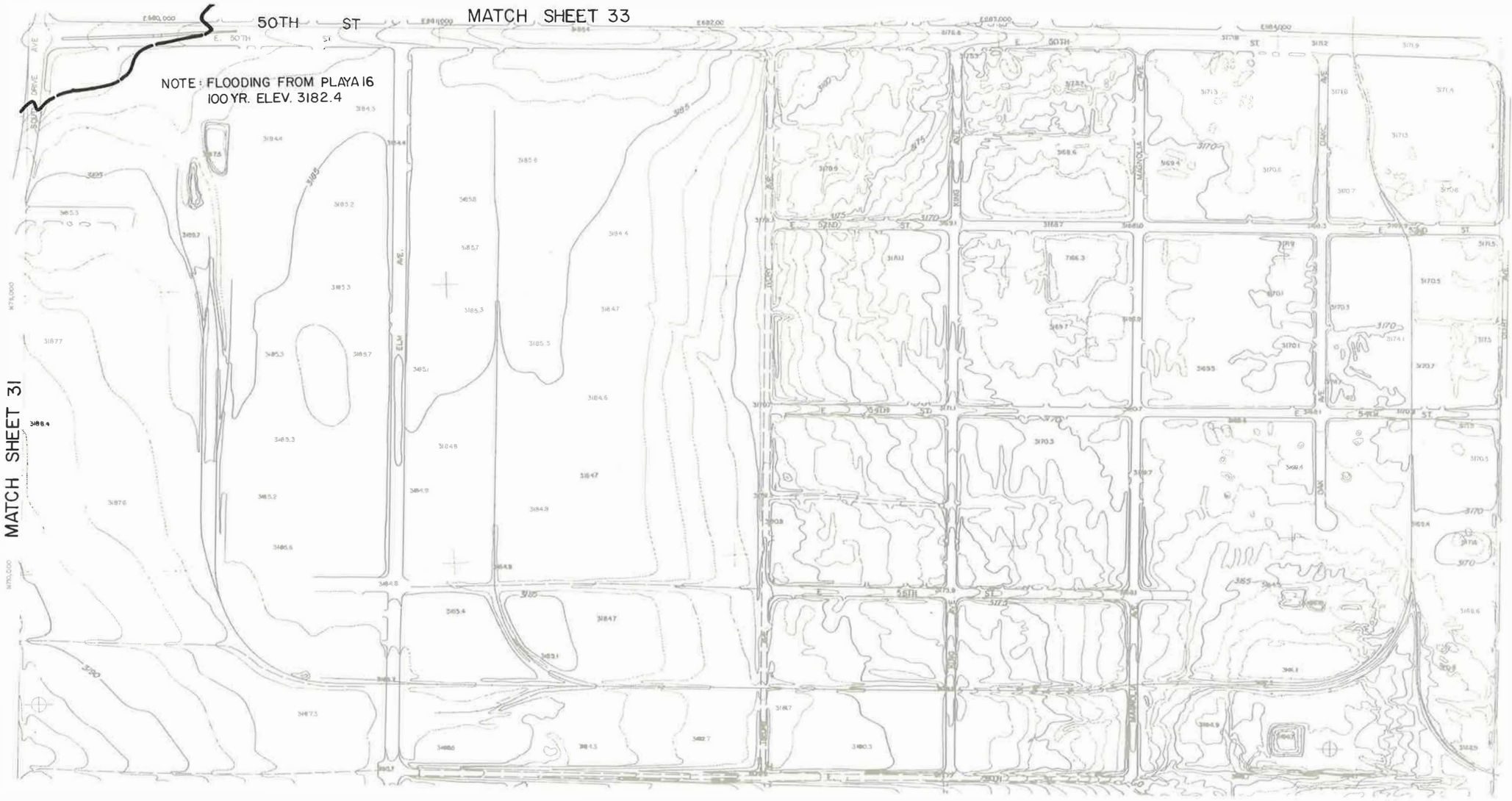
SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.H.H.	BD,CADD	12/88		1102 BORDER.DGN

SHEET 33



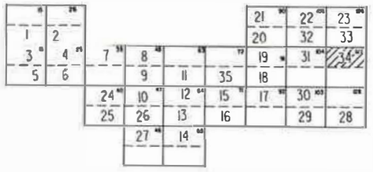
LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED



TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1978 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
AJLH	WB,CADD	12/88		SH2 BORDER.DGN

SHEET 34

MATCH SHEET II

MATCH SHEET 18

A.M. LEFTWICH PARK

PLAYA LAKE 22
100 YR. ELEV.= 3225.2

40-00

30-00

20-00

21+35

27+35

ELGIN AVE.

59TH ST.

60TH ST.

61ST ST.

62ND ST.

63RD ST.

64TH ST.

65TH ST.

66TH ST.

HARTFORD AVE

GARY AVE

INDIANA AVE

CANTON AVE

ASTON AVE

UNIVERSITY AVE

BM 78-26
3215.5

MATCH SHEET 15

N

0 200 400 600
SCALE IN FEET

LEGEND

LIMITS OF 100 YR. FLOOD PLAIN (DENOTES EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED.)

3300 BASELINE CONDITIONS 100 YR. FLOOD ELEVATION•

20+00 SYSTEM CENTERLINE AND STATIONS (FEET)

576+00 CROSS-SECTION

• 100 YEAR FLOOD BASED ON EXISTING LAKE AND OVERFLOW CONDITIONS WITH FUTURE FULLY DEVELOPED WATERSHED

TOPOGRAPHY OBTAINED FROM THE CITY OF LUBBOCK TOPOGRAPHIC MAPS (NOV.,1976 & FEB.,1986). STRUCTURES TAKEN FROM CITY OF LUBBOCK AERIAL PHOTOGRAPHY (1970, 1975, & 1986). ADDITIONAL DEVELOPMENTS AND CONSTRUCTION TAKEN FROM CUT & FILL PLANS PROVIDED BY THE CITY OF LUBBOCK.

SOUTH LUBBOCK DRAINAGE STUDY

100 YEAR FLOOD PLAIN DELINEATION

SYSTEMS E1, E2, F, & SOUTHWEST

CITY OF LUBBOCK, TEXAS

ALBERT H. HALFF ASSOCIATES, INC.
ENGINEERS & SCIENTISTS

DESIGN	DRAWN	DATE	SCALE	NOTES
A.H.H.	BD,CADD	12/88		BD2 BORDER.DGN

SHEET 35

APPENDIX B

PRELIMINARY COST ESTIMATES

APPENDIX B

The utility relocation costs shown as part of the preliminary cost estimates in Appendix B are calculated as lump sum quantities. To determine the sensitivity of the cost estimates to variations in utility relocation costs, the cost estimates were adjusted for comparison by calculating utility relocation costs for all gravity lines as a percentage (10%) of the construction cost subtotal.

Table B-1 compares the cost-benefit analyses for the study alternatives, with utility relocations costs as lump sum and as percentage of construction costs. With utility relocation costs as a percentage of the contruction costs, the total construction cost slightly increases (an average of 6.5%), while the change in benefit-cost ratio is almost negligible.

TABLE B-1

COMPARISON OF ALTERNATIVES
WITH VARIATION OF UTILITY RELOCATIONS COSTS

No.	Alternative Description	Cost Benefit Analysis with Utility Cost as Lump Sum: Average Annual Damages Prevented (Benefits)	Cost Benefit Analysis with Utility Cost as Lump Sum: Estimated Construction Cost	Cost Benefit Analysis with Utility Cost as Lump Sum: Benefit to Cost Ratio	Cost Benefit Analysis with Utility Costs as 10% of Construction: Average Annual Damages Prevented (Benefits)	Cost Benefit Analysis with Utility Costs as 10% of Construction: Estimated Construction Cost	Cost Benefit Analysis with Utility Costs as 10% of Construction: Benefit to Cost Ratio
1	Divert 100-Year Flood from Playa Lake 23 to Yellowhouse Canyon	$461,320	$12,206,700	0.43:1	$461,320	$13,174,300	0.40:1
2	Divert 10-Year Flood from Playa Lake 23 to Yellowhouse Canyon	$361,240	$ 5,910,500	0.70:1	$361,240	$ 6,248,500	0.66:1
3	Divert 100-Year Flood from Playa Lake 21 to Yellowhouse Canyon	$482,160	$ 6,666,500	0.83:1	$482,160	$ 7,080,000	0.78:1
4	Divert 10-Year Flood from Playa Lake 21 to Yellowhouse Canyon	$360,410	$ 2,603,500	1.58:1	$360,410	$ 2,610,800	1.57:1
5	10-Year Design Storm Sewer System Connecting Playa Lakes 31, 27, 26, 25, 24	$ 71,520	$ 3,486,900	0.23:1	$ 71,520	$ 3,669,900	0.22:1
6	10-Year Design Storm Sewer System Connecting Playa Lakes 19, 20, 21	$232,800	$ 3,620,000	0.73:1	$232,800	$ 3,835,400	0.69:1
7	Excavation of Playa Lake 37	$284,800	$ 7,260,000	0.44:1	$284,800	$ 7,260,000	0.44:1
8	Lower System E-1 Playa Lakes Groundwater Table	$347,170	$ 507,600	4.00:1	$347,170	$ 710,300	3.33:1
9a	Lower System E-1 Playa Lakes Normal Pool Elevations by Pump/ Gravity Outfall System (7-day average drain time)	$581,760	$11,300,500	0.59:1	$581,760	$11,989,000	0.55:1
9b	Lower System E-1 Playa Lakes Normal Pool Elevations by Pump/ Gravity Outfall System (14-day average drain time)	$581,760	$ 8,580,000	0.77:1	$581,760	$ 9,034,500	0.73:1

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE03

PROJECT: S. LUBBOCK DRAINAGE STUDY
DIVERSION ALTERNATIVE, SYSTEM E-1
PLAYA 23 TO YELLOWHOUSE CANYON
100 YEAR DESIGN, 2 - 72" PIPES
ALTERNATIVE 1

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	72 inch R.C.P. in place	60,000	LF	$140.00	$8,400,000
2	Trench Safety	30,000	LF	$1.25	$37,500
3	Manholes	20	EA	$2,000.00	$40,000
4	Extra Depth for Manholes	140	FT	$300.00	$42,000
5	Boring/Tunneling	3,750	LF	$500.00	$1,875,000
6	Inlet and Outlet Structures	2	EA	$10,000.00	$20,000
7	Utilities Adjustments	1	LS	$200,000.00	$200,000
	Subtotal				$10,614,500
	15% Contingency				$1,592,175
	TOTAL				$12,206,675

NOTES:

THIS STATEMENT WAS PREPARED UTILIZING STANDARD COST ESTIMATE PRACTICES. IT IS UNDERSTOOD AND AGREED THAT THIS IS AN ESTIMATE ONLY, AND THAT ENGINEER SHALL NOT BE LIABLE TO OWNER OR TO A THIRD PARTY FOR ANY FAILURE TO ACCURATELY ESTIMATE THE COST OF THE PROJECT, OR ANY PART THEREOF.

THIS STATEMENT DOES NOT INCLUDE COSTS FOR RIGHT-OF-WAY, ENGINEERING, SURVEYS FOR DESIGN AND CONSTRUCTION STAKING, AND GEOTECHNICAL INVESTIGATIONS.

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE04

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
DIVERSION ALTERNATIVE, SYSTEM E-1
PLAYA 23 TO YELLOWHOUSE CANYON BY: BAF
10 YEAR DESIGN, 1 - 60" PIPE
ALTERNATIVE 2

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	60 inch R.C.P. in place	30,000	LF	$110.00	$3,300,000
2	Trench Safety	30,000	LF	$1.25	$37,500
3	Manholes	20	EA	$2,000.00	$40,000
4	Extra Depth for Manholes	140	FT	$300.00	$42,000
5	Boring/Tunneling	3,750	LF	$400.00	$1,500,000
6	Inlet and Outlet Structures	2	EA	$10,000.00	$20,000
7	Utilities Adjustments	1	LS	$200,000.00	$200,000
	Subtotal				$5,139,500
	15% Contingency				$770,925
	TOTAL				$5,910,425

NOTES:

THIS STATEMENT WAS PREPARED UTILIZING STANDARD COST ESTIMATE PRACTICES. IT IS UNDERSTOOD AND AGREED THAT THIS IS AN ESTIMATE ONLY, AND THAT ENGINEER SHALL NOT BE LIABLE TO OWNER OR TO A THIRD PARTY FOR ANY FAILURE TO ACCURATELY ESTIMATE THE COST OF THE PROJECT, OR ANY PART THEREOF.

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE01

PROJECT: S. LUBBOCK DRAINAGE STUDY
DIVERSION ALTERNATIVE, SYSTEM E-1
PLAYA 21 TO YELLOWHOUSE CANYON
100 YEAR DESIGN, 2 - 60" DIAM. PIPES
ALTERNATIVE 3

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	60 inch R.C.P. in place	44,000	LF	$110.00	$4,840,000
2	Trench Safety	22,000	LF	$1.25	$27,500
3	Manholes	13	EA	$2,000.00	$26,000
4	Extra Depth for Manholes	338	FT	$300.00	$101,400
5	Street Repair	194,000	SF	$3.00	$582,000
6	Inlet and Outlet Structures	2	EA	$10,000.00	$20,000
7	Utilities Adjustments	1	LS	$200,000.00	$200,000
	Subtotal				$5,796,900
	15% Contingency				$869,535
	TOTAL				$6,666,435

NOTES:

THIS STATEMENT WAS PREPARED UTILIZING STANDARD COST ESTIMATE PRACTICES. IT IS UNDERSTOOD AND AGREED THAT THIS IS AN ESTIMATE ONLY, AND THAT ENGINEER SHALL NOT BE LIABLE TO OWNER OR TO A THIRD PARTY FOR ANY FAILURE TO ACCURATELY ESTIMATE THE COST OF THE PROJECT, OR ANY PART THEREOF.

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE02

PROJECT: S. LUBBOCK DRAINAGE STUDY
DIVERSION ALTERNATIVE, SYSTEM E-1
PLAYA 21 TO YELLOWHOUSE CANYON
10 YEAR DESIGN, 1- 36" DIAM. PIPE
ALTERNATIVE 4

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	36 inch R.C.P. in place	22,000	LF	$75.00	$1,650,000
2	Trench Safety	22,000	LF	$1.25	$27,500
3	Manholes	13	EA	$2,000.00	$26,000
4	Extra Depth for Manholes	338	FT	$300.00	$101,400
5	Street Repair	83,000	SF	$3.00	$249,000
6	Inlet and Outlet Structures	2	EA	$5,000.00	$10,000
7	Utilities Adjustments	1	LS	$200,000.00	$200,000
	Subtotal				$2,263,900
	15% Contingency				$339,585
	TOTAL				$2,603,485

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE05

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PLAYAS 31-27-26-25-24 BY: BAF
10 YEAR DESIGN, REACH 31-27
ALTERNATIVE 5

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	48 inch R.C.P. in place	4,150	LF	$85.00	$352,750
2	Trench Safety	4,150	LF	$1.25	$5,188
3	Manholes	4	EA	$2,000.00	$8,000
4	Extra Depth for Manholes	0	FT	$300.00	$0
5	Street Repair	28,700	SF	$3.00	$86,100
6	Inlet and Outlet Structures	2	EA	$5,000.00	$10,000
7	Utilities Adjustments	1	LS	$10,000.00	$10,000
	Subtotal				$472,038
	15% Contingency				$70,806
	TOTAL				$542,843

NOTES:

THIS STATEMENT WAS PREPARED UTILIZING STANDARD COST ESTIMATE PRACTICES. IT IS UNDERSTOOD AND AGREED THAT THIS IS AN ESTIMATE ONLY, AND THAT ENGINEER SHALL NOT BE LIABLE TO OWNER OR TO A THIRD PARTY FOR ANY FAILURE TO ACCURATELY ESTIMATE THE COST OF THE PROJECT, OR ANY PART THEREOF.

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK

FILE: CE06

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PLAYAS 31-27-26-25-24
10 YEAR DESIGN, REACH 27-26
ALTERNATIVE 5

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	12'x6' Concrete Box	2,200	LF	$330.00	$726,000
2	Trench Excavation	11,000	CY	$7.00	$77,000
3	Trench Safety	2,200	LF	$1.25	$2,750
4	Manholes	4	EA	$2,000.00	$8,000
5	Street Repair	27,000	SF	$3.00	$81,000
6	Inlet and Outlet Structures	2	EA	$10,000.00	$20,000
7	Utilities Adjustments	1	LS	$10,000.00	$10,000
	Subtotal				$924,750
	15% Contingency				$138,713
	TOTAL				$1,063,463

NOTES:

THIS STATEMENT WAS PREPARED UTILIZING STANDARD COST ESTIMATE PRACTICES. IT IS UNDERSTOOD AND AGREED THAT THIS IS AN ESTIMATE ONLY, AND THAT ENGINEER SHALL NOT BE LIABLE TO OWNER OR TO A THIRD PARTY FOR ANY FAILURE TO ACCURATELY ESTIMATE THE COST OF THE PROJECT, OR ANY PART THEREOF.

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK — FILE: CE07

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PLAYAS 31-27-26-25-24
10 YEAR DESIGN, REACH 26-25
ALTERNATIVE 5

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	2 - DBL. 5x4 Box Culverts	120	LF	$260.00	$31,200
2	Lower F.L. of Hwy. Boxes	222	LF	$1,100.00	$244,200
3	Trench Excavation for 5x4's	250	CY	$7.00	$1,750
4	Excavation for Hwy. Boxes	1,400	CY	$10.00	$14,000
5	Regrade Channel	2,600	CY	$1.10	$2,860
6	Street Repair	720	SF	$3.00	$2,160
7	Inlet and Outlet Structures	4	EA	$5,000.00	$20,000
8	Utilities Adjustments	1	LS	$3,000.00	$3,000
	Subtotal				$319,170
	15% Contingency				$47,876
	TOTAL				$367,046

NOTES:

THIS STATEMENT WAS PREPARED UTILIZING STANDARD COST ESTIMATE PRACTICES. IT IS UNDERSTOOD AND AGREED THAT THIS IS AN ESTIMATE ONLY, AND THAT ENGINEER SHALL NOT BE LIABLE TO OWNER OR TO A THIRD PARTY FOR ANY FAILURE TO ACCURATELY ESTIMATE THE COST OF THE PROJECT, OR ANY PART THEREOF.

THIS STATEMENT DOES NOT INCLUDE COSTS FOR RIGHT-OF-WAY, ENGINEERING, SURVEYS FOR DESIGN AND CONSTRUCTION STAKING, AND GEOTECHNICAL INVESTIGATIONS.

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE08

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PLAYAS 31-27-26-25-24
10 YEAR DESIGN, REACH 25-24
ALTERNATIVE 5

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	2 - 60" R.C.P. in place	1,500	LF	$110.00	$165,000
2	Trench Safety	1,500	LF	$1.25	$1,875
3	Street Repair	560	SF	$3.00	$1,680
4	Inlet and Outlet Structures	2	EA	$5,000.00	$10,000
5	Utilities Adjustments	1	LS	$5,000.00	$5,000
	Subtotal				$183,555
	15% Contingency				$27,533
	TOTAL				$211,088

NOTES:

THIS STATEMENT WAS PREPARED UTILIZING STANDARD COST ESTIMATE PRACTICES. IT IS UNDERSTOOD AND AGREED THAT THIS IS AN ESTIMATE ONLY, AND THAT ENGINEER SHALL NOT BE LIABLE TO OWNER OR TO A THIRD PARTY FOR ANY FAILURE TO ACCURATELY ESTIMATE THE COST OF THE PROJECT, OR ANY PART THEREOF.

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE09

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PLAYAS 31-27-26-25-24
10 YEAR DESIGN, REACH 24
ALTERNATIVE 5

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Clear and Grub	35	AC	$500.00	$17,500
2	Trench Excavation	500,000	CY	$1.95	$975,000
3	Grass Slopes and Bottom	1	LS	$130,000.00	$130,000
4	Utilities Adjustments	1	LS	$10,000.00	$10,000
	Subtotal				$1,132,500
	15% Contingency				$169,875
	TOTAL				$1,302,375

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK

FILE: CE10

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PLAYAS 19-20-21
10 YEAR DESIGN, REACH 19-21
ALTERNATIVE 6

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	48" R.C.P. in place	7,170	LF	$85.00	$609,450
2	Trench Safety	7,170	LF	$1.25	$8,963
3	Excavation for Playa 19	256,000	CY	$1.95	$499,200
4	Grass Slopes and Bottom	165,000	SY	$0.50	$82,500
5	Manholes	8	EA	$2,000.00	$16,000
6	Extra Depth for Manholes	48	FT	$300.00	$14,400
7	Street Repair	45,000	SF	$3.00	$135,000
8	Inlet and Outlet Structures	2	EA	$5,000.00	$10,000
9	Utilities Adjustments	1	LS	$20,000.00	$20,000
	Subtotal				$1,395,513
	15% Contingency				$209,327
	TOTAL				$1,604,839

NOTES:

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THIS STATEMENT DOES NOT INCLUDE COSTS FOR RIGHT-OF-WAY, ENGINEERING, SURVEYS FOR DESIGN AND CONSTRUCTION STAKING, AND GEOTECHNICAL INVESTIGATIONS.

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE11

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PLAYAS 19-20-21
10 YEAR DESIGN, REACH 20-21
ALTERNATIVE 6

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	48" R.C.P.	5,050	LF	$85.00	$429,250
2	Trench Safety	5,050	LF	$1.25	$6,313
3	Excavation for Playa 20	101,000	CY	$1.95	$196,950
4	Grass Slopes and Bottom	83,000	SY	$0.50	$41,500
5	Manholes	6	EA	$2,000.00	$12,000
6	Extra Depth for Manholes	36	FT	$300.00	$10,800
7	Street Repair	30,000	SF	$3.00	$90,000
8	Inlet and Outlet Structures	2	EA	$5,000.00	$10,000
9	Utilities Adjustments	1	LS	$10,000.00	$10,000
	Subtotal				$806,813
	15% Contingency				$121,022
	TOTAL				$927,834

NOTES:

THIS STATEMENT WAS PREPARED UTILIZING STANDARD COST ESTIMATE PRACTICES. IT IS UNDERSTOOD AND AGREED THAT THIS IS AN ESTIMATE ONLY, AND THAT ENGINEER SHALL NOT BE LIABLE TO OWNER OR TO A THIRD PARTY FOR ANY FAILURE TO ACCURATELY ESTIMATE THE COST OF THE PROJECT, OR ANY PART THEREOF.

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE12

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PLAYAS 19-20-21
10 YEAR DESIGN, REACH 21
ALTERNATIVE 6

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Excavation for Playa 21	399,000	CY	$1.95	$778,050
2	Grass Slopes and Bottom	315,000	SY	$0.50	$157,500
3	Utilities Adjustments	1	LS	$10,000.00	$10,000
	Subtotal				$945,550
	15% Contingency				$141,833
	TOTAL				$1,087,383

NOTES:

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THIS STATEMENT DOES NOT INCLUDE COSTS FOR RIGHT-OF-WAY, ENGINEERING, SURVEYS FOR DESIGN AND CONSTRUCTION STAKING, AND GEOTECHNICAL INVESTIGATIONS.

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE15

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PLAYA 37 BY: BAF
EXCAVATE TO CONTAIN 50% URB. 100YR
FLOOD
ALTERNATIVE 7

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Excavation for Playa 37	2,556,000	CY	$1.50	$3,834,000
2	Grass Slopes	150,000	SY	$0.50	$75,000
	Subtotal				$3,909,000
	15% Contingency				$586,350
	TOTAL				$4,495,350

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE16

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PLAYA 37 BY: BAF
EXCAVATE TO CONTAIN 100% URB. 100YR
FLOOD
ALTERNATIVE 7

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Excavation for Playa 37	4,110,000	CY	$1.50	$6,165,000
2	Grass Slopes	297,000	SY	$0.50	$148,500
	Subtotal				$6,313,500
	15% Contingency				$947,025
	TOTAL				$7,260,525

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE17

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GROUNDWATER FOR ADDITIONAL
PLAYA LAKE STORAGE
ALTERNATIVE 8

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Water Well/Pump Station	11	EA	$15,000.00	$165,000
2	Trench Excavation	8,800	CY	$7.00	$61,600
3	Stone Embedment	1,280	CY	$12.50	$16,000
4	Select Backfill	6,690	CY	$6.25	$41,813
3	18 inch PVC Pipe	3,000	LF	$14.13	$42,390
4	10 inch PVC Pipe	6,600	LF	$4.06	$26,796
5	8 inch PVC Pipe	6,600	LF	$2.65	$17,490
8	Trench Safety	16,200	LF	$1.25	$20,250
9	Utilities Adjustments	1	LS	$50,000.00	$50,000
	Subtotal				$441,339
	15% Contingency				$66,201
	TOTAL				$507,539

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE27

PROJECT: S. LUBBOCK DRAINAGE STUDY
MAIN TRUNK LINE ALONG LOOP 289
LOWER SYS. E-1 LAKES FOR ADDITONAL STORAGE, 60 INCH PIPE.
ALTERNATIVE 9A

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	60" R.C.P. in place	52,800	LF	$120.00	$6,336,000
2	Trench Safety	50,350	LF	$1.25	$62,938
3	Manholes	10	EA	$2,000.00	$20,000
4	Street Repair	356,120	SF	$3.00	$1,068,360
5	Outlet Structure	1	LS	$10,000.00	$10,000
6	Utilities Adjustments	1	LS	$200,000.00	$200,000
7	Boring/Tunneling	2,450	LF	$200.00	$490,000
	Subtotal				$8,187,298
	15% Contingency				$1,228,095
	TOTAL				$9,415,392

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE25

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL BY: BAF
PLAYA 37 - EXISTING CONDITIONS
ALTERNATIVE 9A

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$264,200.00	$264,200
2	24 inch PVC Pipe	200	LF	$25.72	$5,144
3	18 inch PVC Pipe	200	LF	$14.13	$2,826
4	Excavation	290	CY	$7.00	$2,030
5	Stone Embedment	50	CY	$12.50	$625
6	Select Backfill	220	CY	$6.25	$1,375
7	Manhole	1	EA	$10,000.00	$10,000
8	Air Release Stations	4	EA	$1,875.00	$7,500
9	Air Release Valves	4	EA	$812.00	$3,248
10	Tie Into Main Trunk Line	1	LS	$2,000.00	$2,000
	Subtotal				$298,948
	15% Contingency				$44,842
	TOTAL				$343,790

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE26

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL
PLAYA 37 - FUTURE CONDITIONS
ALTERNATIVE 9A

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$167,000.00	$167,000
2	24 inch PVC Pipe	200	LF	$25.72	$5,144
3	Excavation	170	CY	$7.00	$1,190
4	Stone Embedment	30	CY	$12.50	$375
5	Select Backfill	120	CY	$6.25	$750
6	Air Release Stations	2	EA	$1,875.00	$3,750
7	Air Release Valves	2	EA	$812.00	$1,624
8	Tie Into Main Trunk Line	1	LS	$2,000.00	$2,000
	Subtotal				$181,833
	15% Contingency				$27,275
	TOTAL				$209,108

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE30

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL BY: BAF
PLAYA 31
ALTERNATIVE 9A

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$122,800.00	$122,800
2	18 inch PVC Pipe	2,840	LF	$14.13	$40,129
3	Excavation	2,044	CY	$7.00	$14,308
4	Stone Embedment	260	CY	$12.50	$3,250
5	Select Backfill	1,600	CY	$6.25	$10,000
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	5	EA	$1,875.00	$9,375
8	Air Release Valves	5	EA	$812.00	$4,060
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
	Subtotal				$206,922
	15% Contingency				$31,038
	TOTAL				$237,961

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE18

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL
PLAYA 27
ALTERNATIVE 9A

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	LS	$94,500.00	$94,500
2	12 inch PVC Pipe	3,250	LF	$5.80	$18,850
3	Excavation	1,950	CY	$7.00	$13,650
4	Select Backfill	1,600	CY	$6.25	$10,000
5	Stone Embedment	150	CY	$12.50	$1,875
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	2	EA	$1,875.00	$3,750
8	Air Release Valves	2	EA	$812.00	$1,624
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
10	Street Repair	6500	SF	$3.00	$19,500
	Subtotal				$166,749
	15% Contingency				$25,012
	TOTAL				$191,761

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE19

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL BY: BAF
PLAYA 26
ALTERNATIVE 9A

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$90,900.00	$90,900
2	18 inch PVC Pipe	200	LF	$14.13	$2,826
3	Excavation	133	CY	$7.00	$931
4	Stone Embedment	15	CY	$12.50	$188
5	Select Backfill	93	CY	$6.25	$581
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	2	EA	$1,875.00	$3,750
8	Air Release Valves	2	EA	$812.00	$1,624
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
	Subtotal				$103,800
	15% Contingency				$15,570
	TOTAL				$119,370

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE20

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL BY: BAF
PLAYA 25
ALTERNATIVE 9A

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$96,000.00	$96,000
2	18 inch PVC Pipe	1,850	LF	$14.13	$26,141
3	Excavation	1,290	CY	$7.00	$9,030
4	Stone Embedment	122	CY	$12.50	$1,525
5	Select Backfill	950	CY	$6.25	$5,938
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations/Valves	2	EA	$2,687.00	$5,374
8	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
9	Bore/Tunnel	200	LF	$100.00	$20,000
10	Street Repair	4950	SF	$3.00	$14,850
	Subtotal				$181,857
	15% Contingency				$27,279
	TOTAL				$209,136

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE21

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL BY: BAF
PLAYA 24
ALTERNATIVE 9A

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$90,900.00	$90,900
2	18 inch PVC Pipe	300	LF	$14.13	$4,239
3	Excavation	70	CY	$7.00	$490
4	Stone Embedment	10	CY	$12.50	$125
5	Select Backfill	50	CY	$6.25	$313
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	2	EA	$1,875.00	$3,750
8	Air Release Valves	2	EA	$812.00	$1,624
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
10	Bore/Tunnel	200	LF	$100.00	$20,000
	Subtotal				$124,441
	15% Contingency				$18,666
	TOTAL				$143,107

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK — FILE: CE22

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL
PLAYA 23
ALTERNATIVE 9A

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$71,800.00	$71,800
2	12 inch PVC Pipe	300	LF	$5.80	$1,740
3	Excavation	40	CY	$7.00	$280
4	Stone Embedment	10	CY	$12.50	$125
5	Select Backfill	30	CY	$6.25	$188
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	2	EA	$1,875.00	$3,750
8	Air Release Valves	2	EA	$812.00	$1,624
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
10	Bore/Tunnel	200	LF	$100.00	$20,000
	Subtotal				$102,507
	15% Contingency				$15,376
	TOTAL				$117,882

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE23

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL
PLAYA 19
ALTERNATIVE 9A

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$71,800.00	$71,800
2	12 inch PVC Pipe	200	LF	$5.80	$1,160
3	Excavation	40	CY	$7.00	$280
4	Stone Embedment	10	CY	$12.50	$125
5	Select Backfill	30	CY	$6.25	$188
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	2	EA	$1,875.00	$3,750
8	Air Release Valves	2	EA	$812.00	$1,624
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
10	Bore/Tunnel	100	LF	$100.00	$10,000
	Subtotal				$91,927
	15% Contingency				$13,789
	TOTAL				$105,715

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK — FILE: CE24

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL
PLAYA 20
ALTERNATIVE 9A

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$97,700.00	$97,700
2	12 inch PVC Pipe	4,160	LF	$5.80	$24,128
3	Excavation	1,700	CY	$7.00	$11,900
4	Stone Embedment	190	CY	$12.50	$2,375
5	Select Backfill	1,300	CY	$6.25	$8,125
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	3	EA	$1,875.00	$5,625
8	Air Release Valves	3	EA	$812.00	$2,436
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
10	Street Repair	8320	SF	$3.00	$24,960
	Subtotal				$180,249
	15% Contingency				$27,037
	TOTAL				$207,286

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE40

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
MAIN TRUNK LINE ALONG LOOP 289
LOWER SYS. E-1 LAKES FOR ADDITONAL STORAGE, 48 INCH PIPE. BY: BAF
14 DAY DRAIN
ALTERNATIVE 9B

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	48" R.C.P. in place	52,800	LF	$85.00	$4,488,000
2	Trench Safety	50,350	LF	$1.25	$62,938
3	Manholes	10	EA	$2,000.00	$20,000
4	Street Repair	305,246	SF	$3.00	$915,738
5	Outlet Structure	1	LS	$10,000.00	$10,000
6	Utilities Adjustments	1	LS	$200,000.00	$200,000
7	Boring/Tunneling	2,450	LF	$200.00	$490,000
	Subtotal				$6,186,676
	15% Contingency				$928,001
	TOTAL				$7,114,677

NOTES:

THIS STATEMENT WAS PREPARED UTILIZING STANDARD COST ESTIMATE PRACTICES. IT IS UNDERSTOOD AND AGREED THAT THIS IS AN ESTIMATE ONLY, AND THAT ENGINEER SHALL NOT BE LIABLE TO OWNER OR TO A THIRD PARTY FOR ANY FAILURE TO ACCURATELY ESTIMATE THE COST OF THE PROJECT, OR ANY PART THEREOF.

THIS STATEMENT DOES NOT INCLUDE COSTS FOR RIGHT-OF-WAY, ENGINEERING, SURVEYS FOR DESIGN AND CONSTRUCTION STAKING, AND GEOTECHNICAL INVESTIGATIONS.

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE38

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL BY: BAF
PLAYA 37 - EXISTING CONDITIONS, 14 DAY DRAIN
ALTERNATIVE 9B

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$66,200.00	$66,200
2	24 inch PVC Pipe	200	LF	$25.72	$5,144
3	18 inch PVC Pipe	200	LF	$14.13	$2,826
4	Excavation	290	CY	$7.00	$2,030
5	Stone Embedment	50	CY	$12.50	$625
6	Select Backfill	220	CY	$6.25	$1,375
7	Manhole	1	EA	$10,000.00	$10,000
8	Air Release Stations	4	EA	$1,875.00	$7,500
9	Air Release Valves	4	EA	$812.00	$3,248
10	Tie Into Main Trunk Line	1	LS	$2,000.00	$2,000
	Subtotal				$100,948
	15% Contingency				$15,142
	TOTAL				$116,090

NOTES:

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THIS STATEMENT DOES NOT INCLUDE COSTS FOR RIGHT-OF-WAY, ENGINEERING, SURVEYS FOR DESIGN AND CONSTRUCTION STAKING, AND GEOTECHNICAL INVESTIGATIONS.

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE39

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL BY: BAF
PLAYA 37 - FUTURE CONDITIONS, 14 DAY DRAIN
ALTERNATIVE 9B

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$167,000.00	$167,000
2	24 inch PVC Pipe	200	LF	$25.72	$5,144
3	Excavation	170	CY	$7.00	$1,190
4	Stone Embedment	30	CY	$12.50	$375
5	Select Backfill	120	CY	$6.25	$750
6	Air Release Stations	2	EA	$1,875.00	$3,750
7	Air Release Valves	2	EA	$812.00	$1,624
8	Tie Into Main Trunk Line	1	LS	$2,000.00	$2,000
	Subtotal				$181,833
	15% Contingency				$27,275
	TOTAL				$209,108

NOTES:

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THIS STATEMENT DOES NOT INCLUDE COSTS FOR RIGHT-OF-WAY, ENGINEERING, SURVEYS FOR DESIGN AND CONSTRUCTION STAKING, AND GEOTECHNICAL INVESTIGATIONS.

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK — FILE: CE43

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL
PLAYA 31, 14 DAY DRAIN
ALTERNATIVE 9B

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$72,000.00	$72,000
2	18 inch PVC Pipe	2,840	LF	$14.13	$40,129
3	Excavation	2,044	CY	$7.00	$14,308
4	Stone Embedment	260	CY	$12.50	$3,250
5	Select Backfill	1,600	CY	$6.25	$10,000
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	5	EA	$1,875.00	$9,375
8	Air Release Valves	5	EA	$812.00	$4,060
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
	Subtotal				$156,122
	15% Contingency				$23,418
	TOTAL				$179,541

NOTES:

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THIS STATEMENT DOES NOT INCLUDE COSTS FOR RIGHT-OF-WAY, ENGINEERING, SURVEYS FOR DESIGN AND CONSTRUCTION STAKING, AND GEOTECHNICAL INVESTIGATIONS.

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE31

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL
PLAYA 27 - 14 DAY DRAIN
ALTERNATIVE 9B

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	LS	$69,000.00	$69,000
2	12 inch PVC Pipe	3,250	LF	$5.80	$18,850
3	Excavation	1,950	CY	$7.00	$13,650
4	Select Backfill	1,600	CY	$6.25	$10,000
5	Stone Embedment	150	CY	$12.50	$1,875
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	2	EA	$1,875.00	$3,750
8	Air Release Valves	2	EA	$812.00	$1,624
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
10	Street Repair	6500	SF	$3.00	$19,500
	Subtotal				$141,249
	15% Contingency				$21,187
	TOTAL				$162,436

NOTES:

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THIS STATEMENT DOES NOT INCLUDE COSTS FOR RIGHT-OF-WAY, ENGINEERING, SURVEYS FOR DESIGN AND CONSTRUCTION STAKING, AND GEOTECHNICAL INVESTIGATIONS.

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE32

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL BY: BAF
PLAYA 26 - 14 DAY DRAIN
ALTERNATIVE 9B

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$72,000.00	$72,000
2	18 inch PVC Pipe	200	LF	$14.13	$2,826
3	Excavation	133	CY	$7.00	$931
4	Stone Embedment	15	CY	$12.50	$188
5	Select Backfill	93	CY	$6.25	$581
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	2	EA	$1,875.00	$3,750
8	Air Release Valves	2	EA	$812.00	$1,624
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
	Subtotal				$84,900
	15% Contingency				$12,735
	TOTAL				$97,635

NOTES:

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THIS STATEMENT DOES NOT INCLUDE COSTS FOR RIGHT-OF-WAY, ENGINEERING, SURVEYS FOR DESIGN AND CONSTRUCTION STAKING, AND GEOTECHNICAL INVESTIGATIONS.

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE33

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL
PLAYA 25 - 14 DAY DRAIN
ALTERNATIVE 9B

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$85,400.00	$85,400
2	18 inch PVC Pipe	1,850	LF	$14.13	$26,141
3	Excavation	1,290	CY	$7.00	$9,030
4	Stone Embedment	122	CY	$12.50	$1,525
5	Select Backfill	950	CY	$6.25	$5,938
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations/Valves	2	EA	$2,687.00	$5,374
8	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
9	Bore/Tunnel	200	LF	$100.00	$20,000
10	Street Repair	4950	SF	$3.00	$14,850
	Subtotal				$171,257
	15% Contingency				$25,689
	TOTAL				$196,946

NOTES:

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THIS STATEMENT DOES NOT INCLUDE COSTS FOR RIGHT-OF-WAY, ENGINEERING, SURVEYS FOR DESIGN AND CONSTRUCTION STAKING, AND GEOTECHNICAL INVESTIGATIONS.

ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE34

PROJECT: S. LUBBOCK DRAINAGE STUDY DATE: 9/88
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL BY: BAF
PLAYA 24 - 14 DAY DRAIN
ALTERNATIVE 9B

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$71,700.00	$71,700
2	18 inch PVC Pipe	300	LF	$14.13	$4,239
3	Excavation	70	CY	$7.00	$490
4	Stone Embedment	10	CY	$12.50	$125
5	Select Backfill	50	CY	$6.25	$313
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	2	EA	$1,875.00	$3,750
8	Air Release Valves	2	EA	$812.00	$1,624
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
10	Bore/Tunnel	200	LF	$100.00	$20,000
	Subtotal				$105,241
	15% Contingency				$15,786
	TOTAL				$121,027

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE35

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL
PLAYA 23 - 14 DAY DRAIN
ALTERNATIVE 9B

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$66,200.00	$66,200
2	12 inch PVC Pipe	300	LF	$5.80	$1,740
3	Excavation	40	CY	$7.00	$280
4	Stone Embedment	10	CY	$12.50	$125
5	Select Backfill	30	CY	$6.25	$188
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	2	EA	$1,875.00	$3,750
8	Air Release Valves	2	EA	$812.00	$1,624
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
10	Bore/Tunnel	200	LF	$100.00	$20,000
	Subtotal				$96,907
	15% Contingency				$14,536
	TOTAL				$111,442

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK

FILE: CE36

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL
PLAYA 19 - 14 DAY DRAIN
ALTERNATIVE 9B

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$66,200.00	$66,200
2	12 inch PVC Pipe	200	LF	$5.80	$1,160
3	Excavation	40	CY	$7.00	$280
4	Stone Embedment	10	CY	$12.50	$125
5	Select Backfill	30	CY	$6.25	$188
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	2	EA	$1,875.00	$3,750
8	Air Release Valves	2	EA	$812.00	$1,624
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
10	Bore/Tunnel	100	LF	$100.00	$10,000
	Subtotal				$86,327
	15% Contingency				$12,949
	TOTAL				$99,275

NOTES:

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ALBERT H. HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TEXAS 76137
817 847-1422

CLIENT: CITY OF LUBBOCK FILE: CE37

PROJECT: S. LUBBOCK DRAINAGE STUDY
FLOOD CONTROL ALTERNATIVE, SYSTEM E-1
PUMP GRAVITY OUTFALL
PLAYA 20 - 14 DAY DRAIN
ALTERNATIVE 9B

DATE: 9/88

BY: BAF

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Pump Station	1	L.S.	$63,400.00	$63,400
2	12 inch PVC Pipe	4,160	LF	$5.80	$24,128
3	Excavation	1,700	CY	$7.00	$11,900
4	Stone Embedment	190	CY	$12.50	$2,375
5	Select Backfill	1,300	CY	$6.25	$8,125
6	Manhole	1	EA	$2,000.00	$2,000
7	Air Release Stations	3	EA	$1,875.00	$5,625
8	Air Release Valves	3	EA	$812.00	$2,436
9	Tie Into Main Trunk Line	1	LS	$1,000.00	$1,000
10	Street Repair	8320	SF	$3.00	$24,960
	Subtotal				$145,949
	15% Contingency				$21,892
	TOTAL				$167,841

NOTES:

THIS STATEMENT WAS PREPARED UTILIZING STANDARD COST ESTIMATE PRACTICES. IT IS UNDERSTOOD AND AGREED THAT THIS IS AN ESTIMATE ONLY, AND THAT ENGINEER SHALL NOT BE LIABLE TO OWNER OR TO A THIRD PARTY FOR ANY FAILURE TO ACCURATELY ESTIMATE THE COST OF THE PROJECT, OR ANY PART THEREOF.

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APPENDIX C

PROFILES AND COMPUTER SUMMARIES OF HYDROLOGIC AND HYDRAULIC MODELS
(Printed in Separate Volume)