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March 23, 1996
AVO 14191

City of McAllen
1300 West Houston
McAllen, Texas 78501

Attn: Mr. Tom Martin, P.E.
Assistant City Manager

City of Mission
900 Doherty
Mission, Texas 78572

Attn: Pat Townsend, Jr.
City Manager

Re: Flood Protection Planning Study
for Southern McAllen and Mission, Texas
TWDB Contract No. 95-483-077

Dear Messrs. Martin and Townsend:

Transmitted herewith are twenty (20) bound copies of the Final Report entitled, Flood Protection Planning Study for Southern McAllen and Mission, Texas.

This report includes a brief executive summary and a detail discussion of study procedures, results of technical analyses, alternative improvements, and recomendations. A detailed watershed delineation, 10-, 25-, and 100-year flood plain delineations, and computed flood profiles of the Mission Floodway, for existing and ultimate land use conditions, are included.

It has been a privilege and a challenge for our firm to prepare this most important study. Halff Associates are especially appreciative of the cooperation of the members of the City Staff of McAllen and Mission who have assisted in the development of this study.

Sincerely,

HALFF ASSOCIATES, INC.

STATE OF TEXAS
MICHAEL A. MOYA
63170
REGISTERED
PROFESSIONAL ENGINEER

Michael A. Moya

Michael A. Moya, P.E.

enclosures

cc: Mr. Abu Sayeed, Texas Water Development Board

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TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

APPENDICES

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

Halff Associates, Inc. wishes to acknowledge the valuable assistance of the various organizations and individuals who have assisted in the preparation of the Flood Protection Planning Study for Southern McAllen and Mission, Texas. We wish to express our gratitude to all those listed below who have contributed their time and effort to this study.

The following have provided a tremendous amount of information and personal experience related to flooding problems and have also provided valuable suggestions for solutions to these problems. Mr. Tom Martin, P.E., City of McAllen City Engineer, Mr. Pat Townsend Jr., City of Mission City Manager, Ms. Vona Walker, Hidalgo County, and Mr. Abu Sayeed, Texas Water Development Board.

The employees of Halff Associates who have worked most closely with the project include: Mr. Michael A. Moya, P.E., Ms. Emilia Salcido, P.E., Ms. Cindy Mosier, E.I.T., Ms. Dana Woods, E.I.T., Mr. Ron Slonaker, Ms. Nancy MacSwain, Mr. Raul Wong, Jr., P.E., Mr. Celso Gonzalez, E.I.T., Mr. Joe Novoa, P.E., and Mr. Martin Molloy, P.E. Halff Associates deeply appreciates the dedicated efforts of all the groups and individuals who have helped in the performance of this study.

GLOSSARY OF TERMS

BASE FLOOD. The flood having a one percent chance of being equalled or exceeded in any given year, the 100-year flood. Note, for this study the base flood is based on a future fully urbanized watershed and existing channels and bridges with floodway encroachments in-place to account for potential upstream losses in valley storage. The FEMA base flood is based on existing land use and existing channels/bridges.

DISCHARGE. As applied to a stream, the rate of flow, or volume of water flowing in a given stream at a given place and 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 lake, stream, sewer, or drain. Also called catchment area, watershed, and river basin.

DTM. Digital Terrain Model, three dimensional digital surface model, with x, y, and z attributes, generated from field surveys and/or aerial photography

FLOOD. An overflow of 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 river or stream or an ocean, lake, or other body of standing water. Normally, a "flood" is considered as any temporary rise is a stream flow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, and rise of ground water coincident with increased stream flow.

FLOOD FREQUENCY. A means of expressing the probability of flood occurrences as determined from a statistical analysis of representative stream flow, rainfall and runoff records. A 10-year frequency flood would have an average frequency of occurrence in the order 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 an average frequency of occurrence in the order 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 an average frequency of occurrence in the order 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 an average frequency 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 PEAK. The maximum instantaneous discharge of a flood at a given location. It usually occurs at or near the time of the flood crest.

FLOOD PLAIN. The relatively flat area or low lands adjoining the channel of a river, stream or watercourse or ocean, lake or other body of standing water, which has been or may be covered by flood water.

GLOSSARY OF TERMS
(Continued)

FLOOD PROFILE. A graph showing the relationship of water surface elevation to location, the latter generally expressed as distance above the mouth for a stream of water flowing in an open channel. It is generally drawn to show surface elevation for the peak of a specific flood, but may be prepared for conditions at a given time or stage.

FLOOD STORAGE. The term used to describe a channel and flood plain's capacity to store some portion of the runoff volume as a flood wave moves downstream.

FLOODWAY. The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.

FULLY URBANIZED CONDITIONS. In the context of a drainage study, the watershed or drainage area of a stream is considered to be completely developed, i.e. all land is assumed to be functioning in it's ultimate use. Other descriptions include: Fully Developed, 100 Per Cent Urbanized, Ultimate Development or Land Use, and Maximum Development.

ONE HUNDRED YEAR FLOOD. A flood having an average frequency of occurrence in the order of once in 100 years, at a designated location, although the flood may occur in any year and possibly in successive years. It would have a 1 percent chance of being equalled or exceeded in any year. In the past, this flood has been referred to as the Intermediate Regional Flood.

WATERSHED. The area contained within a divide above a specified point on a stream.

EXECUTIVE SUMMARY

The Texas Water Development Board and the Cities of McAllen and Mission contracted Halff Associates in January 1995 to prepare a detail flood study for the developing areas of southern McAllen and southern Mission, located between the Old Mission Inlet and the Banker Floodway. The purpose of this study was to develop detailed hydrologic and hydraulic computer models of the watershed to analyze the existing drainage system, estimate potential flood damages, and evaluate alternative design schemes to alleviate flood damages.

Frequent flooding problems in the area are attributed to an insufficient drainage system, inadequate topographic relief, and low permeability of the soils. The most severe recorded catastrophic storm in the Lower Rio Grande Valley was Hurricane Beulah in September 1967. This event resulted in millions of dollars of flood related damages throughout south Texas. This storm produced a total rainfall of about 16 inches, observed in the City of McAllen. This corresponds to a return period of about 125 years.

The total contributing watershed draining to the Mission Inlet encompasses about 76 square miles. Contributing storm water runoff originates in the City of Penitas and from as far north as FM 1924 (Mile 3 North). The detail study area, referred to as "Sharyland/Foreign Trade Zone," is located between the Mission Inlet and the Banker Floodway. This detail study area includes about 16 square miles.

The Mission Inlet watershed is about 53% urbanized at this time. Existing non-urbanized areas include about 30% agricultural and 17% undeveloped open space. Anticipated future development, determined from available zoning and land use maps of various cities, will consist of about 76% urbanization with about 24% and 7% reserved for agriculture and open space respectively. The Sharyland/Foreign Trade Zone is about 89% undeveloped (includes 17% open space and 72% agriculture) at this time. Anticipated future development will include about 98% urbanization.

Soil types found in the Mission Inlet watershed generally have moderate to low permeability rates. The majority of the soils found in the Sharyland/Foreign Trade Zone have low permeability rates; thus, the detailed study area has a high runoff potential.

Hydrologic analysis were prepared for existing and future land use conditions. Peak flood discharges were computed for the 10-, 25-, 50-, and 100-year flood frequencies. These events have a 10, 4, 2, and 1 percent chance of being equalled or exceeded (one or multiple occurrences) during any single year. Differences in computed peak flood discharges, for contributing areas along the Mission inlet, generally varied less than 5% for existing and future land use conditions. This slight difference can be attributed to the estimated infiltration rates for irrigated cropland, which are only slightly less than those for residential (urbanized) land use.

The Mission Floodway is about 10 miles is length, from the outlet structure to near FM 1016. The average levee height, from the top bank of the pilot channel, is about 15 feet. There are nine structures, including the structure at the levee closure, crossing the Mission Floodway. Assuming the outlet gates are closed, the computed future fully urbanized 100-year flood will overtop the existing roadway or embankment at six of these nine structures. In addition, the 100-year flood will overtop the existing levee at five (5) locations including; the levee closure, McAllen Miller International Airport, Palm View Golf Course, Cimarron Country Club, and at a location west of FM 1016. If flow is not diverted to the Banker and the Mission outlet gates are open, the Mission Levee will be overtopped at three (3) locations including the Miller International Airport, Cimarron Country Club, and at a location west of FM 1016.

Following Hurricane Beulah, the IBWC closed the Rio Grande diversion to the Mission Floodway and constructed the Banker Weir to permit an effective diversion of about 106,300 cfs to the Banker Floodway. Assuming this is the maximum permitable flow to the Banker Floodway, the estimated minimum freeboard (computed water surface to top of levee) is within 1 foot of the top of levee at the Mission outlet structure.

As part of this study, a Digital Terrain Model (DTM) was developed from aerial photography for the Sharyland/Foreign Trade Zone study area. Halff Associates utilized this DTM to compute available flood storage volumes and subsequent flood elevations, for existing and future land use conditions, for the low lying areas of widespread shallow ponding of flood waters. Generally, the difference in computed flood elevations for ultimate and existing land use conditions is less than 0.4 feet, for the frequencies studied. This slight difference could be attributed the amount of existing agricultural land use, where the estimated loss rates (infiltration) for irrigated cropland, for soils with low permeability, are only slightly less than those for urbanized land use. In addition, this slight difference in computed flood elevations can be also attributed to the flood storage capacity of the land at shallow depths, where the difference in total flood storage is somewhat more significant than the variation in actual depth of ponding.

The estimated total property inundated by the future (assumed ultimate land use) 100-year flood within the study area is approximately 7,681 acres. This includes about 2,590 acres within the Mission Floodway and about 5,091 acres between the Mission and Banker Levees. Visual inspection of these flood plain areas indicate about 2,958 acres of 100-year flood plain consist of agricultural cropland.

An inventory of existing structures indicate that there are about 1,236 structures with estimated finish floor elevations below the computed future 100-year flood. The majority of these structures (1,085) are residential properties located in Balboa Acres. An additional 75 flood prone residential structures are located in the Cimarron Country Club. As many as 955 residential structures, located in the Cimarron Country Club and Balboa Acres, are susceptible to the 10-year flood event, assuming ultimate development.

Recommended structural improvements to help alleviate flooding of existing structures include reconstruction of the Mission Levee at Cimarron Country Club and excavation of about 2.4 million cubic yards of material for flood storage at Balboa Acres and the Foreign Trade Zone. The estimated cost to redirect flood water around Cimarron Country Club and provide flood protection for 75 existing residential structures is about $6.4 million. The estimated cost to alleviate flooding of about 1,155 existing residential, warehouse, and commercial structures in Balboa Acres and the Foreign Trade Zone is about $10.1 million.

Recommended future structural improvements for the Cities to consider include raising the existing levee three feet above the 100-year flood (in accordance with FEMA criteria) at all locations where the computed future 100-year flood will overtop the Mission Levee. In addition, the Cities should consider constructing a designated emergency spillway at the Mission Floodway outlet structure to the Banker Floodway. The estimated cost for the emergency spillway is about $2 million.

Halff Associates also recommends that the Cities consider adopting a flood plain management policy that would require all new developments within the Sharyland/Foreign Trade Zone provide a minimum of 0.8 acre-feet of flood storage for every one acre of development.

It is further recommended that the Cities formally adopt the flood levels shown in this report for their flood plain management program.

SECTION I
INTRODUCTION

I. INTRODUCTION

A. PURPOSE OF REPORT

The purpose of this study is to develop detailed hydrologic and hydraulic computer models to analyze the existing drainage system and evaluate alternative design schemes to help alleviate existing and potential flood damages for the developing areas of southern McAllen and southern Mission, Texas, located between the Old Mission Inlet Floodway and the Banker Floodway. The limits of the detail study area are illustrated on Figure 1.

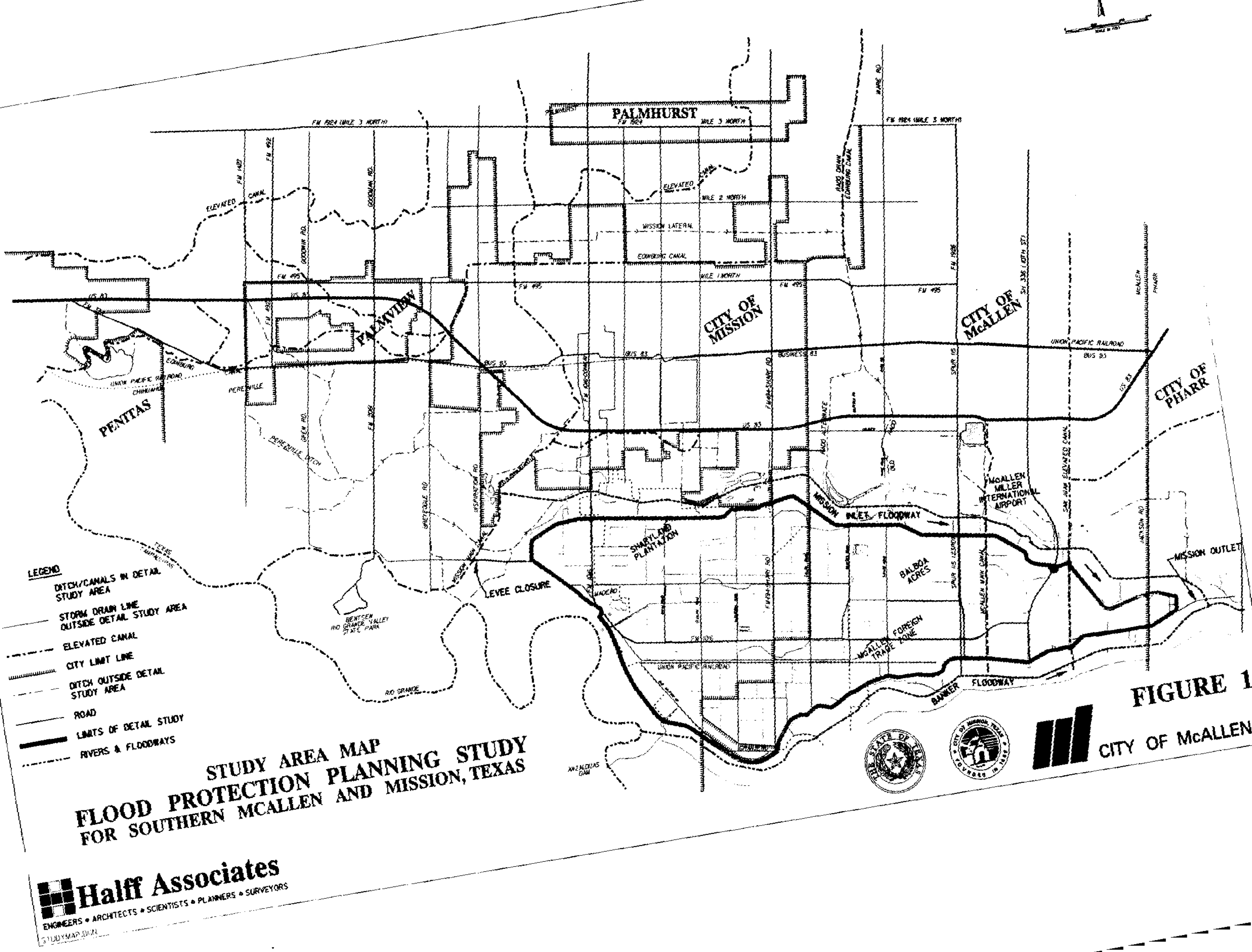
This study identifies and quantifies existing and potential flooding problems endangering the Foreign Trade Zone, Balboa Acres, Cimarron Country Club, the McAllen Sewage Treatment Plant, and other areas including significant amount of agricultural property. In addition, the results of this study provides planning alternatives and design concepts to improve the existing drainage system and help alleviate subsequent flooding. The information presented in this report will provide the Cities of McAllen and Mission with the necessary updated drainage information to coordinate future development and help minimize existing and potential flood damages within the detail study area (Sharyland/ Foreign Trade Zone). For the purposes of this report, the detail study area shall be referred to as the Sharyland/Foreign Trade Zone.

This report provides a summary of the procedures used to analyze the existing drainage system and associated flood problems and the results and recommendations that were derived from the analyses. Additional information (i.e. 1995 topographic mapping, digital terrain model (DTM), photographs, work maps, and computer files) used in the production of this report are available from Halff Associates and from the Cities of McAllen and Mission.

Specific objectives of the Flood Protection Planning Study for Southern McAllen and Mission, Texas are:

1. Establish survey control network (see Appendix H) for aerial mapping of the project area bounded on the north by the Old Mission Inlet Floodway and on the south by the Banker Floodway.

2. Compile pertinent existing engineering data and newly developed information into a comprehensive report with an *up-to-date, fully developed watershed, 10-, 25-, and 100-year flood plain delineation* of the study area.



STUDY AREA MAP
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN McALLEN AND MISSION, TEXAS

FIGURE 1

3. Determine the impact of future urbanization of the contributing watershed on the study area.

4. Formulate *conceptual plans* and analyze the effects of *proposed improvements* to reduce the flooding potential within the study area. Consideration of improvements to flood storage areas, channel flow characteristics, gated outfall structures, existing levee, and possible secondary levee. Prepare pre-design estimates of probable cost for the various improvement plans.

5. Based on the analysis of various alternative plans to reduce flooding, make *specific recommendations* to the Cities of McAllen and Mission.

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

B. COMMUNITY DESCRIPTION

The study area is located in the south central region of Hidalgo County, commonly known as the Lower Rio Grande Valley. The detail study area includes the developing areas of southern McAllen and southern Mission, Texas, located between the Old Mission Inlet Floodway and the Banker Floodway. Existing land use within the detail study is predominantly agricultural, consisting of vegetables, sugar cane, grain, and citrus. Major existing development includes the Foreign Trade Zone and residential subdivisions including Balboa Acres, Cimarron Country Club, Madero, and Granjeno. Proposed future planned development will most likely consist of warehousing/manufacturing and residential properties.

The study area's terrain is characteristic of the Texas Coastal Plains. The topography is rather flat with elevations (in the detail study area) varying from about 92 feet to 112 feet above the National Geodetic Vertical Datum of 1929 (NGVD). The soils in the area generally consist of moderately permeable loams and clays (Reference 1).

The climate of the study area is subtropical. Summers are hot and winters are short and mild. Extremes of temperature and precipitation are of relatively short duration. Temperatures range from an average July maximum of about 97°F to a January minimum of about 49°F (Reference 2). The mean annual precipitation is about 20 inches. These weather conditions, along with an plentiful source of water for irrigation from the Rio Grande, sustain an ideal growing season of 327 day per year.

C. PRINCIPAL FLOOD PROBLEMS

Most of the frequent flooding problems in the area are attributed to an insufficient drainage system, inadequate topographic relief, and the low permeability of the soils. Drainage ditch grades of 0.02 % (about 1 foot per mile) and flat grades for overland flow account for widespread shallow ponding of excess storm water (Reference 2). In addition, the drainage ditches in the study area outfall to the Mission Inlet through manually operated gated drainage structures that are often old and deteriorated and possibly frozen open or closed. During flood stage along the Mission Inlet, flood waters may surcharge these structures, resulting in additional flooding problems.

The most severe recorded catastrophic storm in the Lower Rio Grande Valley was Hurricane Beulah in September 1967. This event resulted in millions of dollars of flood related damages throughout south Texas. Thousands acres of land were inundated with flood waters. Figure 2, taken from the Corps of Engineers' "Report on Hurricane Beulah" (Reference 3), is an illustration of the extent of flooding near the Miller International Airport in McAllen, Texas. Ponding water was prevalent for months following the storm. A total rainfall of about 16 inches was observed in the City of McAllen. This corresponds to a return period of about 125 years (Reference 3). As a result of Hurricane Beulah, the Mission Inlet Floodway was abandoned as an overflow route to the Rio Grande. Today the Mission Inlet Floodway is used to convey and store only local storm water runoff.


MISSOURI
PACIFIC
ELEVATED
MC ALLEN
Refinery
Magic Valley
Bowie Sch
Radio Tower
Athletic Field
Lincoln Sch
Travis Jr High Sch
Sam Houston Sch
Eli Whitney Sch
JACKSON AVE
KELLY
2 LANE
Temple Emanuel Cem
Lake Conception
MILLER INTERNATIONAL AIRPORT
WICHITA
Pumping Sta
MAIN
109.0
107.3
106.2
98.1
BM 117
BM 113
LEGEND
NORMAL WATER LEVELS
STREAM OR SURFACE RUNOFF FLOODING
DEBRIS OR DRIFTLINE ELEVATION
NOTES:
1. ALL ELEVATIONS REFER TO MEAN SEA LEVEL DATUM
2. BASE MAP REPRODUCED FROM U.S.G.S. QUADRANGLE, PHARR AND MISSION, TEXAS, DATED 1963
HURRICANE BEULAH 8-21 SEPT. 1967
LIMITS OF FLOODING
MC ALLEN, TEXAS
(SOUTH)
SCALE OF FEET
1000 0 1000 2000 3000
U.S. ARMY ENGINEER DISTRICT GALVESTON, TEXAS SEPTEMBER 1968
TO ACCOMPANY REPORT ON HURRICANE BEULAH
FILE: 2009-8

PLATE 46

SECTION II
STUDY PROCEDURES

II. STUDY PROCEDURES

A. HYDROLOGIC STUDIES

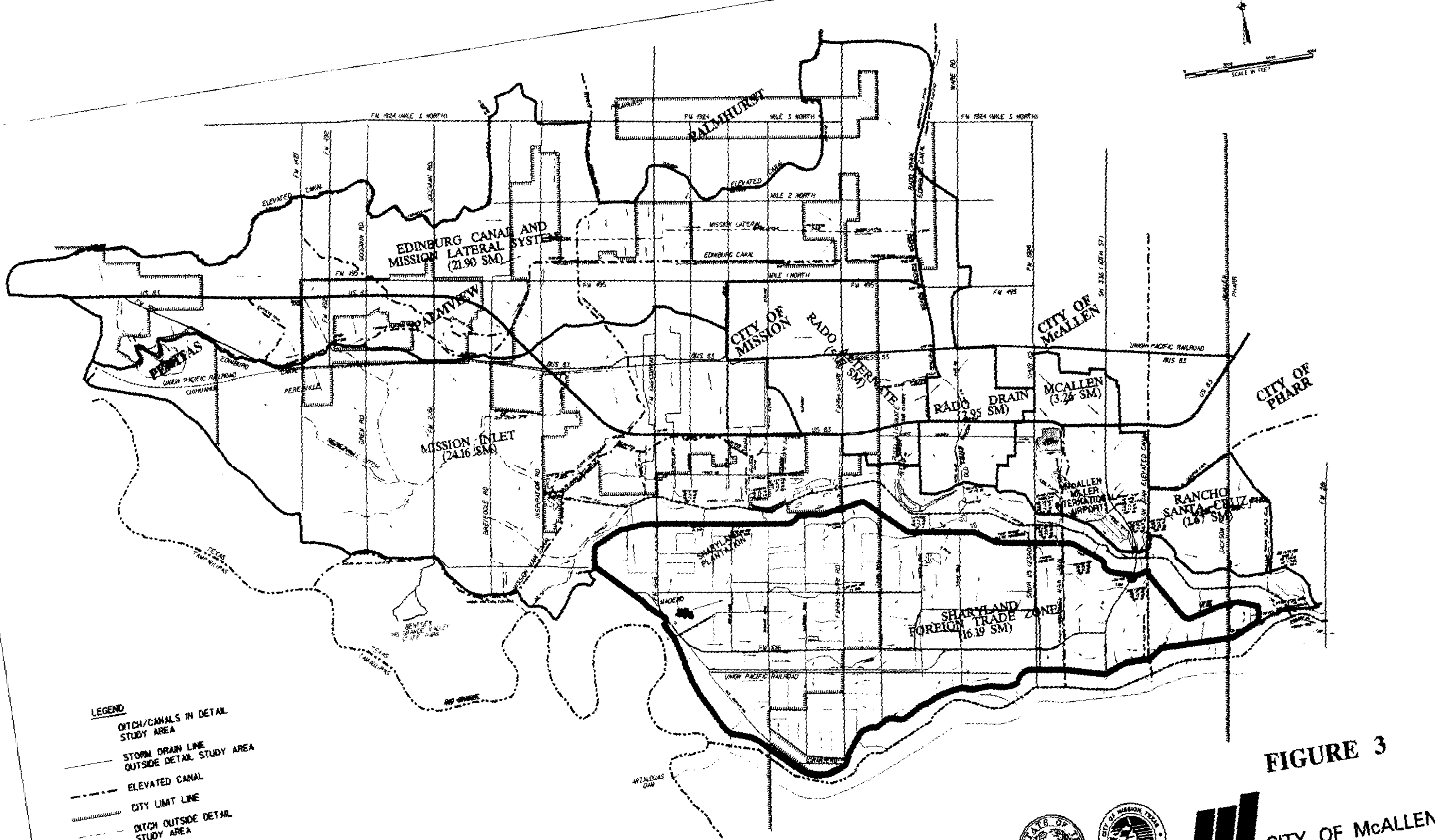
1. General

Hydrologic analyses were conducted by Halff Associates for the Mission Inlet Watershed basin using the Corps of Engineers hydrologic computer program HEC-1 (Reference 5). This methodology is consistent with previous hydrologic studies prepared by the Galveston District U.S. Army Corps of Engineers (Reference 6) and City of McAllen Study, dated May 1991, prepared by Phase V Engineering, Inc. in cooperation with Furlong Engineering, Inc. (Reference 7). Halff Associates utilized portions of the City of McAllen HEC-2 model and associated work maps to develop an updated detailed HEC-1 model of the Mission Inlet watershed basin for this study.

Halff Associates' hydrologic analysis for this study was prepared using existing (1995) and future, fully-urbanized watershed conditions. Flood events of a magnitude which are expected to be equalled or exceeded once on the average of any 10-, 25-, 50-, and 100-years have been selected as having special significance for this study. These events have a 10, 4, 2, and 1 percent chance, respectively, of being equalled or exceeded (one or more occurrences) during any one year. Tables of peak flood discharges can be found in Chapter 3. Although the recurrence interval represents the long term, average 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 (one percent chance of annual occurrence) in any 50-year period is about 40 percent (4 in 10), and for any 90-year period, the risk increases to about 60 percent (6 in 10).

2. Watershed

The total contributing Mission Inlet watershed encompasses approximately 76 square miles. Contributing storm water runoff originates in the City of Penitas, just west of the intersection of U.S. Highway 83 (US 83) and Business Route 374 (Bus. 374). Runoff from the north drains to the Mission from near FM 1924 (Mile 3 North). Figure 3 is a schematic illustration of the study watershed depicting the major drainage systems including the Mission Inlet, Edinburg Canal & Mission Lateral, Rado Alternate, Rado Drain, McAllen Airport, Rancho Santa Cruz, and the Sharyland/Foreign Trade Zone.



LEGEND

DITCH/CANALS IN DETAIL STUDY AREA

STORM DRAIN LINE OUTSIDE DETAIL STUDY AREA

ELEVATED CANAL

CITY LIMIT LINE

DITCH OUTSIDE DETAIL STUDY AREA

ROAD

LIMITS OF DETAIL STUDY

RIVERS & FLOODWAYS

DRAINAGE SYSTEM DIVIDE

FIGURE 3

DRAINAGE AREA MAP

FLOOD PROTECTION PLANNING STUDY FOR SOUTHERN McALLEN AND MISSION, TEXAS

CITY OF McALLEN

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For this study, the watershed basin was sub-divided into approximately 101 sub-watershed basins (see Appendix A - Overall Drainage Area Map). Watershed characteristics such as drainage area, watercourse length, basin slope, land use, soil type, and channel/flood plain storage were determined for each sub-watershed basin. The hydrologic procedure used in the preparation of this report includes the development of synthetic unit hydrographs at each of these sub-basin locations. Derived runoff hydrographs were then combined and routed through existing channels. The program HEC-1 (Reference 5) was used to compute storm runoff based on Soil Conservation Service (SCS) curve numbers (Reference 8), derived from land use and hydrologic soil types. The Snyder's unit hydrograph method and the Modified Puls routing method were used to determine peak flood discharges for a given frequency rainfall.

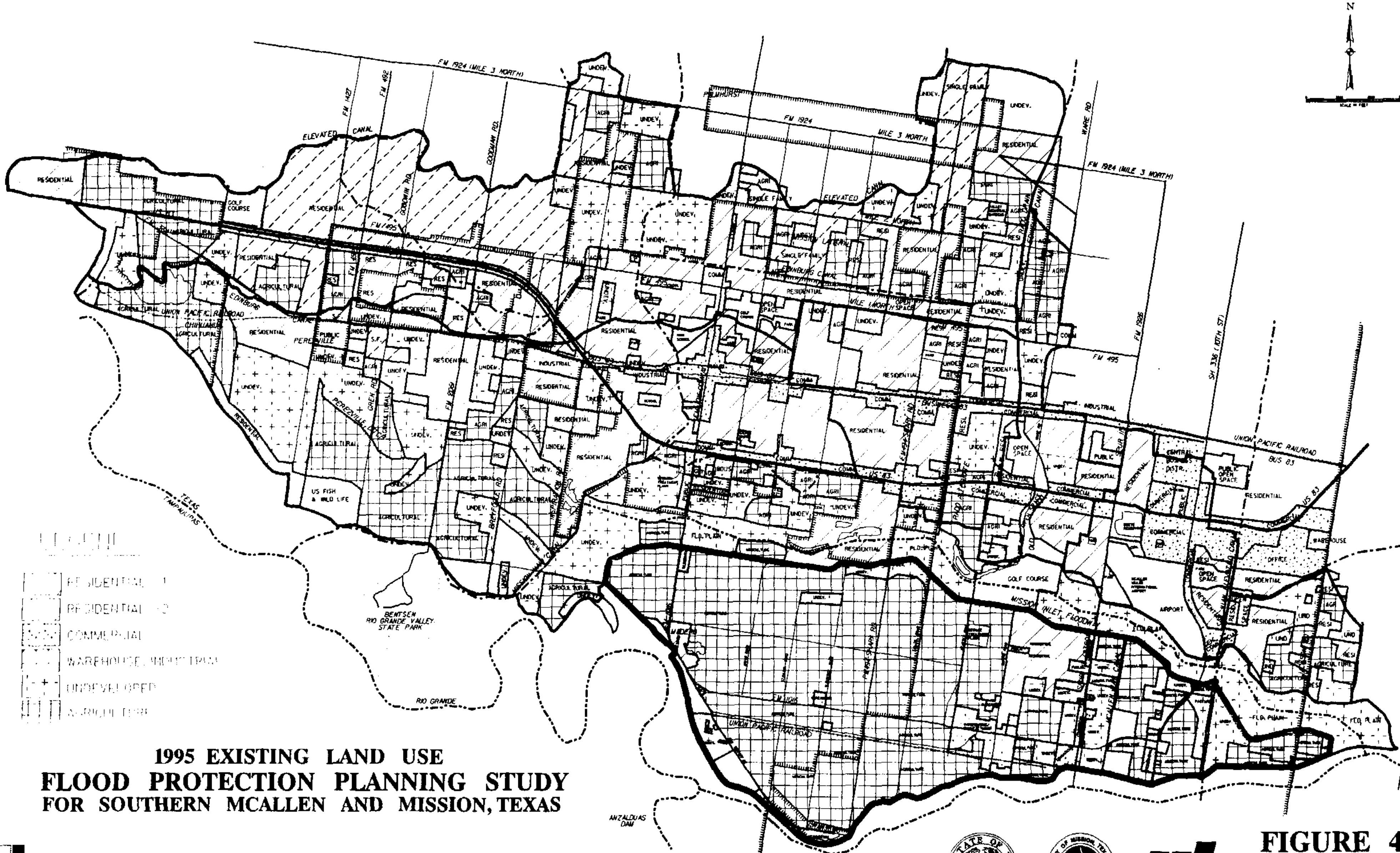
3. Land Use

Existing land uses were determined from March 1995 aerial topography, for areas within the detail study area (Sharyland/Trade Zone). Available land use maps and aerial photographs (dated 1992) were utilized for areas beyond the detail study area. These existing land use classifications were then verified and adjusted based on field observations. Figure 4 is an illustration of the 1995 existing land uses assumed for this study.

As communities such as Mission and McAllen develop, farms and pastures are replaced with residential, commercial, and industrial land uses. Future land classifications and growth patterns were generally determined from available published city maps including the McAllen Physical Development Plan (adopted September 12, 1993, the City of Mission Zoning Map, the of City of Mission-5 Mile Extra-Territorial Jurisdiction (ETJ) Map, and Land Use Districts Conceptual Development for Sharyland Plantation. Future land use classifications for areas beyond the ETJ were estimated based on present development trends and coordination with City staff. Assumed ultimate land use for the study area is depicted on Figure 5.

4. Impervious Coverage

Percent impervious is a function of the various land uses within the watershed basin. Residential impervious coverage typically reflects the housing market by allowing greater building and pavement coverage as land prices increase. The assumed impervious coverage for land uses found in the study watershed area are summarized in Table 1.



1995 EXISTING LAND USE
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

FIGURE 4

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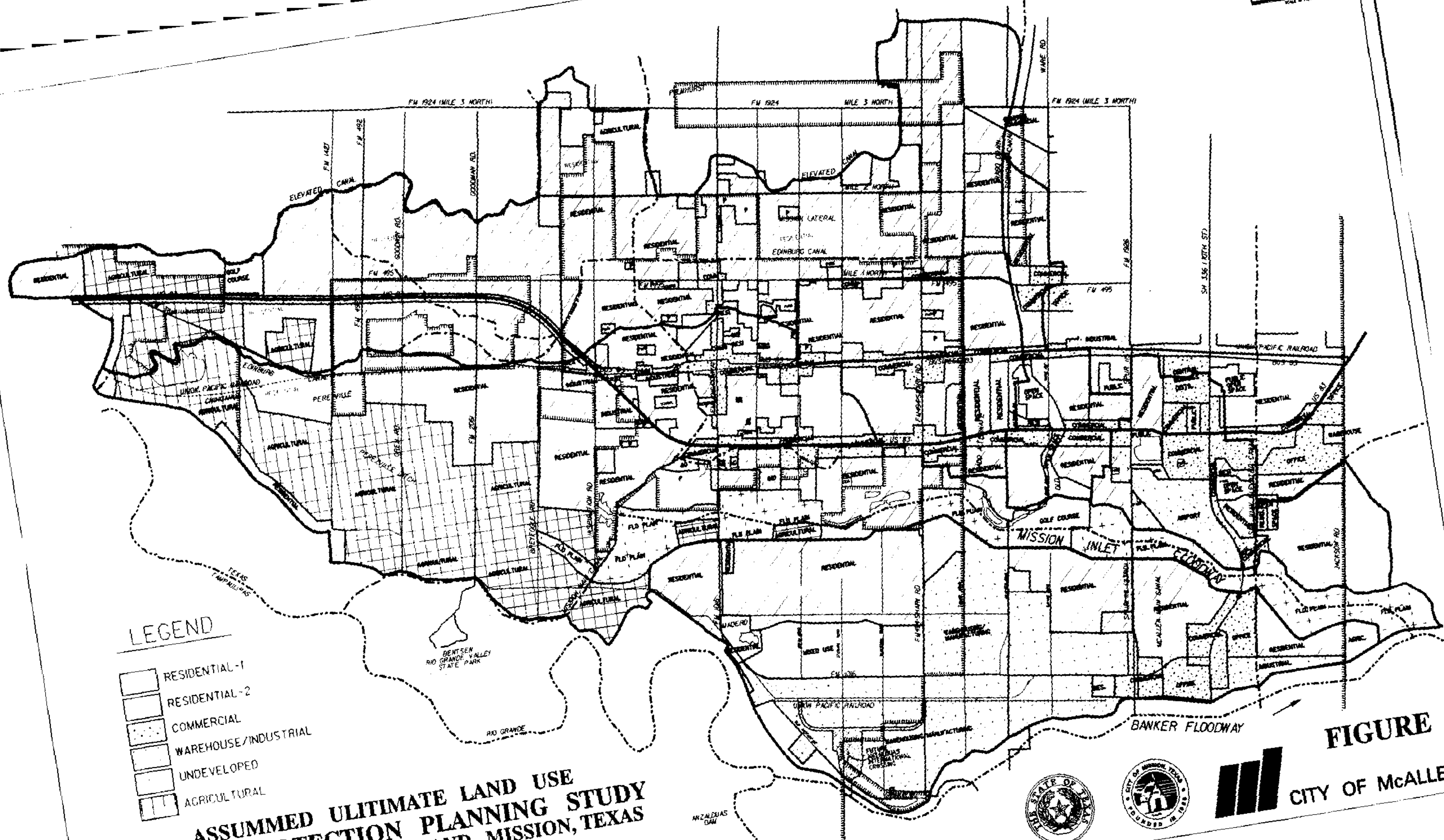
EXLAND.DGN

CITY OF McALLEN



ASSUMMED ULITIMATE LAND USE
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

FIGURE 5

CITY OF McALLEN

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FPSLAND.DGN

Residential land use classifications within the city limits were assigned a "Residential-1" land use category for this study. This classification was devised to simplify the varying definitions for residential development within the Cities of McAllen and Mission. For instance, low density residential development in the City of Mission includes residential lots of 6,000 square feet or greater (R1 & R1A), while low density residential development in the City of McAllen includes duplexes, townhouses, and some mobile homes (R-2, R-3T, and R-4). "Residential-2" classification was assigned for areas beyond the city limits, generally located west of Mission, where typical observed residential lots are 1/2 acre or greater.

Percent impervious values were derived by Halff Associates using Corps of Engineers and Soil Conservation Service (SCS) publications (References 6 and 8) and drainage design manuals from various Texas cities. Halff Associates has also derived impervious coverage values for typical Dallas-Fort Worth Metroplex and other Texas Cities using detailed measurements of developed areas.

Table 1
Characteristic Imperviousness
for Land Uses found in the Mission Inlet Watershed

Land Use Classification	Characteristic Imperviousness (Percent)
Residential-1 (1)	45%
Residential-2 (2)	30%
Warehouse / Manufacturing / Industrial	85%
Commercial / Office	90%
Mixed Use (3)	80%
Agricultural	0%
Schools / Public	30%
Parks / Golf Courses / Cemeteries / Open Space	5%
Undeveloped Areas (brush, range land)	0%

(1) All residential land use classifications within the city limits were grouped into "Residential-1" land use to simplify the different residential density definitions between the cities of McAllen and Mission.
(2) "Residential-2" classification was used for areas outside the city limits, generally west of Mission, where typical lots are 1/2 acre or more.
(3) Mixed Use land use classification within the Sharyland Plantation includes 75 % Warehousing and 25% Residential land uses.

5. Soil Types

Hydrologic soil types are divided into four groups (A, B, C, and D). Group A soils have the highest infiltration rates and the lowest runoff potential of the four soil types. Group B soils have moderate infiltration rates. Group C soils have slow infiltration rates. Group D soils have the slowest infiltration rates and the highest runoff potential. Group A soils are usually well drained and consist of sand or gravel. Group D soils, on the other hand, are often clayey, have a high water table, or consist of bedrock or other nearly impervious material. Hydrologic Soil Types for the Mission Inlet watershed basin were estimated from the Soil Conservation Service Hidalgo County, Texas Soil Survey (Reference 1). Figure 6 is an illustration of the hydrologic soils typically found in the study watershed.

According to Figure 6, the majority of the watershed consists of type B and D soils with some C soils at the western boundary in the City of Penitas. The Sharyland/Foreign Trade Zone study area is predominantly type D soil (highest runoff potential).

The *antecedent moisture condition (AMC)* defines the soil moisture condition prior to a storm. The Soil Conservation Service has defined three levels of antecedent moisture conditions (Reference 8).

AMC-I	*Dry soils and low runoff potential* *(0 to 0.5" total rainfall in preceding 5 days)*
AMC-II	*Average soil moisture conditions* *(0.5" to 1.1" total rainfall in preceding 5 days)*
AMC-III	*Saturated soil condition from antecedent rains* *(greater than 1.1" total rainfall in preceding 5 days)*

An average antecedent soil moisture condition (AMC-II) was chosen for the purposes of this study.

6. Loss Rates

The *SCS Curve Number Method* is a technique, developed by the Soil Conservation Service (SCS) (Reference 8), for classifying land use and soil type using a single parameter called the Curve Number (CN). The curve number is dependent on the land use, impervious coverage, soil classification, and antecedent runoff conditions.

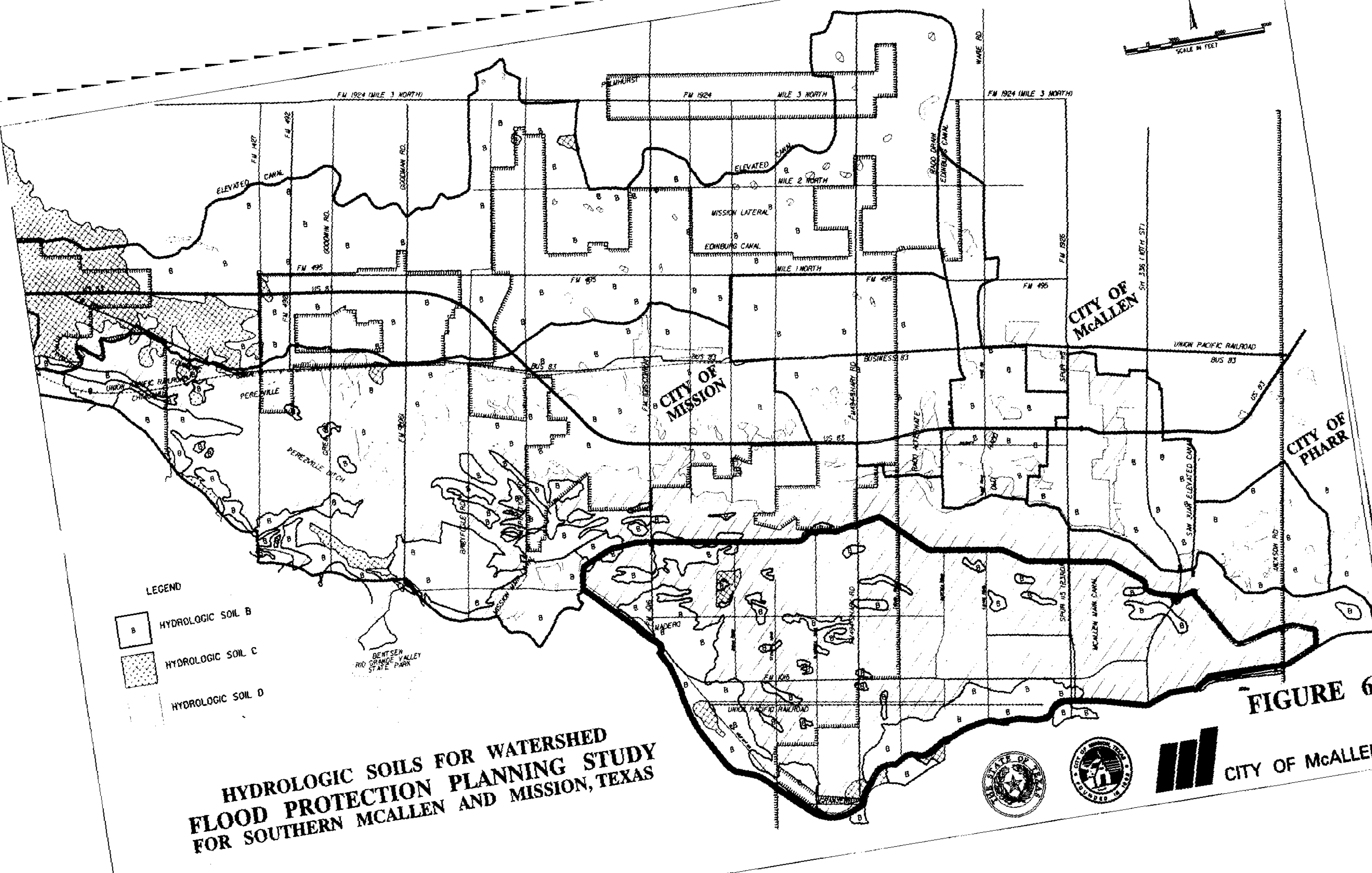

FIGURE 6

HYDROLOGIC SOILS FOR WATERSHED
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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Table 2 is a list of composite CN's for land uses and AMC-II hydrologic soil types representative of the study area.

Halff Associates computed SCS Curve Number's using a weighted average percent imperviousness for individual soil types and land use within each sub-watershed basin. The composite CN's shown in Table 2 were computed using the assumed percent impervious values for the various land uses shown in Table 1.

The *initial abstraction (IA)* was computed for AMC-II (average) soil conditions using the following equation (Reference 5):

$$IA = 0.2 * (1000 - 10 * CN) / CN$$

Table 2
Composite SCS Curve Numbers for the Land Use found in the Study Area

Land Use Classification	Composite SCS Curve Number for each Hydrologic Soil Type			
	Soil A	Soil B	Soil C	Soil D
Residential-1	64	76	84	87
Residential-2	56	71	80	85
Warehouse / Manufacturing/Industrial	87	90	92	93
Commercial/Office	89	92	93	94
Agricultural	64	75	82	85
Schools / Public	56	71	80	85
Parks / Golf Courses / Cemeteries	42	63	75	81
Undeveloped Areas	35	56	70	77

Composite Curve Numbers were computed using the average percentage of impervious area shown on Table 1. These curve numbers were computed assuming all impervious areas have a curve number of 95. Pervious areas are considered equivalent to open space in good hydrologic soil conditions (CN for soil A = 39, soil B = 61, soil C = 74, and soil D = 80). Undeveloped areas is considered equivalent to a mixture of brush and rangeland (CN for A soil= 35, B soil= 56, C soil = 70, and D soil = 77). Agricultural areas are considered equivalent to row crops with straight rows and crop residue cover in good condition (CN for A soil= 64, B soil= 75, C soil = 82, and D soil = 85).

7. Snyder's Unit Hydrograph

Snyder's Unit Hydrograph Lag Times (Tp) were determined from regional relationships, developed by the Corps of Engineers, of sub-basin geometry (Reference 9). These regional relationships are a function of watercourse length, basin slope.

Halff Associates computed lag times for many of the smaller sub-basins (less than 2,000 acres) using the following equation (Reference 8):

$$Tp = 0.6 * \text{Time of Concentration}$$

Snyder's Peaking Coefficient (Cp) was determined from information developed specifically for the Hidalgo County by the U.S. Army Corps of Engineers Galveston District (Reference 6).

8. Rainfall

Point rainfall depths for the Mission Inlet watershed were taken from the National Weather Service Publication *Technical Paper No. 40* (Reference 10) and from the National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum *Hydro-35* (Reference 11). The National Weather Service has developed a relationship to convert point rainfall depths to areal average rainfall based on the size of the drainage area and the duration of the storm. However, because of the small drainage basin studied, areal reduction of point rainfall depths was not necessary for this study.

Table 3 are the point rainfall depths used for this study for the 10-, 25-, 50-, 100-, and 500-year flood frequencies.

Table 3
Rainfall Depth / Duration for the Hidalgo County Study Area *

Return Period (years)	Point Rainfall Depths (inches) for Hidalgo County Study Area							
	5-min.	15-min.	60-min.	2-hour	3-hour	6-hour	12-hour	24-hour
2-Year	0.50	1.10	2.00	2.60	2.70	3.25	3.70	4.30
5-Year	0.58	1.28	2.57	3.40	3.70	4.40	5.20	6.00
10-Year	0.64	1.42	2.97	3.95	4.30	5.20	6.10	7.10
25-Year	0.74	1.63	3.53	4.60	5.00	6.20	7.20	8.50
50-Year	0.81	1.79	3.97	5.10	5.70	7.00	8.30	9.60
100-Year	0.88	1.95	4.40	5.70	6.30	7.80	9.50	11.00
500-Year	1.7	3.2	5.75	7.25	8.0	9.9	12.0	13.75

* Data taken from Technical Paper No. 40 and Technical Memorandum Hydro-35.

9. Flood Routing

The *Modified Puls* routing method was utilized by establishing storage-outflow relationships from steady-flow water surface profiles determined from HEC-2 hydraulic analyses of the Mission Floodway. Storage-outflow relationships were determined for existing channel (floodway) conditions.

Halff Associates utilized a Digital Terrain Model developed for this study to determine the elevation storage relationship routing data through the detail study area (Sharyland/Foreign Trade Zone). For areas beyond the detail study area, Halff Associates utilized available ditch system construction plans and prepared cursory HEC-2 hydraulic models to develop storage-discharge relationships.

B. HYDRAULIC ANALYSES

1. General

Flood profiles for Mission Floodway and Banker Floodway were developed using the Corps of Engineer's computer program HEC-2 (Reference 12). Halff Associates developed a detail hydraulic model of the Mission Floodway to reflect 1995 floodway and bridge conditions. The Banker Floodway HEC-2 model, utilized for this study, was obtained from the International Boundary and Water Commission (IBWC). In addition, Halff Associates prepared cursory HEC-2 models of major drainage courses (i.e. Mission Lateral, Rado Drain, Rado Alternate, Rancho Santa Cruz, etc.) for flood storage routing purposes.

2. Existing Channel and Bridge Conditions

Cross-sections used in the Mission Floodway HEC-2 computer model were located at close intervals above and below bridges, culverts, and elevated canal crossings in order to compute the significant effective flow and backwater effects of these structures. Mission Floodway hydraulic cross-section data was obtained from the 1995 digital terrain model (DTM) developed for this study. Bridges, culverts, and elevated canal crossings were modeled based on available construction plans. Generally, these plans correlated well with the 1995 DTM.

Hydraulic models of the major drainage courses were developed from available construction plans and field observations.

Channel roughness factors (Manning's "n") were assigned on the basis of field inspections of flood plain areas and from previous studies by the Corps of Engineers. For study purposes, it was assumed that no clogging would occur and that all bridge structures would stand intact. 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 profiles and flood plain maps that supplement this report. All elevations are measured from National Geodetic Vertical Datum of 1929 (NGVD).

C. STUDY ASSUMPTIONS

The development of detailed hydrologic and hydraulic computer models and the ensuing conclusions of this study are based on a number of assumptions. Following is a brief summary of study assumptions.

1. <u>Detail Study Area Modeled as Enclosed System</u>

Halff Associates assumed that storm water runoff from the detail study area, the area bounded by the Mission and Banker Levees (Sharyland/Foreign Trade Zone), could not enter the Mission Floodway. This assumption is based on the premise that the Mission Floodway is flowing full; therefore, all gated structures along the interior levee are closed. Likewise, the Mission Floodway flood waters were not permitted to enter the Sharyland/Foreign Trade Zone study area, with the exception of the Cimarron Country Club where the Mission levee has been removed.

The Sharyland/Foreign Trade Zone study area encompasses about 16 square miles (10,240 acres). This area was divided into eleven (11) separate flood storage cells as illustrated on Figure 7. The configuration of each flood storage cell was determined from topographic features. Halff Associates selected the boundary of each cell based on the relative grade change from one cell to another. These cell boundaries were generally associated with a structure such as an elevated canal or roadway embankment. Stage-Storage (elevation-volume) relationships were developed for each cell utilizing the 1995 DTM. This information was then used to compute flood elevations for each cell.

2. <u>Banker Floodway Full with Mission Floodway Outlet Structure Gates Closed</u>

Following Hurricane Beulah, the IBWC closed the Rio Grande diversion to the Mission Floodway and constructed the Banker Weir to permit an effective diversion of about 106,300 cfs to the Banker Floodway. This flow would produce a computed

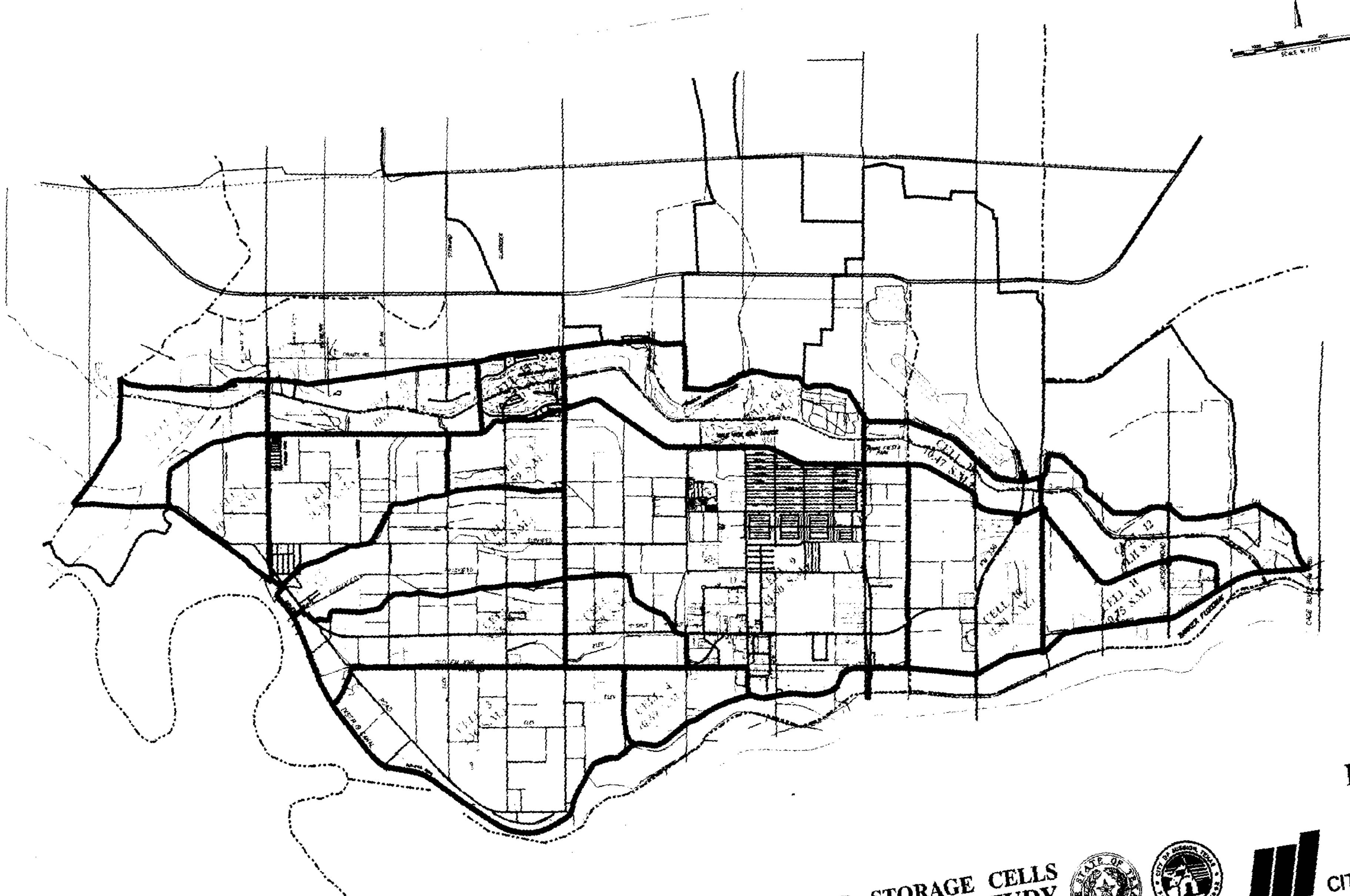

FIGURE 7

CITY OF McALLEN

DETAIL STUDY AREA – FLOOD STORAGE CELLS
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

Halff Associates
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flood elevation in the Banker Floodway of about 101 feet at the Mission Floodway outfall closure levee; thus, requiring the Mission Floodway outlet structure gates closed to prevent the Banker backwater from entering the Mission Floodway.

Halff Associates assumed the Mission Floodway outlet structure gates closed for this study. This assumption prevents Mission Floodway storm water from entering the Banker Floodway, unless the levee is overtopped. Likewise, the Banker Floodway flows are not permitted to enter the Mission Floodway. The limits of flooding depicted in Appendix C is based on future development with the Banker Floodway flowing full (106,300 cfs) (References 13 and 14) and the Mission Floodway outlet structure gates closed.

3. <u>Mission Floodway Modeled as Series of Reservoirs</u>

The Mission Floodway generally functions as a series of large linear flood storage reservoirs separated by eight outlet structures or hydraulic restrictions (i.e. Jackson Road, San Juan Elevated Canal, SH 336, Old FM 336, 23rd Street, Shary Road, Rio Grande Road, and FM 1016). In order to account for the variation in flood elevation over the entire length of the floodway, Halff Associates prepared a detailed hydraulic analyses along the Mission Floodway. Headlosses were computed at all hydraulic restrictions. Available flood storage between each restriction were computed using the 1995 DTM. Information from the hydraulic analysis and DTM were then utilized to compute stage-storage relationships for flood storage routing through each reach of the floodway (see Appendix B). The resulting analysis produced a flood profile depicting the varying flood elevations due to each roadway and elevated canal.

4. <u>Mission Floodway Contributing Drainage Areas Regulated</u>

Storm water runoff from west of the Mission Main Canal was generally permitted to enter Mission Floodway uncontrolled; thus, the detention effects of upstream ponding (at low areas, roadway embankments, etc.) were not accounted for in this study.

Flows to the Mission Lateral were routed based on a typical cross sectional area of the drainage channel. Available record construction plans indicate Mission Lateral storm water flows are diverted at the Rado Drain. For this study, 50% (not to exceed 750 cfs) of the Mission Lateral flow was permitted to drain to the south, to the Mission Floodway, and the remaining flow was diverted to the north. This assumption is based on a cursory analysis of the available head and tailwater conditions at the diversion (7' X 6' box culvert) located at the intersection of the Edinburg Canal and the Rado Drain.

Drainage ditches entering the Mission Floodway from the north (Rado Drain, Rado Alternate, 23rd and 18th Street Ditch, Rancho Santa Cruz, etc.) were regulated based on a comparison of the timing of the computed flood stage of the subject drainage ditch and the Mission Floodway. Ideally, ditch flow should not be permitted to enter the Floodway when the computed flood stage of the Floodway exceeds the stage of the subject drainage ditch. In order to model this scenario using HEC-1, a plot of stage vs time was prepared for the each drainage ditch and the Floodway at each corresponding location. Utilizing these plots, Halff Associates estimated a time when flow could no longer enter the floodway. This time was then used to estimate the effective volume of storm water, based on the ditch flood hydrograph, permitted to enter the Floodway. The remaining volume, from the contributing ditch hydrograph was diverted out of the system.

D. FLOOD PLAIN DELINEATION

The current flood regulatory maps for the project area are the FEMA Flood Insurance Rate Maps prepared for the 1991 City of Mission (Reference 15), 1980 City of McAllen (Reference 4), and the 1980 Hidalgo County Flood Insurance Studies (Reference 2). The National Flood Insurance Program uses the 100-year flood (existing conditions) as the "base flood" for insurance and mapping purposes. Since floods greater than the 100-year flood may occur, citizens should bear in mind that if the level of protection is for a 100-year flood, it is possible for flood levels to exceed this limit.

For this study, the 10-, 25-, and 100-year flood plain limits, ponding elevations, and flood profiles were prepared for existing (1995) topography, channel and bridge conditions with peak flood discharges based on existing and future (ultimate) land use conditions. Flood plain maps are presented in Appendix C of this report. The delineation of the future fully urbanized flood plain for the Mission Floodway and the Sharyland/Foreign Trade Zone provides the Cities of McAllen and Mission with one of the basic tools of flood plain management. This data will be instrumental in the performance of many flood plain management functions, some of which are listed below.

1. Formulation of flood plain management alternatives;
2. Outlining of flood-hazard areas;
3. Planning for parks and recreation in flood-prone areas;
4. Compliance with requirements of federal flood insurance programs;
5. Establishment of safe finished-floor elevations;
6. Planning of subdivisions to provide room for the passage of floodwater;
7. Design of roads, bridges, and utilities; and
8. Designation of easements or land to be purchased and used for open space.

Included in this study are computer diskettes containing copies of all hydrologic and hydraulic computer model data used in the production of this report. These baseline computer models will enable City Engineering staff to predict flood levels for flows based on existing and/or future land use conditions. The Cities of McAllen and Mission will also have the ability to periodically update and modify the models prepared for this study to predict anticipated changes in land use and/or watershed characteristics.

SECTION III
STUDY RESULTS

III. STUDY RESULTS

A. GENERAL

Halff Associates revised and updated previous hydrologic studies of the Mission Inlet watershed basin and developed the detailed drainage area map provided in Appendix A. This detailed drainage area map includes approximately 101 sub-basins, of which 19 sub-basins are located in the Sharyland/Foreign Trade Zone detail study area. Sub-basin names were assigned based on those of previous studies.

Table 4 is a list of computed drainage areas and estimated SCS Curve Numbers, for existing and future (ultimate) land use conditions, for each sub-watershed basin in the study area.

Table 4
Summary of Drainage Areas and Estimated SCS Curve Numbers

Drainage Area Number	Drainage Area (sm)	Existing SCS Curve Number	Future SCS Curve Number	SCS Curve Number Difference
MI-1	0.49	74.9	74.9	0.0
MI-2	0.62	74.9	74.9	0.0
MI-4	0.34	77.0	77.0	0.0
MI-5	0.13	77.0	77.0	0.0
MI-6	0.80	78.1	78.1	0.0
MI-7	0.77	83.8	83.8	0.0
MI-8	0.61	81.1	81.1	0.0
MI-9A	0.39	84.4	88.0	3.7
MI-9B	1.01	76.1	83.6	7.5
MI-9C	0.29	83.0	83.0	0.0
MI-10A	0.54	83.2	83.2	0.0
MI-10B	0.42	77.0	77.0	0.0
MI-10C	0.48	84.0	84.0	0.0
MI-10D	0.41	78.0	78.0	0.0
MI-11A	1.25	77.9	81.2	3.3
MI-11B	1.50	77.0	77.0	0.0

Table 4
Summary of Drainage Areas and Estimated SCS Curve Numbers

Drainage Area Number	Drainage Area (sm)	Existing SCS Curve Number	Future SCS Curve Number	SCS Curve Number Difference
MI-13	0.73	76.5	80.4	3.9
MI-14	0.94	80.2	82.6	2.4
MI-15	1.17	82.4	82.4	0.0
MI-16	0.62	71.8	78.1	6.3
MI-17	0.36	82.6	83.3	0.7
MI-18	3.19	82.4	82.4	0.0
MI-19	0.47	83.0	83.0	0.0
MI-20	0.37	81.0	85.3	4.4
MS-1	0.37	72.6	80.3	7.7
MS-2A	0.53	88.5	88.5	0.0
MS-2B	0.82	80.1	80.1	0.0
MS-2C	1.39	79.8	79.8	0.0
MS-3A	0.82	82.0	84.3	2.3
MS-3B	0.68	75.7	78.8	3.1
MS-4A	0.70	79.1	79.1	0.0
MS-4B	0.54	78.1	78.1	0.0
MC-1A	1.39	85.1	88.3	3.2
MC-1B	1.52	72.5	78.2	5.7
MC-1C	0.21	74.8	79.4	4.6
MC-1D	0.07	66.2	76.3	10.0
MC-2A	0.90	85.6	85.6	0.0
MC-2B	0.37	90.6	90.6	0.0
MC-3	0.60	80.2	81.2	1.0
MC-4A	2.02	74.8	82.7	7.8
MC-4B	0.42	80.3	84.5	4.2
R-2	0.42	78.8	79.8	1.0
R-3	0.10	75.3	75.3	0.0
R-4	0.41	81.0	81.0	0.0

Table 4
Summary of Drainage Areas and Estimated SCS Curve Numbers

Drainage Area Number	Drainage Area (sm)	Existing SCS Curve Number	Future SCS Curve Number	SCS Curve Number Difference
R-5A	0.13	73.7	78.3	4.6
R-5B	0.23	72.2	72.2	0.0
R-6	0.82	73.9	77.9	4.0
R-9	2.50	75.8	78.7	2.9
R-10	0.64	73.6	78.7	5.1
R-11	0.97	77.7	78.7	1.0
R-13	2.77	69.9	76.5	6.5
R-14	0.32	66.8	76.3	9.5
R-15	1.85	74.1	74.7	0.6
E1	0.26	73.6	73.6	0.0
E2	0.49	72.1	73.2	1.1
E3	0.44	69.4	70.3	0.9
E4	0.14	77.2	77.2	0.0
E5	0.35	71.5	71.5	0.0
E6	0.21	74.9	74.9	0.0
E7	0.34	76.1	76.1	0.0
E8	0.19	76.0	76.0	0.0
E9	0.22	84.5	84.5	0.0
E10	0.25	78.0	78.0	0.0
E11	0.19	56.0	76.3	20.0
E12	0.15	61.4	76.8	15.0
E13	0.17	57.0	76.8	19.0
E14	2.52	74.9	75.2	0.3
E15	0.50	73.3	76.0	2.7
E16	2.24	70.1	71.6	1.4
E17	0.27	76.5	76.5	0.0
E18	0.56	74.3	74.3	0.0
E19	0.36	79.1	79.3	0.2

Table 4
Summary of Drainage Areas and Estimated SCS Curve Numbers

Drainage Area Number	Drainage Area (sm)	Existing SCS Curve Number	Future SCS Curve Number	SCS Curve Number Difference
E20A	2.05	76.9	76.9	0.0
E20B	1.24	75.8	76.0	0.2
E21	0.10	82.4	82.4	0.0
E22	1.53	81.2	83.3	2.1
E23	0.52	76.6	82.9	6.3
E24	0.28	81.7	81.7	0.0
E25	0.25	73.7	81.5	7.8
E26	0.24	84.4	84.4	0.0
E27	0.26	76.3	76.3	0.0
ES1	0.69	82.7	82.7	0.0
TZ-1	0.75	81.7	87.8	6.1
TZ-2	0.68	83.2	92.9	9.7
TZ-3	0.91	81.2	89.5	8.2
TZ-4	0.61	79.8	88.8	9.0
TZ-5	1.74	82.7	85.0	2.3
TZ-6A	0.57	83.0	89.6	6.6
TZ-6B	0.64	84.0	92.5	8.5
TZ-6C	0.58	84.5	92.6	8.1
TZ-6D	0.18	88.8	91.5	2.7
TZ-6E	0.51	84.7	92.8	8.1
TZ-6F	0.55	76.8	89.8	13.0
TZ-7	0.69	77.2	90.5	13.3
TZ-8	2.36	79.4	89.1	9.7
TZ-9	1.06	80.0	91.3	11.3
TZ-10A	1.83	82.8	88.0	5.1
TZ-10B	0.59	83.2	86.8	3.6
TZ-11A	0.67	80.3	82.6	2.3
TZ-11B	1.03	80.0	81.4	1.4
TZ-11C	0.23	84.5	86.2	1.7

The results of this study includes flood information for the following land use and flood plain conditions:

- *Flood discharges based on existing 1995 land use conditions with existing topographic features. Note, this data could be very useful if the Cities of Mission and McAllen decide to submit an update of the current FEMA Flood Insurance Rate Maps.*

- *Flood discharges based on future (ultimate) land use conditions (fully urbanized watershed) and existing topographic features.*

- *10-, 25, and 100-Year flood plain delineations for existing topographic conditions with flood discharges based on future land use conditions. (See Appendix C).*

- *Selective levee and flood storage (sump) improvements with flood discharges based on future land use conditions (fully urbanized watershed).*

B. MISSION INLET FLOODWAY

1. Description of Watershed

The Mission Floodway flows in a southeasterly direction. The study watershed includes the Cities of Penitas, Palmview, Palmhurst, Mission, McAllen, and Phar. Contributing storm water runoff originates in the City of Penitas, just west of the intersection of U.S. Highway 83 (US 83) and Business Route 374 (Bus. 374). At FM 1016, near the entrance to the Mission Levee, the total drainage area is about 16 square miles (10,240 acres). The total contributing area at the Mission Levee closure is approximately 60 square miles (38,400 acres), excluding the 16 square mile interior drainage area located between the Mission and Banker levees.

The Mission Inlet watershed study area is about 53% developed at this time (1995). Existing land uses consist of approximately 17% undeveloped open space; 30% agricultural; 42% residential; 9% business/commercial/industrial areas; and scattered public/semi-public areas (i.e. schools, churches, etc.). According to information compiled from future land use maps, from cities within the watershed, anticipated future development could consist of approximately 7% parks and undeveloped open space; 24% agricultural; 56% residential; 12% business/ commercial/industrial areas; and scattered public/semi-public areas (i.e. schools, churches, etc.).

2. Hydrologic Study Results

Halff Associates prepared detailed HEC-1 hydrologic computer models of the watershed to analyze existing land use conditions and projected future (ultimate) land use conditions. Existing and ultimate land use conditions were analyzed with flood storage routing data based on existing topography and existing bridges and culverts. Peak flood discharges calculated for this study include the 10-, 25-, 50-, and 100-year flood frequencies. Tables 5 and 6 contain peak flood discharge information at key locations along the Mission Floodway.

Table 5 is a summary of computed peak flood discharges at key locations along the Mission Floodway for existing and ultimate land use conditions, assuming the Mission outlet gates are closed. A summary of computed existing and ultimate peak flood discharges at major contributing ditch systems to the Mission Floodway are presented in Table 6. Note, the discharges presented in Table 6 do not necessarily correspond to the actual amount of runoff permitted to enter the Mission Floodway (see Chapter II, "Study Assumptions" for detail explanation).

Table 5
Mission Floodway
Summary of Computed Peak Flood Discharges
Existing and Ultimate Land Use Conditions (Gates Closed)

Location	Drainage Area (sm)	Existing Peak Discharge (cfs)				Ultimate Peak Discharge (cfs)			
		10-yr	25-yr	50-yr	100-yr	10-yr	25-yr	50-yr	100-yr
At Mission Main Canal	12.5	7800	9900	11500	13200	8100	10200	11800	13500
At Confluence with Old Inlet	15.6	8800	11300	13400	15600	9100	11700	13700	15900
At FM 1016 - Conway Rd	16.0	9000	11600	13700	15900	9300	11900	14000	16200
At Rio Grande Rd	21.4	4500	6600	9100	11600	4600	7000	9500	12100
At Shary Rd	22.0	4500	6400	8200	10100	4600	6900	8500	10400
At 23rd Street	51.1	7400	10800	12600	15100	7500	11200	12900	15500
At San Juan Elevated Canal	57.2	4200	6700	8200	10500	4500	7000	8500	10800
At Jackson Road	58.1	2800	5700	7600	10000	3300	6000	7900	10300

Note: Peak discharges are based on existing and ultimate land use conditions with existing (1995) topography. See Figures 4 and 5 for assumed existing and ultimate land use.

Although assumed future development will increase from about 50% urbanization (existing) to about 76% urbanization (future), the difference in computed peak flood discharges for ultimate and existing land use conditions, computed along the Mission Inlet Floodway, generally appear less than 5%. This slight difference could be attributed the assumed portion of the watershed to be preserved for agricultural land use. The estimated loss rates (infiltration) for irrigated cropland are only slightly less than those for residential (urbanized) land use (see Chapter II, Table 2 - Composite SCS Curve Numbers for Land Uses Found in the Study Area). The percent of total urbanized and agricultural land use for existing and future conditions is about 83% and 93% respectively. Similarly, a comparison of future and existing undeveloped open space is about 17% and 7% respectively. This comparison of non-urbanized areas (excluding agricultural land use) appears to compare fairly well with the differences in computed peak discharges for existing and assumed ultimate land use conditions.

Table 6
Major Contributing Ditch Systems
Summary of Computed Peak Flood Discharges
Existing and Ultimate Land Use Conditions (Gates Closed)

Location	Drainage Area (sm)	Existing Peak Discharge (cfs)				Ultimate Peak Discharge (cfs)			
		10-yr	25-yr	50-yr	100-yr	10-yr	25-yr	50-yr	100-yr
Rado Alternate	27.0	4070	5410	6340	7360	4290	5610	6510	7520
Old Rado	3.0	620	800	940	1120	650	830	970	1150
23rd Street Ditch	1.5	1710	2070	2300	2560	1730	2080	2310	2570
South Airport	0.4	160	180	190	200	160	180	190	200
Airport Ditch	1.4	850	930	1020	1110	870	960	1040	1140
Rancho Santa Cruz Ditch	1.5	320	350	370	400	340	360	390	410

Note: Peak discharges are based on existing and ultimate land use conditions with existing (1995) topography. See Figures 4 and 5 for assumed existing and ultimate land use.

3. Hydraulic Study Results

The Mission Floodway is approximately 10 miles in length, from the levee outlet structure to near FM 1016. The average pilot channel grade through the study area is about 0.04%. The pilot channel is well defined with average depths of about 15 feet. Average height of levee, from the top bank of the pilot channel, is about 15 feet. A summary of computed peak flood elevations for the 10-, 25-, 50-, and 100-year flood frequencies (along the Mission Inlet Floodway) for existing and ultimate land use conditions, are presented in Table 7.

Table 7
Mission Floodway
Summary of Computed Peak Flood Elevations[1]
Existing and Ultimate Land Use Conditions (Gates Closed)

Location	Existing Peak Flood Elevation (ft.)				Ultimate Peak Flood Elevation (ft)			
	10-Yr	25-Yr	50-Yr	100-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Cell 12 (Mission Levee Closure to San Juan Canal)	96.2[2]	101.3[2]	102.7	103.4	96.9[2]	102.0	102.8	103.4
Cell 13 (San Juan Canal to 23rd St)	103.2	103.9	104.3	104.8	103.3	104.0	104.4	104.9
Cell 14 (23rd St to Shary Rd)	103.7	104.3	104.6	105.2	103.7	104.3	104.7	105.3
Cell 15 (Shary Rd to Rio Grande Rd)	103.9	104.5	105.0	105.6	104.0	104.6	105.1	105.6
Cell 16 (Rio Grande Rd to FM 1016)	104.2	104.8	105.4	106.0	104.2	104.9	105.5	106.1
Cell 17 (FM 1016 to Old Inlet)	109.3	110.6	111.0	111.4	109.6	110.7	111.0	111.4

1. Peak flood elevations are based on existing and ultimate land use conditions with existing (1995) topography. See Figures 4 and 5 for assumed existing and ultimate land use.
2. The computed "post-storm" flood pool is slightly above elevation 102, the minimum elevation of the Mission Levee at a location where flood waters overflow to the Banker Floodway.

There area nine structures, including the structure at the levee closure, crossing the Mission Inlet Floodway. Pertinent data for each of these structures is summarized in Table 8. The computed future fully urbanized 100-year flood will overtop the existing roadway or embankment at six of these nine structures.

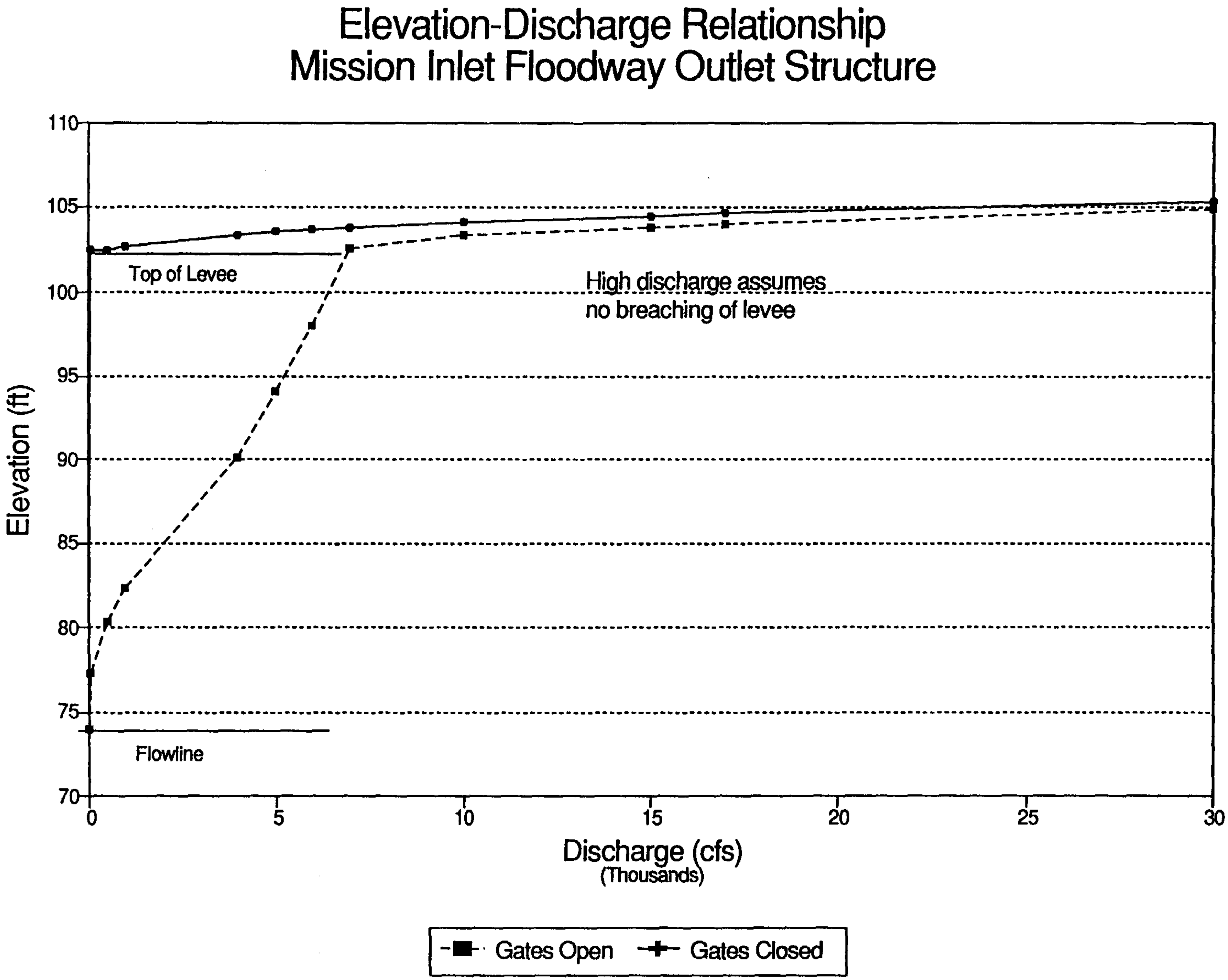
Table 8
Mission Floodway
Summary of Structure Crossings
Ultimate Land Use Conditions (Gates Closed)

Bridge Identification	Upstream Flowline[1]	Low Chord[1]	Top of Road[1]	X-Sect Area (sf)	Q_{100} (cfs)[2]	100-Yr WSEL[3]	Description
Mission Floodway Outlet	73.9	81.4	101.9	322.5	4,000	103.5	2-7.5'x 7.5' and 6-7'x 5' gated box culverts
FM 2061 (Jackson Road)	73.0	89.8	93.2	1600	11,600	103.5	Concrete Bridge w/5 Piers
San Juan Elevated Canal	76.6	92.4	107.4	1580	12,300	104.9	Concrete Bridge w /10 Piers
SH 336 (10th Street)	75.0	95.0	96.2	2170	12,300	104.9	Concrete Bridge w/7 Piers
Old FM 336	77.0	107.0	108.9	1170	15,800	104.9	Wooden Bridge w/Piers
Spur 115 (23rd Street)	80.2	93.9	94.9	790	15,800	105.3	Concrete Bridge w/3 Piers
FM 494 (Shary Road)	87.0	101.0	100.7	640	10,800	105.6	Concrete Bridge w/3 Piers
Rio Grande Dr.	89.1	99.0	101.2	430	12,100	106.1	Concrete Bridge w/2 Piers
Union Pacific Railroad	92.9	106.6	108.6	760	16,200	106.1	Wooden Bridge w/Piers
FM 1016 (Conway Rd)	92.9	104.0	109.4	200	16,200	111.4	2-10'x 10' box culverts

(1) Approximate elevations (NGVD)
(2) 100-year peak discharge based on ultimate fully urbanized watershed with existing (1995) topography and gates closed at Mission Levee closure.
(3) 100-Year peak flood elevation based on existing (1995) topography, channel, and bridges/culverts.

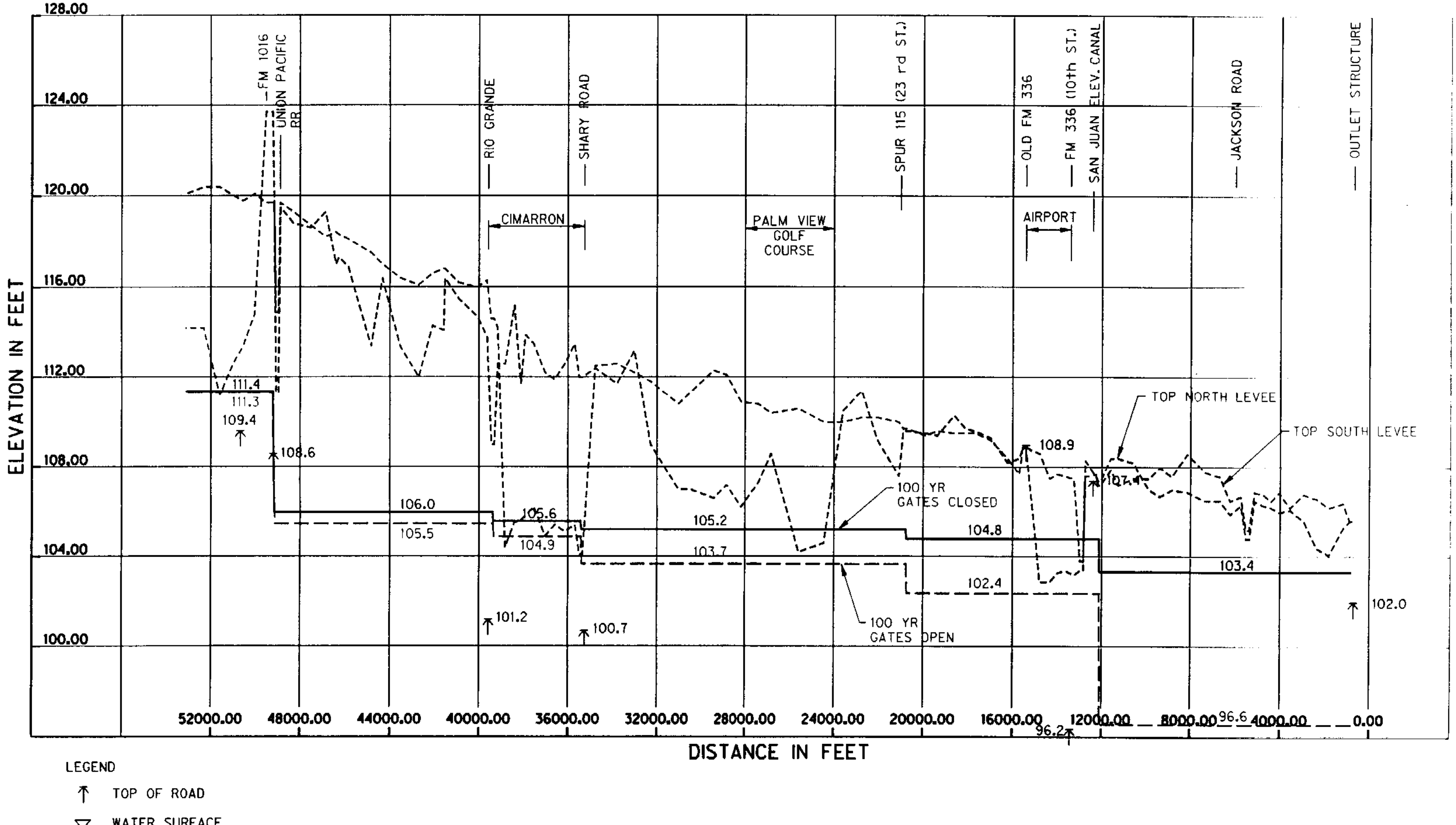
Additional analyses were prepared for the Mission Floodway assuming no flow was diverted to the Banker Floodway and the gates at the Mission outlet were open. A comparison of elevation vs discharge at the Mission outlet for gates open and closed is illustrated on Figure 8.

Computed 100-year flood profiles of the Mission Floodway are presented on Figures 9 and 10 for existing and ultimate land use conditions with gates open and with gates closed. The effect of Mission outlet gates open is most apparent at locations downstream of the San Juan Canal. Upstream of the San Juan Canal, the effects of the open gates is much less. This is due to the restricted conveyance of the San Juan Canal drainage structure and the limited flood storage capacity of the Mission Floodway. The estimated flood storage capacity of the Mission Floodway for varying flood elevations, computed using the 1995 DTM, are presented in Appendix B.



Elevation-Discharge Relationship
Mission Inlet Floodway Outlet Structure
110
105
100
95
90
85
80
75
70
Elevation (ft)
Top of Levee
High discharge assumes
no breaching of levee
Flowline
0
5
10
15
20
25
30
Discharge (cfs)
(Thousands)
Gates Open
Gates Closed

FIGURE 8



MISSION INLET FLOOD PROFILE
100 YEAR EVENT – EXISTING LANDUSE
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

FIGURE 9

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Assuming the Mission outlet gates are closed, the computed 100-year flood will overtop the Mission Levee at five (5) locations including; the levee closure, McAllen Miller International Airport, Palm View Golf Course, Cimarron Country Club, and at a location west of FM 1016. If flow is not diverted to the Banker and the Mission outlet gates are open, the Mission Levee will be overtopped at three (3) locations including the Miller International Airport, Cimarron Country Club, and at a location west of FM 1016. These locations are depicted, for existing and ultimate land use conditions, on the flood profiles presented on Figures 9 and 10 respectively. In addition, graphical representation of these and other potential flooding areas along the Mission Inlet are presented on the flood plain maps and flood frequency profiles in Appendix C of this report.

C. BANKER FLOODWAY

The IBWC closed the Rio Grande diversion to the Mission Floodway and constructed the Banker Weir, following Hurricane Beulah, to permit an effective diversion of about 106,300 cfs to the Banker Floodway (Reference 13). Halff Associates conducted a cursory hydraulic analysis of the Banker Floodway utilizing the IBWC HEC-2 hydraulic computer model. Additional hydrological analysis for the Banker Floodway were not performed, for this study, an effective flood discharge of 106,300 cfs was used for the Banker hydraulic analysis. Assuming this is the maximum permitable flow to the Banker Floodway, the estimated minimum freeboard (computed water surface to top of levee) is within 1 foot of the top of levee at the Mission outlet structure.

D. SHARYLAND/FOREIGN TRADE ZONE

1. Description of Watershed

The Sharyland/Foreign Trade Zone study area includes the area bounded by the Mission and Banker Levees. The total study watershed for this region includes about 16 square miles (10,240 acres). Figure 11 is a detail watershed map of the Sharyland/Foreign Trade Zone study area.

The study area is about 89% undeveloped at this time (1995). Existing land uses consist of approximately 17% undeveloped open space; 72% agricultural; 7% residential; 4% business/commercial/industrial areas; and scattered public/semi-public areas (i.e. schools, churches, etc.). According to information compiled from future land use maps, projected development could consist of approximately 1% parks and undeveloped open space; 1% agricultural; 44% residential; 53% business/ commercial/industrial areas; and scattered public/semi-public areas (i.e. schools,

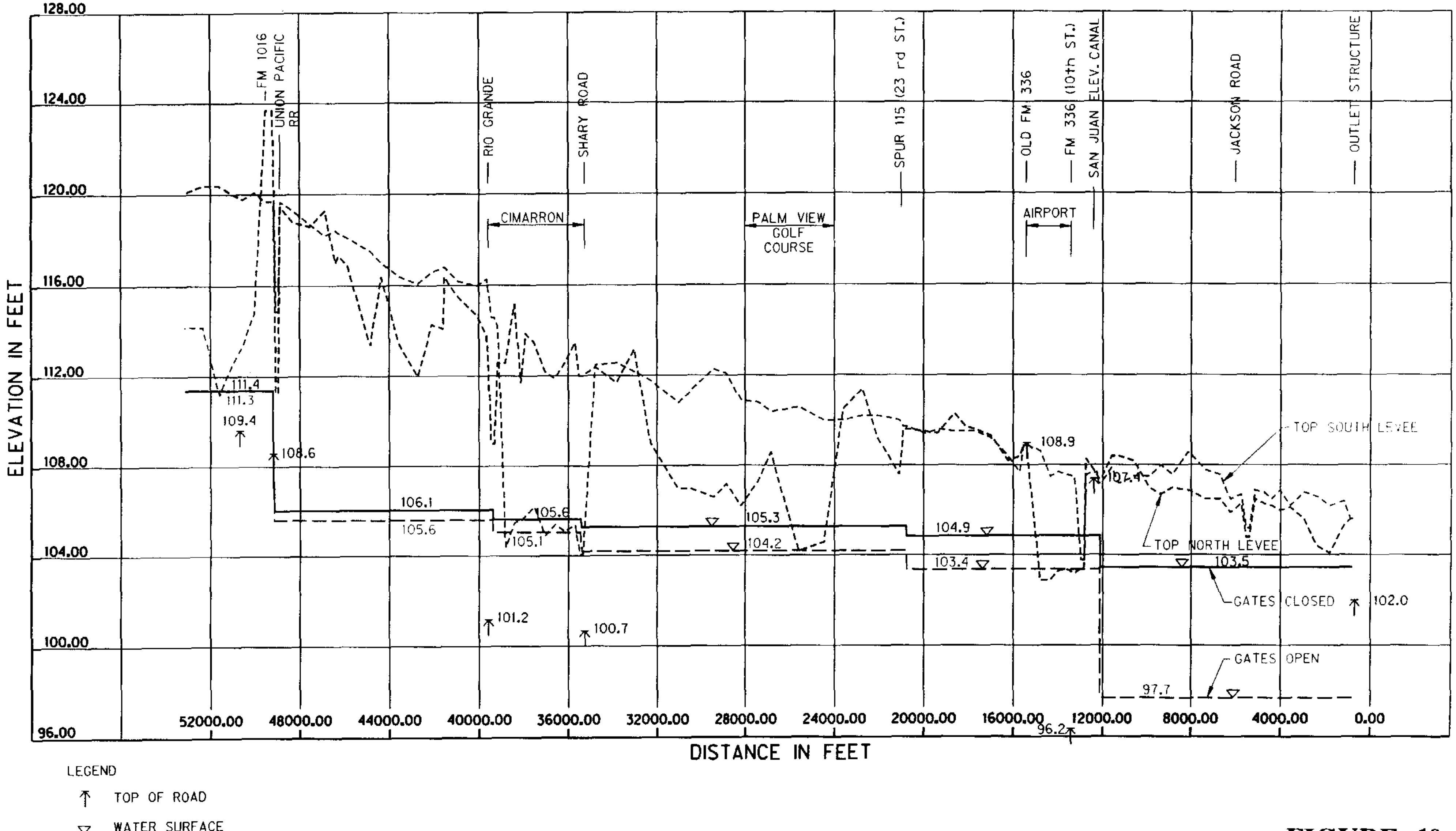

FIGURE 10

MISSION INLET FLOOD PROFILE
100 YEAR EVENT - ULTIMATE LANDUSE
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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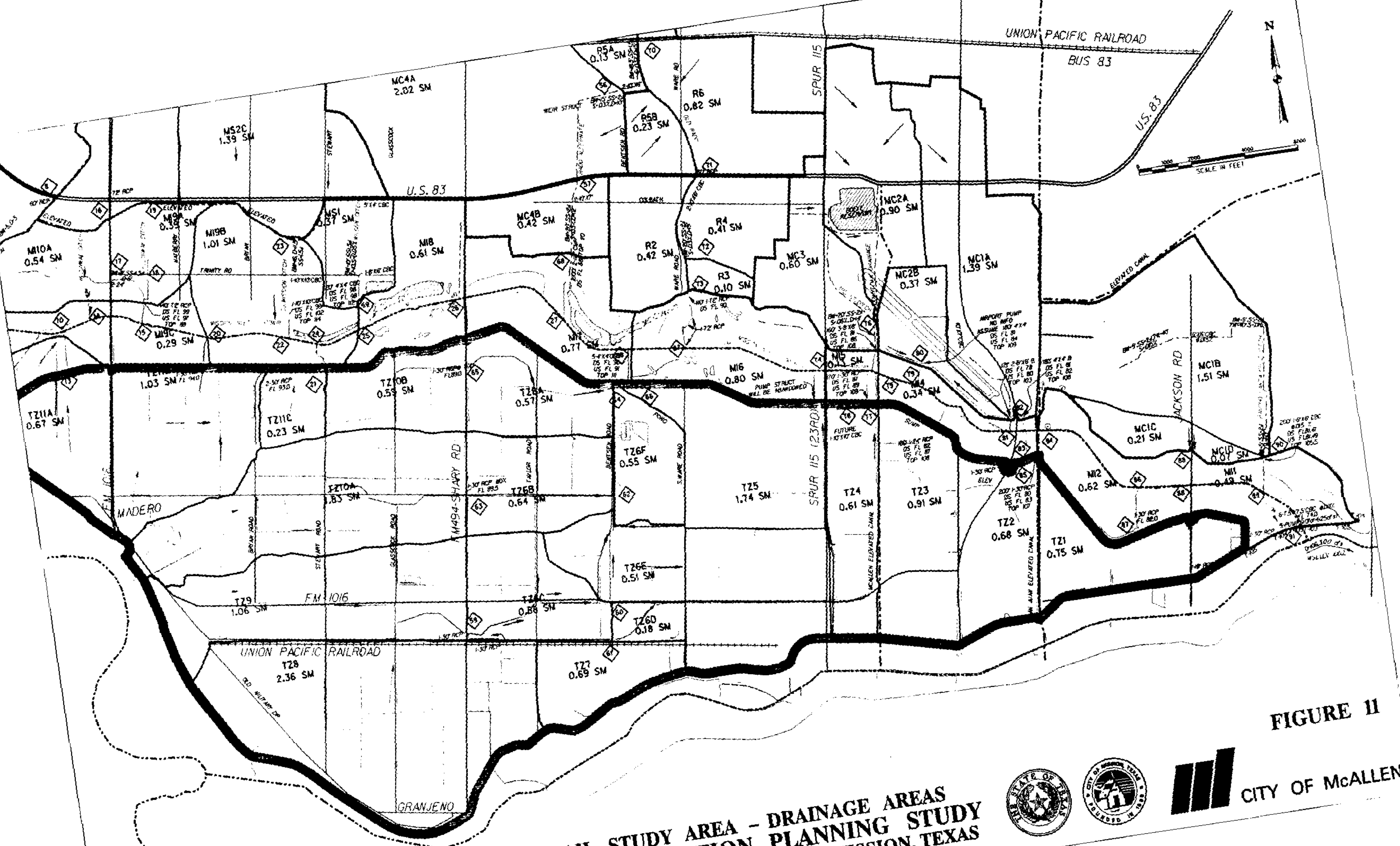

FIGURE 11

DETAIL STUDY AREA – DRAINAGE AREAS

FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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churches, etc.). Note, this study proposes large portions of land to be dedicated to storm water retention (flood storage); therefore, resulting in additional open space.

2. Hydrologic Study Results

Halff Associates prepared detailed HEC-1 hydrologic computer models of the Sharyland/Foreign Trade Zone watershed to analyze existing land use conditions and projected future (ultimate) land use conditions. The study area was divided into eleven (11) separate flood storage cells. Cell boundaries were generally associated with a structure such as an elevated canal or roadway embankment. Flood storage routing data was obtained for each cell utilizing the 1995 DTM. Elevation-storage relationships for each cell are included in Appendix B. This information was then used to compute peak flood elevations and flood storage at each cell for the 10, 25, 50, and 100-year flood frequencies. A summary of computed peak flood elevations, within the Sharyland/Foreign Trade Zone, for ultimate and existing land use conditions is presented in Table 9.

Table 9
Sharyland/Foreign Trade Zone
Summary of Computed Peak Flood Elevations
Existing and Ultimate Development Conditions

Location	Existing Peak Flood Elevation (ft)				Ultimate Peak Flood Elevation (ft)			
	10-Yr	25-Yr	50-Yr	100-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Cell 1	111.8	112.0	112.1	112.1	111.8	112.0	112.1	112.1
Cell 2	105.1	105.3	105.4	105.6	105.1	105.3	105.5	105.6
Cell 3	106.2	106.3	106.4	106.5	106.3	106.4	106.5	106.5
Cell 4	103.7	104.1	104.2	104.4	104.1	104.3	104.4	104.6
Cell 5	105.3	105.5	105.6	105.6	105.5	105.6	105.6	105.7
Cell 6	101.7	101.9	102.1	102.3	101.9	102.1	102.3	102.6
Cell 7	105.1	105.2	105.3	105.4	105.1	105.3	105.4	105.4
Cell 8	103.0	103.2	103.2	103.3	103.0	103.2	103.2	103.3
Cell 9	100.8	101.3	101.6	102.0	101.1	101.5	101.9	102.3
Cell 10	95.6	96.1	96.3	96.5	96.0	96.3	96.5	96.7
Cell 11	92.5	92.9	93.1	93.3	92.7	93.0	93.2	93.5

Note: Peak flood elevations are based on existing and ultimate land use conditions with existing (1995) topography. See Figures 4 and 5 for assumed existing and ultimate land use.

A graphical representation of the peak flood elevations presented in Table 9 is presented on Figure 12, Detail Study Area Overall Flood Plain Map. Additional detail is provided on the flood plain maps in Appendix C of this report.

Although assumed ultimate development will increase from approximately 11% urbanization (existing) to about 98% urbanization (future), a comparison of computed flood elevations for ultimate and existing land use conditions is generally less than 0.4 feet, for the frequencies studied. This slight difference could be attributed the amount of existing agricultural land use. The estimated loss rates (infiltration) for irrigated cropland are only slightly less than those for urbanized land use (see Chapter II, Table 2 - Composite SCS Curve Numbers for Land Uses Found in the Study Area). The percent of total urbanized and agricultural land use for existing and future conditions is about 83% and 99% respectively. Similarly, a comparison of existing and future undeveloped open space is about 17% and 1% respectively. Thus, the actual difference in total potential runoff is not as great as the difference in existing and ultimate per cent urbanization may indicate.

In addition, this slight difference in computed flood elevations can be attributed to the flood storage capacity of each drainage cell at shallow depths. Comparisons of existing and ultimate ponding elevations and associated flood storage for the 10-, 25-, and 100-year flood frequencies are presented in Tables 10, 11, and 12 respectively. The information presented in these tables indicate the difference in total flood storage appears somewhat more significant than the variation in actual depth of ponding.

The results of this study indicate Cell 9 contains the greatest amount of flood storage in comparison to the other Flood Storage Cells in the Sharyland/Foreign Trade Zone study area. This is because excess overflow from adjacent cells drain to Cell 9. Flood depths in Cell 9 range from 0 to 7 feet. Figure 13 is an illustration of the variation in depths of flooding in Cell 9 for the future (assumed ultimate land use) 100-year event.

Table 10
Sharyland/Foreign Trade Zone
Comparison of Existing and Ultimate
10-Year Ponding Elevations and Flood Storage

Location	10-Year Peak Flood Elevation (ft)			10-Year Peak Flood Storage (ac-ft)		
	Existing	Future	Difference	Existing	Future	Difference
Cell 1	111.8	111.8	0.0	94	96	2
Cell 2	105.1	105.1	0.0	76	78	2
Cell 3	106.2	106.3	0.1	280	318	38
Cell 4	103.7	104.1	0.4	99	137	38
Cell 5	105.3	105.5	0.2	166	222	56
Cell 6	101.7	101.9	0.2	56	67	11
Cell 7	105.1	105.2	0.1	261	279	18
Cell 8	103.0	103.0	0.0	182	188	6
Cell 9	100.8	101.1	0.3	3390	3944	554
Cell 10	95.6	96.0	0.4	417	502	85
Cell 11	92.5	92.7	0.2	195	222	27

Note: Peak flood elevations and flood storage are based on existing and ultimate land use conditions with existing (1995) topography.
See Figures 4 and 5 for assumed existing and ultimate land use.

Table 11
Sharyland/Foreign Trade Zone
Comparison of Existing and Ultimate
25-Year Ponding Elevations and Flood Storage

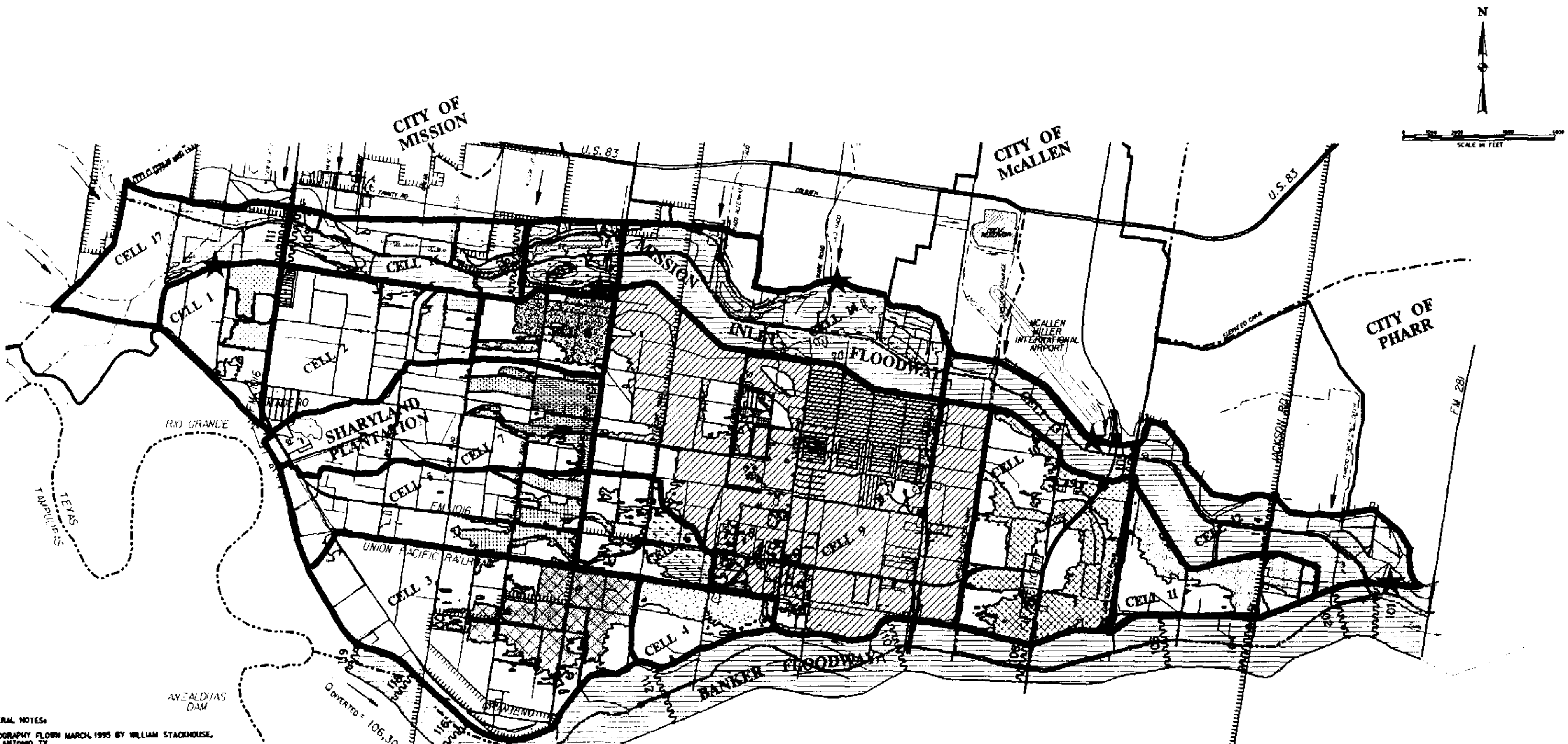
Location	25-Year Peak Flood Elevation (feet)			25-Year Peak Flood Storage (acre-feet)		
	Existing	Future	Difference	Existing	Future	Difference
Cell 1	111.9	112.0	0.1	106	108	2
Cell 2	105.3	105.3	0.0	102	104	2
Cell 3	106.3	106.4	0.1	325	362	37
Cell 4	104.0	104.3	0.3	135	176	41
Cell 5	105.5	105.6	0.1	225	251	26
Cell 6	101.9	102.1	0.2	69	88	19
Cell 7	105.2	105.3	0.1	302	319	17
Cell 8	103.2	103.2	0.0	212	215	3
Cell 9	101.3	101.5	0.2	4355	4946	591
Cell 10	96.1	96.3	0.2	534	625	91
Cell 11	92.9	93.0	0.1	250	279	29

Note: Peak flood elevations and flood storage are based on existing and ultimate land use conditions with existing (1995) topography.
See Figures 4 and 5 for assumed existing and ultimate land use.

Table 12
Sharyland/Foreign Trade Zone
Comparison of Existing and Future
100-Year Ponding Elevations and Flood Storage

Location	100-Year Peak Flood Elevation (feet)			100-Year Peak Flood Storage (acre-feet)		
	Existing	Future	Difference	Existing	Future	Difference
Cell 1	112.1	112.1	0.0	127	131	4
Cell 2	105.6	105.6	0.0	144	147	3
Cell 3	106.5	105.5	0.1	389	420	31
Cell 4	104.4	104.6	0.2	193	218	25
Cell 5	105.6	105.7	0.1	272	296	24
Cell 6	102.3	102.6	0.3	125	172	47
Cell 7	105.4	105.4	0.0	353	364	11
Cell 8	103.3	103.3	0.0	236	239	3
Cell 9	102.1	102.3	0.2	6192	6846	654
Cell 10	96.5	96.7	0.2	737	833	96
Cell 11	93.3	93.5	0.2	346	377	31

Note: Peak flood elevations are based on existing and ultimate land use conditions with existing (1995) topography.
See Figures 4 and 5 for assumed existing and ultimate land use.



	EXISTING ELEVATIONS 10 YR.	25 YR.	100 YR.	FUTURE ELEVATIONS 10 YR.	25 YR.	100 YR.
CELL 1	111.8	112.0	112.1	111.8	111.9	112.1
CELL 2	105.1	105.3	105.6	105.1	105.3	105.6
CELL 3	106.3	106.4	106.5	106.2	106.3	106.5
CELL 4	104.1	104.3	104.6	103.7	104.0	104.4
CELL 5	105.5	105.6	105.6	105.3	105.5	105.6
CELL 6	101.9	102.1	102.6	101.7	101.9	102.3
CELL 7	105.1	105.3	105.4	105.1	105.2	105.4
CELL 8	103.0	103.2	103.3	103.0	103.2	103.3
CELL 9	101.1	101.5	102.3	100.8	101.3	102.0

	EXISTING ELEVATIONS 10 YR.	25 YR.	100 YR.	FUTURE ELEVATIONS 10 YR.	25 YR.	100 YR.
CELL 10	96.0	96.3	96.7	95.6	96.1	96.5
CELL 11	92.7	93.0	93.5	92.5	92.9	93.3
CELL 12	96.9	102.0	103.5	96.2	101.3	103.4
CELL 13	103.3	104.0	104.9	103.2	103.9	104.8
CELL 14	103.7	104.3	105.3	103.7	104.2	105.2
CELL 15	103.0	104.6	105.6	103.9	104.5	105.6
CELL 16	104.2	104.9	106.1	104.2	104.8	106.0
CELL 17	109.6	110.7	111.4	109.4	110.6	111.4

GENERAL NOTES:

1. TOPOGRAPHY FLOWN MARCH, 1995 BY WILLIAM STACKHOUSE, SAN ANTONIO, TX.
2. PONDING ELEVATIONS BASED ON EXISTING (1995) PLANIMETRICS WITH FUTURE FULLY URBANIZED WATERSHED.
3. BASE FLOOD ELEVATIONS FOR BANKER FLOODWAY ARE BASED ON THE MAXIMUM ALLOWABLE DIVERSION FLOW (Q=106,300 CFS).
4. FLOOD ELEVATIONS AT MISSION INLET FLOODWAY BASED ON GATES CLOSED AT MISSION OUTLET.

LEGEND

119 ∿∿∿∿ BASE FLOOD ELEVATION

CELL 3 100 YEAR FLOOD ELEVATION

★ LEVEE OVERTOPPED BY 100 YEAR FLOOD

FIGURE 12

OVERALL 100 YR. FLOOD PLAIN MAP
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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FIGURE 13

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DEPTH OF FLOODING FOR CELL 9
100 YEAR FULLY URBANIZED CONDITIONS
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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E. SINGLE OCCURRENCE FLOOD LOSSES

The estimated total property inundated by the future (assumed ultimate land use) 100-year flood within the study area is approximately 7,681 acres. This includes about 2,590 acres within the Mission Floodway and about 5,091 acres between the Mission and Banker Levees. Visual inspection of these flood plain areas indicate about 2,958 acres of 100-year flood plain consist of agricultural cropland.

Flood profiles, developed for this project, were utilized to determine a relationship of damageable properties to both elevation and flood frequency. The 1995 DTM was utilized to identify flood prone properties and estimate finished floor elevations of structures. Generally, finished floor elevations of structures were assumed about twelve (12) inches above thc elevation shown on the 1995 DTM. Finish floor elevations of some warehouses and commercial structures were estimated as high as four (4) feet above the DTM. Criteria for estimating floor elevations was determined from field observations.

Flood prone properties were classified as residential, warehouse, commercial, and other (including churches, schools, and public buildings). An inventory of existing structures, indicate that there are about 1,236 structures with estimated finish floor elevations below the computed 100-year flood. The majority of these structures (1,085) are residential properties in Balboa Acres located in Cell 9. Table 13 is a summary of flood plain acres and estimated single occurrence flood losses for the 100-year flood frequency, assuming ultimate land use conditions. All known flood prone structures are located within the Mission Floodway, Cell 9, and Cell 11. Flooding at these locations include the residential neighborhoods of Cimarron Country Club, Balboa Acres, and properties located along Jackson Road. The greatest concentration of warehouse and commercial flooding occurs within the Foreign Trade Zone.

A summary of the estimated number of structures with finish floor elevations below the computed 10-, 25-, 50-, and 100-year flood frequencies, for ultimate land use conditions, is provided in Table 14. As many as 955 residential structures, located in the Cimarron Country Club and Balboa Acres, are susceptible to the 10-year flood event, assuming ultimate development. The computed existing 10-year flood elevations at Cimarron and Balboa are less than 0.05 feet and 0.2 feet lower than computed ultimate flood elevations. Thus, the difference in the number of structures with estimated finish floor elevations below the existing and ultimate 10-year flood is within the accuracy of the assumption and subsequent results of this study.

Table 13
Summary of 100-Year Single Occurrence Flood Losses
Ultimate Land Use Conditions

Location	Total Flood Plain (acres)	Cropland Flood Plain (acres)	Number of Structures in Flood Zone			
			Residential	Warehouse	Commercial	Other
Mission Floodway	2590	160	75	0	0	0
Cell 1	118	118	0	0	0	0
Cell 2	110	110	0	0	0	0
Cell 3	419	298	0	0	0	0
Cell 4	158	150	0	0	0	0
Cell 5	179	67	0	0	0	0
Cell 6	181	181	0	0	0	0
Cell 7	237	195	0	0	0	0
Cell 8	196	115	0	0	0	0
Cell 9	2715	1079	1085	18	47	5
Cell 10	540	365	0	0	0	0
Cell 11	238	120	6	0	0	0
Total	**7681**	**2958**	**1166**	**18**	**47**	**5**

Note: Peak flood elevations are based on ultimate land use conditions with existing (1995) topography. See Figure 5 for assumed ultimate land use.
Flood prone properties were classified as residential, warehouse, commercial, and other (including churches, schools, and public buildings).

Table 14
Summary of Flooded Structures
10-, 25-, 50-, and 100-Year Flood Frequencies
Ultimate Land Use Conditions

Location	Flood Event	Estimated Number of Structures in Flood Zone							
		Contribution of Inundated Structures per Event				Total Structures Inundated for Event			
		Residential	Warehouse	Commercial	Other	Residential	Warehouse	Commercial	Other
Mission Floodway	10-yr	29	0	0	0	29	0	0	0
	25-yr	0	0	0	0	29	0	0	0
	50-yr	46	0	0	0	75	0	0	0
	100-yr	0	0	0	0	75	0	0	0
Cell 9	10-yr	926	9	46	4	926	9	46	4
	25-yr	0	0	0	0	926	9	46	4
	50-yr	0	0	0	0	926	9	46	4
	100-yr	159	9	1	1	1085	18	47	5
Cell 11	10-yr	0	0	0	0	0	0	0	0
	25-yr	6	0	0	0	6	0	0	0
	50-yr	0	0	0	0	6	0	0	0
	100-yr	0	0	0	0	6	0	0	0
Total	10-yr	955	9	46	4	955	9	46	4
	25-yr	6	0	0	0	961	9	46	4
	50-yr	46	0	0	0	1007	9	46	4
	100-yr	159	9	1	1	1166	18	47	5

SECTION IV
ALTERNATIVE IMPROVEMENTS

IV. ALTERNATIVE IMPROVEMENTS

A. GENERAL

Conceptual design improvements were prepared to help alleviate flooding and the subsequent potential damages. Improvements along the Mission Floodway include modifications to the existing levee to help prevent overtopping and alleviate flooding of residential properties. Basic design criteria within the Sharyland/Foreign Trade Zone was to provide adequate flood storage for the future (ultimate land use conditions) 100-year frequency flood. Proposed sump storage areas were generally located at natural low areas in non-urban areas in an attempt to minimize disruption to the land and to avoid major utility crossings. A summary of required flood storage for areas within the Sharyland/Foreign Trade Zone are presented in Table 15.

Table 15
Sharyland/Foreign Trade Zone
Summary of 100-Year Peak Storage Requirements for Ultimate Land Use Conditions

100-YEAR PEAK STORAGE REQUIREMENT				
DRAINAGE AREA	AREA (sm)	AREA (ac)	PEAK STORAGE (ac-ft)	STORAGE/ACRE (ac-ft/ac)
Cell 1	0.67	429	313	0.73
Cell 2	1.26	806	586	0.73
Cell 3	2.36	1510	1205	0.80
Cell 4	0.69	442	364	0.82
Cell 5	1.06	678	558	0.82
Cell 6	0.58	371	311	0.84
Cell 7	1.83	1172	922	0.79
Cell 8	0.59	378	293	0.78
Cell 9	4.80	3072	2441	0.79
Cell 10	1.59	1018	835	0.82
Cell 11	0.75	480	377	0.79
Total	**16.18**	**10355**	**8201**	**0.80 acre-ft / acre**
Note: Flood storage requirements are based on ultimate fully urbanized watershed with existing (1995) topography. See Figure 5 for assumed ultimate development.				

B. MISSION FLOODWAY IMPROVEMENTS

1. Mission Floodway Emergency Spillway

The computed future 100-year flood will overtop the Mission Levee at five locations, assuming the Banker Floodway is flowing full and the Mission outlet gates are closed. The Federal Emergency Management criteria for levees requires a minimum three (3) feet freeboard above the 100-year flood. Proposed levee modifications are depicted for each of these five locations on Figure 14.

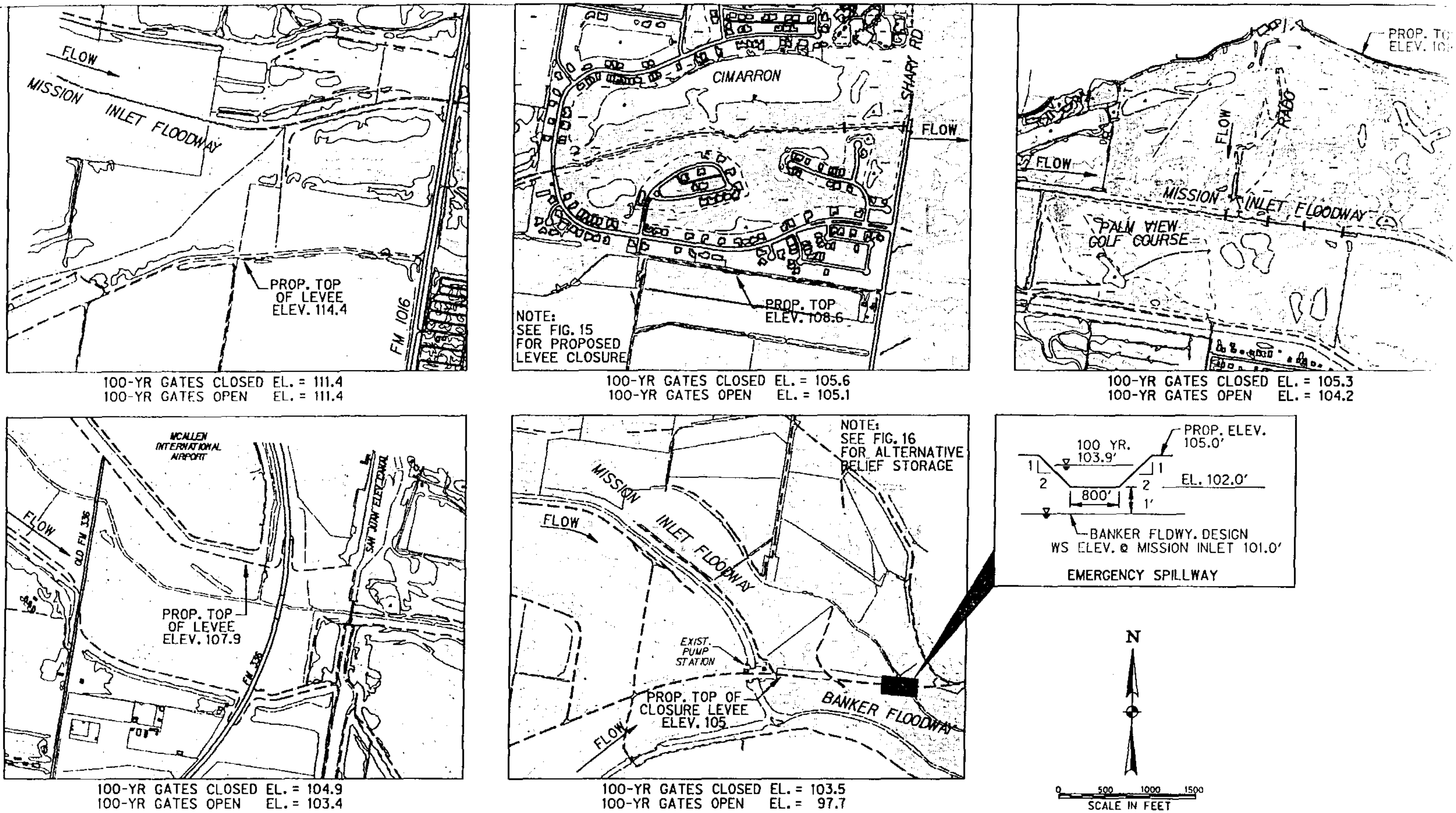
In order to prevent the Mission Levee from breaching, during the 100-year event, an adequate emergency spillway is needed. A proposed 800 foot length rock lined emergency spillway will be required to convey the future 100-year flood, assuming gates closed. The proposed spillway crest shall be constructed at elevation 102 feet, the IBWC regulated flood elevation of the Banker floodway at the proposed spillway location is about 101 feet. In addition, about 3,000 linear feet of the existing levee will be raised to elevation 105 feet. Note, the purpose of these improvements is to protect the levee from breaching, not to alleviate flooding of properties.

A conceptual illustration of the Mission Floodway Emergency Spillway is presented on Figure 14. The estimated construction cost of these improvements is about $2,033,000. An itemized statement of probable cost is provided in Appendix E.

2. Mission Floodway Relief Flood Storage

An alternative plan to the aforementioned proposed Mission Floodway Emergency Spillway, is to provide adequate flood storage at a location upstream of the Mission outlet. In order to retain the ultimate 100-year flood (assuming outlet gates are closed) to below elevation 103.5 feet, an additional 5,660 acre-feet of flood storage are needed. One possible location for this proposed retention pond is within Cell 11. Construction of a 13 foot high levee located just west of Jackson Road and excavation of about 1.6 million cubic yards of material will provide approximately 5,660 acre-feet of flood storage, at an elevation of about 103 feet. In addition, about 3,000 linear feet of the existing levee will be raised to elevation 105 feet.

A conceptual illustration of the Mission Floodway Relief Flood Storage is presented on Figure 15. The estimated construction cost of these improvements is about $7,108,000. An itemized statement of probable cost is provided in Appendix E.



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PROPOSED LEVEE MODIFICATIONS MISSION INLET FLOODWAY

FLOOD PROTECTION PLANNING STUDY FOR SOUTHERN MCALLEN AND MISSION, TEXAS

FIGURE 14

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NOTE:
FOR "GATES CLOSED" SCENARIO ADDITIONAL STORAGE REQUIRED: 5660 ac. ft. FOR 100 YR. EVENT.

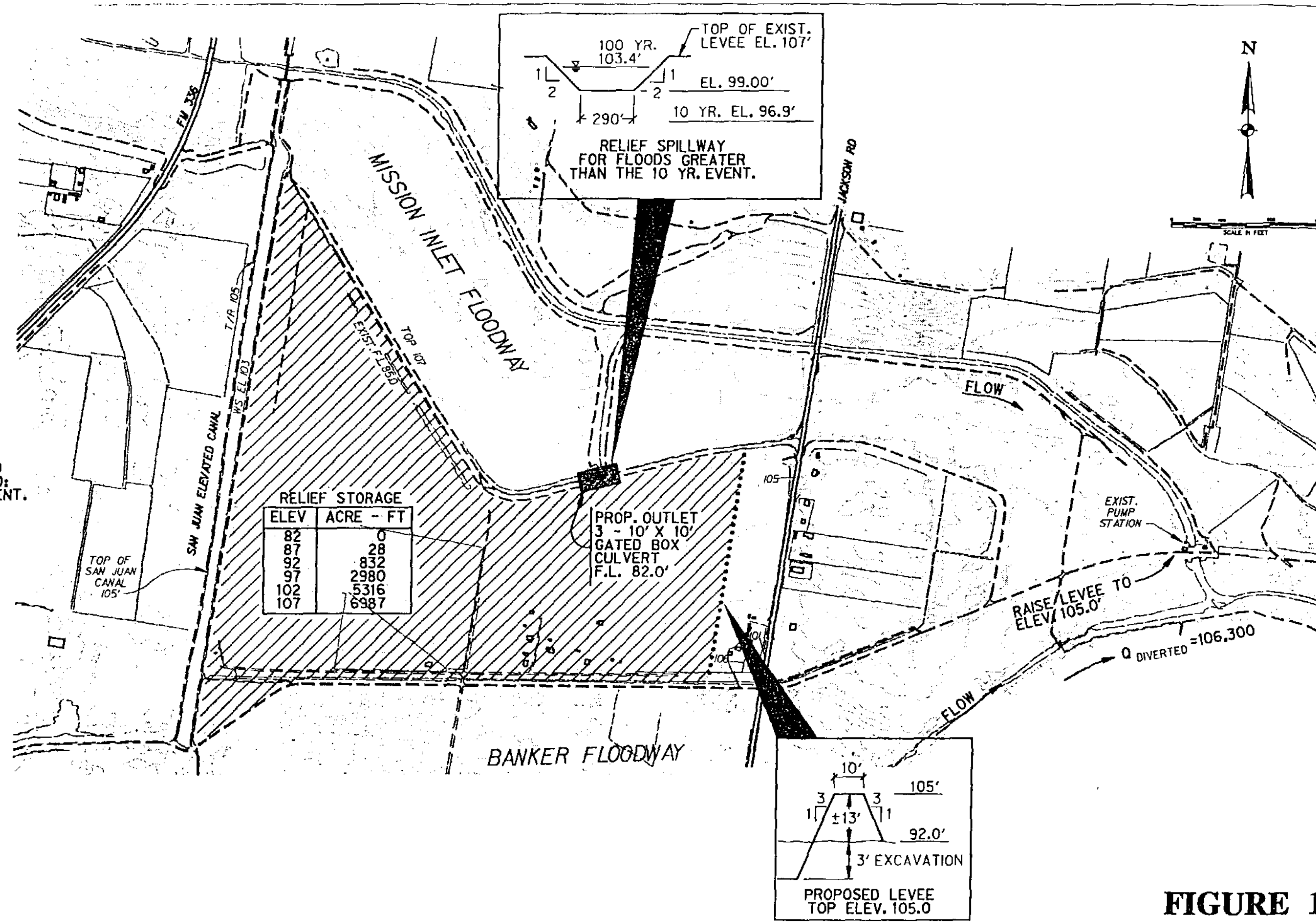

FIGURE 15

MISSION INLET FLOODWAY RELIEF STORAGE FOR 100 YR ULTIMATE LAND USE (GATES CLOSED)
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN McALLEN AND MISSION, TEXAS

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A second possible alternative location for flood storage is within the existing Mission levees. Approximately 5,660 acre-feet of flood storage could be obtained by excavating an average depth of about 2.5 feet throughout an area of 2,260 acres. This would require excavation along the entire floodway, excluding the Palm View Golf Course and Cimarron Country Club.

3. Mission Levee Reconstruction at Cimarron Country Club

Modifications of the south Mission levee at Cimarron Country Club are needed to help alleviate flooding to approximately 75 residential structures and to prevent Mission flood waters from exiting the floodway. The estimated lowest finished floor elevation (assumed elevation 12" above the 1995 DTM) at Cimarron is about 104 feet. The computed ultimate 100-year flood elevation at Cimarron is approximately 105.6 feet.

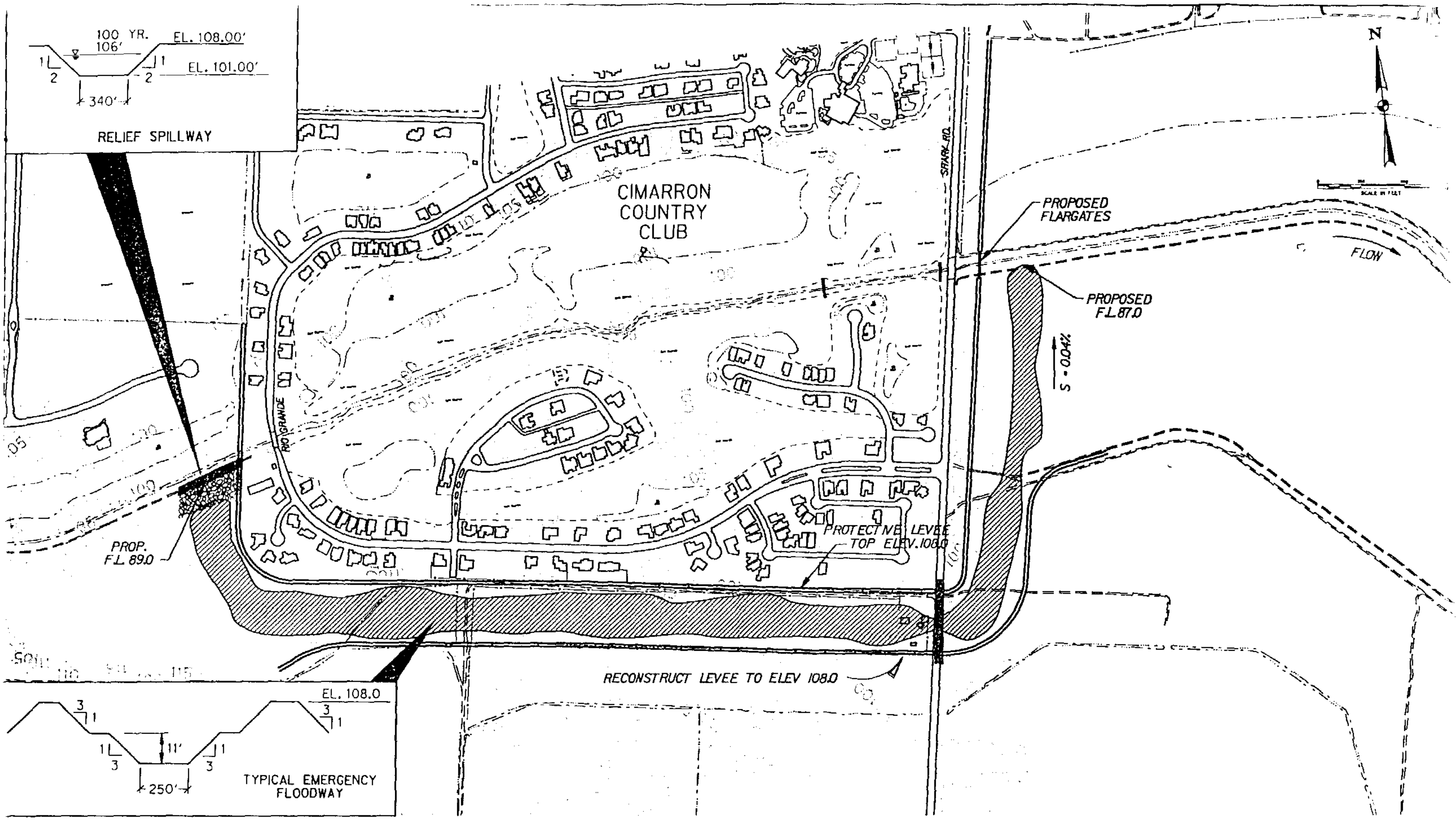
One possible solution to reduce the flooding at Cimarron, is to direct flood waters around the Cimarron development. This would include construction of a relief spillway just upstream of Rio Grande Drive and an overflow floodway along the south side of Cimarron. The proposed 340 foot wide relief spillway will convey the computed ultimate 100-year peak flow at about 5 feet depth. Flows will be directed along the south boundary of Cimarron where the south levee will be reconstructed to an elevation of about 108, approximately 4 feet above existing ground elevations. The proposed overflow floodway could be constructed as a series of linear lakes with a minimum 250 foot bottom width, 3:1 side slopes, and 12 foot depth. A flap gated outlet structure with an emergency manually operated backup gate will be required downstream of Shary Road to prevent back flow into Cimarron. In addition, a new bridge will be required where Shary Road crosses the proposed overflow floodway.

A conceptual illustration of the Mission Levee Reconstruction at Cimarron is presented on Figure 16. The estimated construction cost of these improvements is about $6,371,000. An itemized statement of probable cost is provided in Appendix E.

C. SHARYLAND/FOREIGN TRADE ZONE

1. Cell 1 Improvements (Outlet No. 1)

The Cell 1 flood storage necessary to reclaim about 70 acres of property inundated by the future (ultimate development) 100-year flood is approximately 313 acre-feet.



PROPOSED DRAINAGE IMPROVEMENT FOR CIMARRON
RECONSTRUCTION OF SOUTH LEVEE

FIGURE 16

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FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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CIMARON.DGN

About 131 acre-feet (ultimate 100-year flood) are currently stored in Cell 1 at a peak elevation of 112.1 feet, the minimum top of the Mission Levee is about 111 feet. All flows above elevation 111 feet currently spill into Mission Floodway. The future 100-year peak flood elevation of the Mission Floodway at this location is about 111.4 feet. Cell 1 improvements include raising the Mission levee to 113.4 feet (2 feet above the computed ultimate 100-yr flood elevation) and providing adequate flood storage to retain all runoff within Cell 1. A flap gated 6' X 4' box culvert outlet structure, with a manually operated emergency backup gate, will also be required at Outlet No. 1 to drain to the Mission Floodway.

A possible configuration of proposed sump areas and storage ditches draining to Outlet No. 1 are illustrated on Figure 17. The estimated construction cost of these improvements is about $2,252,000. An itemized statement of probable cost is provided in Appendix E.

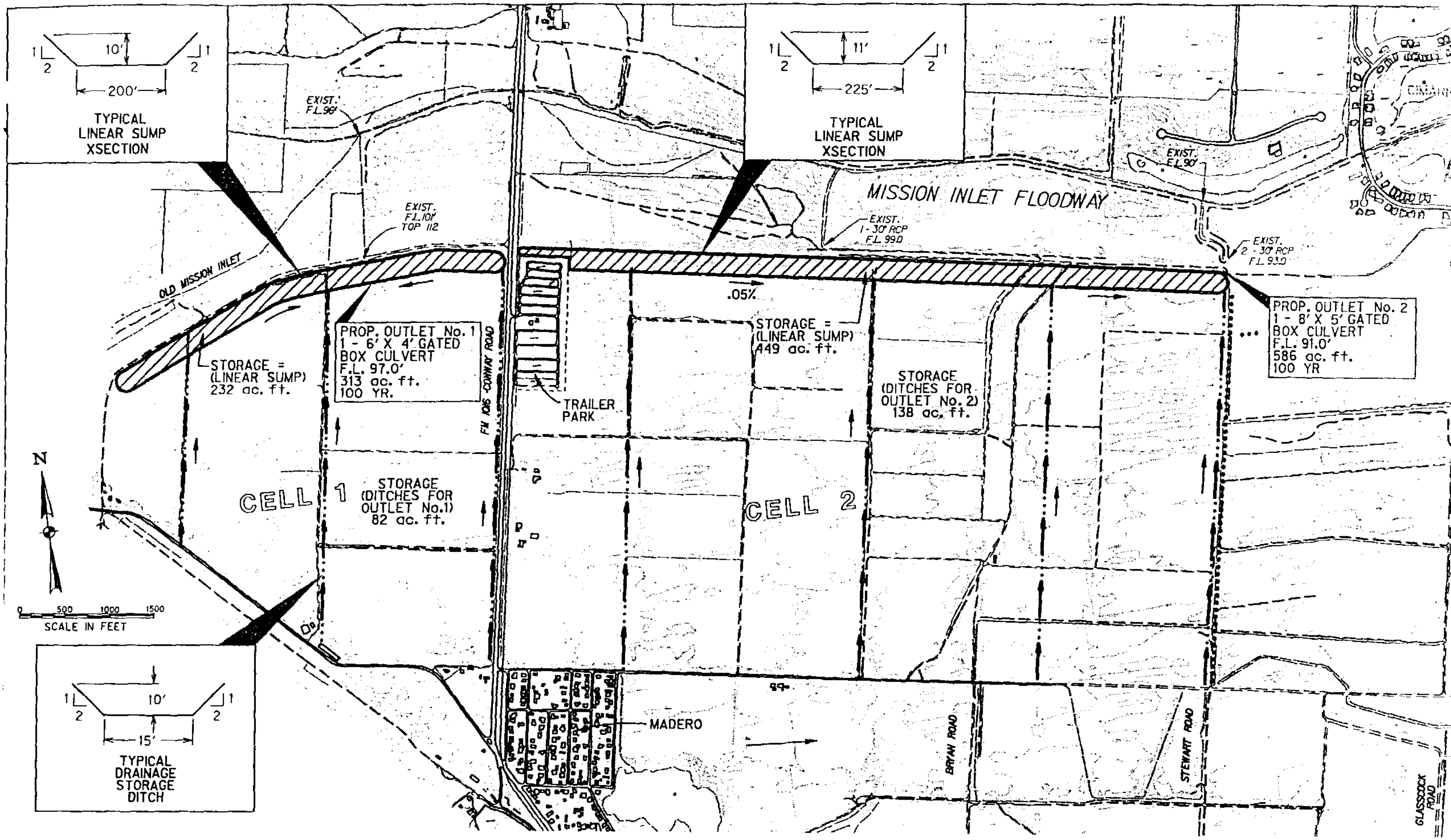
2. Cell 2 Improvements (Outlet No. 2)

Approximately 586 acre-feet of flood storage is required in Cell 2 to reclaim about 25 acres of property inundated by the future (ultimate development) 100-year flood. Currently, about 147 acre-feet, for future 100-year flood, are stored at a computed peak flood elevation of 105.6; the remaining runoff overflows to Cell 8 and eventually to Cell 9. Proposed Cell 2 Improvements include a 2 foot high berm along Stewart Road and provisions for adequate sump storage to retain the future 100-year flood. A flap gated 8' X 5' box culvert outlet structure, with a manually operated emergency backup gate, will also be required at Outlet No. 2 to drain to the Mission Floodway.

A possible configuration of proposed sump areas and storage ditches draining to Outlet 2 are illustrated on Figure 17. The estimated construction cost of these improvements is about $4,093,000. An itemized statement of probable cost is provided in Appendix E.

3. Cells 3 to 9 Improvements (Outlet No. 3)

Cells 3 thru 9 were divided into 2 improvement zones draining to Outlet No. 3 and Outlet No. 4. Cells 3 thru 8 and a portion of Cell 9 drain into Outlet No. 3, the remaining Cell 9 (Balboa Acres and Foreign Trade Zone) drain to Outlet No. 4. These zones are separated by a 3 foot high berm generally situated encircling the existing developed areas of Balboa Acres and the Foreign Trade Zone.



PROPOSED DRAINAGE IMPROVEMENT FOR CELLS 1 & 2

FLOOD PROTECTION PLANNING STUDY

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FIGURE 17

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CELL 1&2.DGN

The flood storage necessary to reclaim about 1,820 acres of property inundated by the future (ultimate development) 100-year flood is approximately 4,793 acre-feet, including about 169 acre-feet from Cimarron. Note, following implementation of the Mission Levee Reconstruction at Cimarron, the required flood storage to Outlet No. 3 will be about 4,624 acre-feet. Outlet No. 3 improvements include the excavation of about 7.5 million cubic yards of material for sump storage and two proposed 10' X 10' box culverts in addition to the existing five 4' X 4' box culverts. Flap gates with manually operated emergency backup gates will be required at all proposed and existing culverts draining to the Mission Floodway.

A possible configuration of proposed layout of sump areas and storage ditches draining to Outlet No. 3 are illustrated on Figures 18, 19, 20, and 21. The estimated construction cost of these improvements is about $31,340,000. An itemized statement of probable cost is provided in Appendix E.

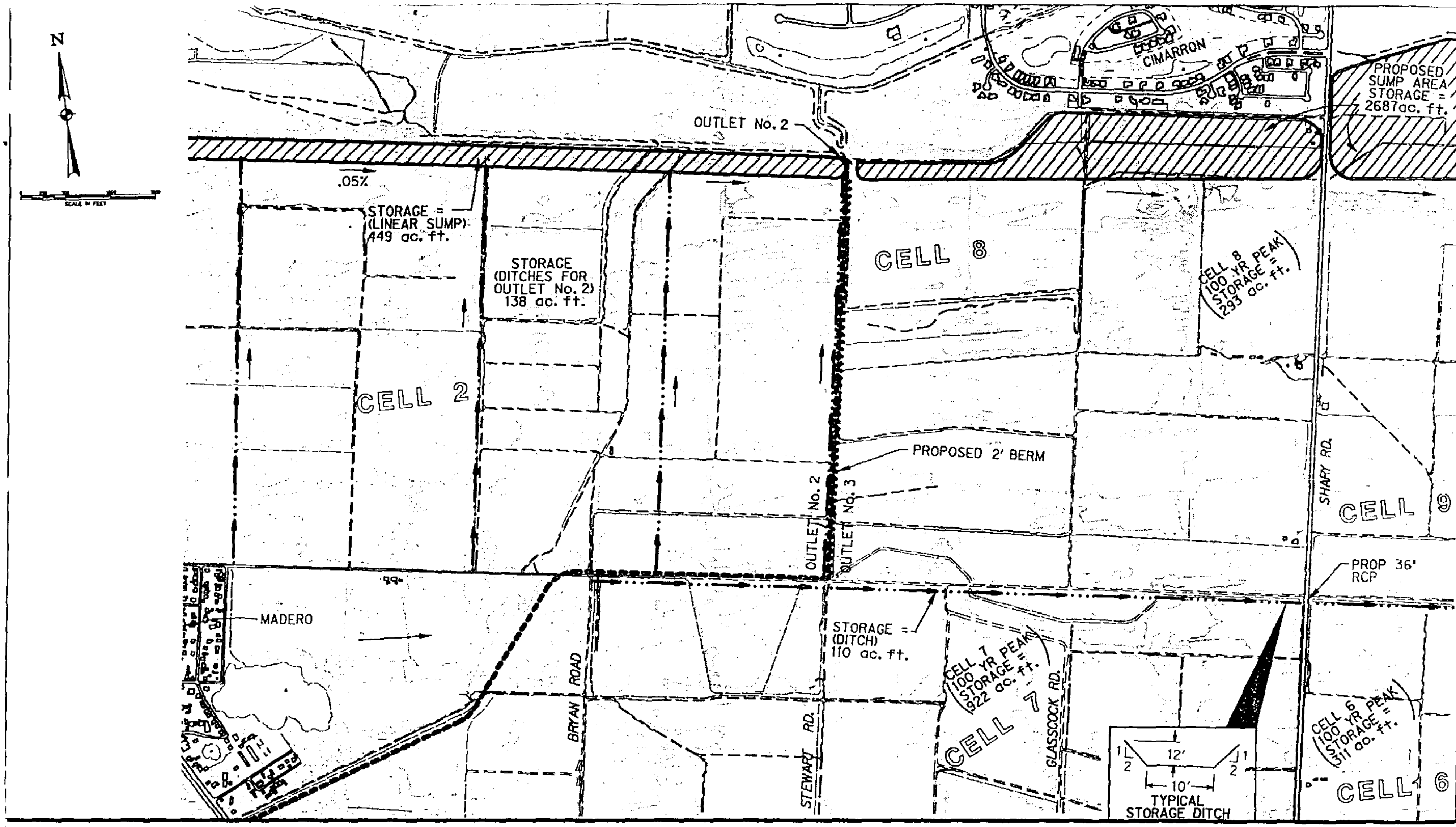
4. **Cells 3 to 9 Improvements (Outlet No. 4):**

The flood storage necessary to alleviate flooding of approximately 1,155 residential, warehouse and commercial structures, located in Balboa Acres and the Foreign Trade Zone, currently inundated by the future 100-year flood is approximately 1,470 acre-feet. Proposed improvements draining to Outlet No. 4 include the excavation of about 2.4 million cubic yards of material for sump storage and a proposed 10' X 10' box culvert outlet structure. In addition, a flap gate with manually operated emergency backup gate will be required at the outfall to Outlet 4.

A possible configuration of proposed layout of sump areas and storage ditches draining to Outlet No. 4 are illustrated on Figures 19, and 20. The estimated construction cost of these improvements is about $10,147,000. An itemized statement of probable cost is provided in Appendix E.

5. **Cell 10 Improvements (Outlet No. 5):**

Cell 10 improvements are bounded by the McAllen Main Canal and the San Juan elevated canal. The total flood storage necessary to reclaim about 100 acres of property inundated by the future (ultimate development) 100-year flood is approximately 780 acre-feet. Proposed improvements draining to Outlet No. 5 include the excavation of about 1.3 million cubic yards of material for sump storage. A flap gated 10' X 6' box culvert outlet structure, with a manually operated emergency backup gate, will also be required at Outlet No. 5 to drain to the Mission Floodway.



MATCH LINE SEE FIGURE 20

FIGURE 18

PROPOSED DRAINAGE IMPROVEMENT FOR CELLS 3 – 9
SHEET 1 OF 4

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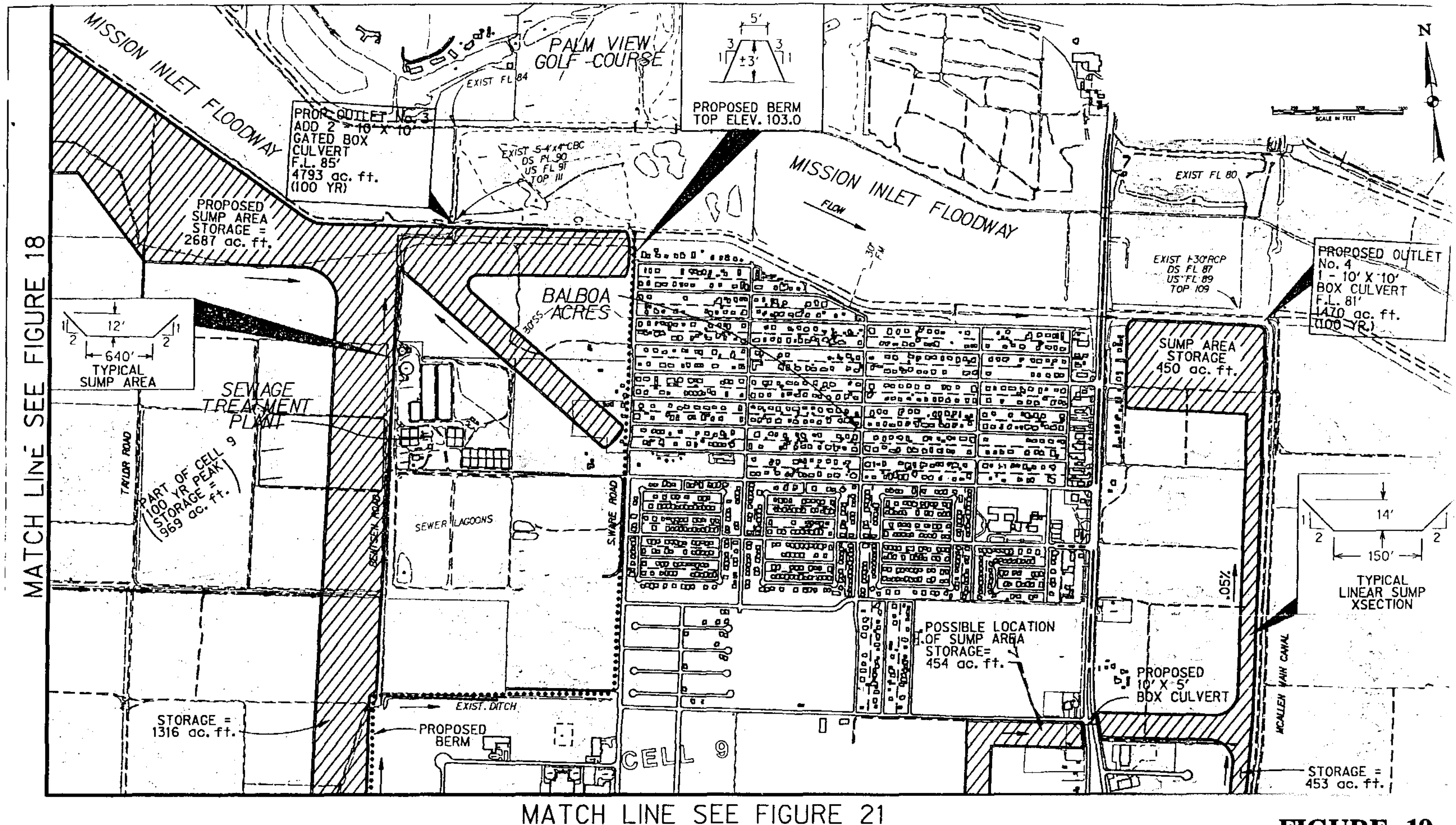

FIGURE 19

PROPOSED DRAINAGE IMPROVEMENT FOR CELLS 3 – 9
SHEET 2 OF 4

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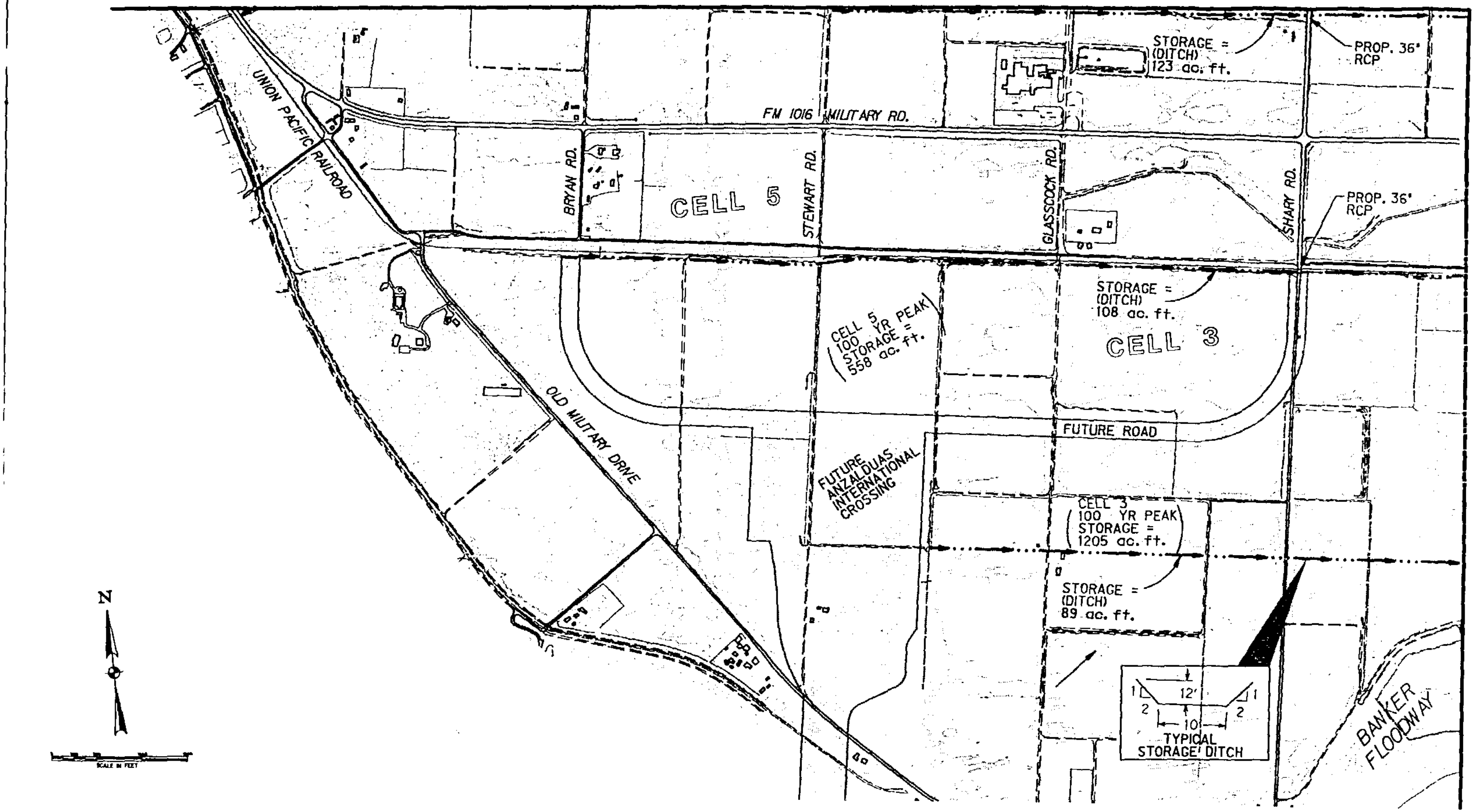

PROPOSED DRAINAGE IMPROVEMENT FOR CELLS 3-9
SHEET 3 OF 4

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FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

FIGURE 20

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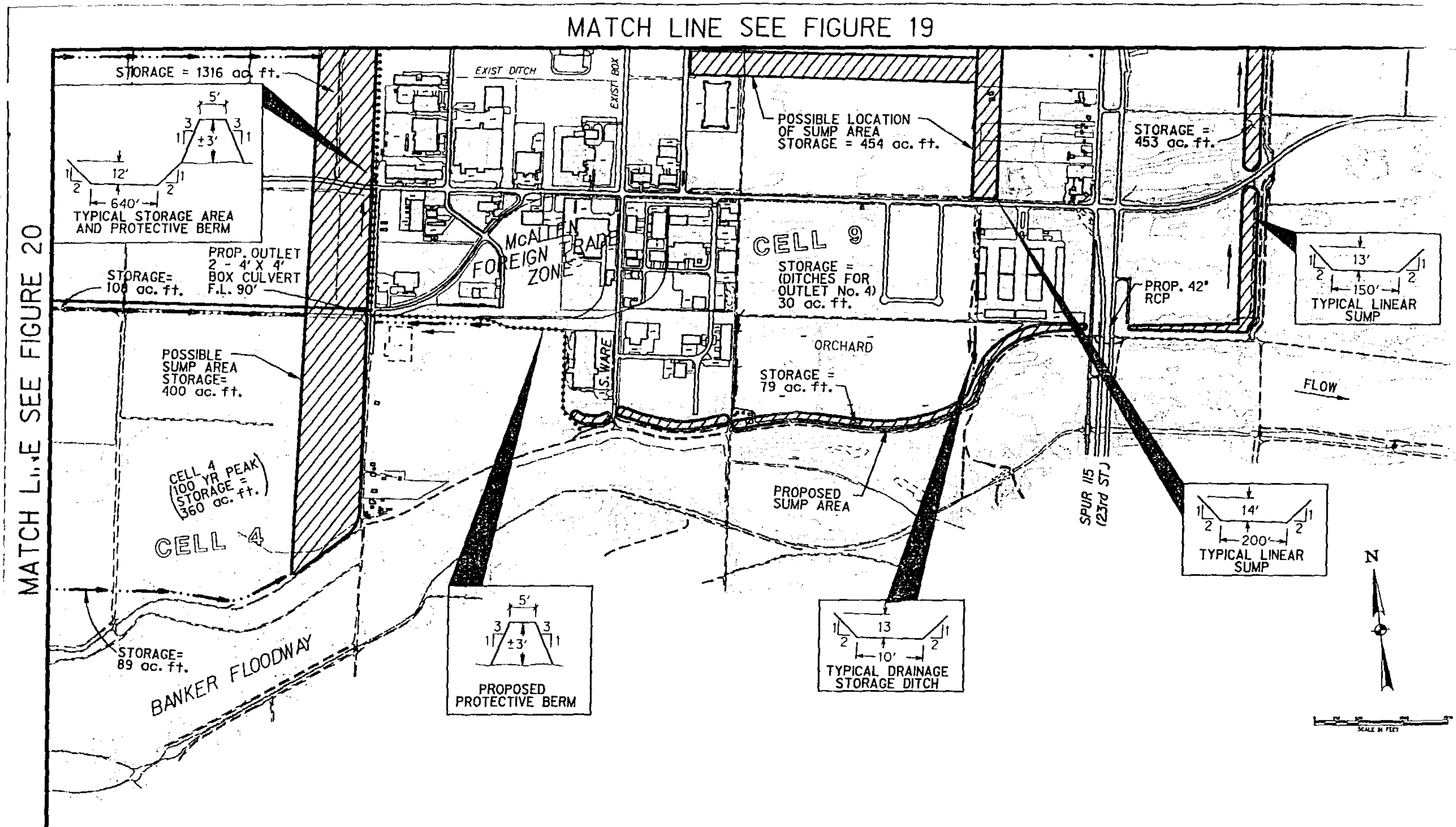
CELL9_3.DGN



PROPOSED DRAINAGE IMPROVEMENT FOR CELLS 3 – 9
SHEET 4 OF 4

FIGURE 21

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FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

CITY OF McALLEN

CELL9-4.DGN

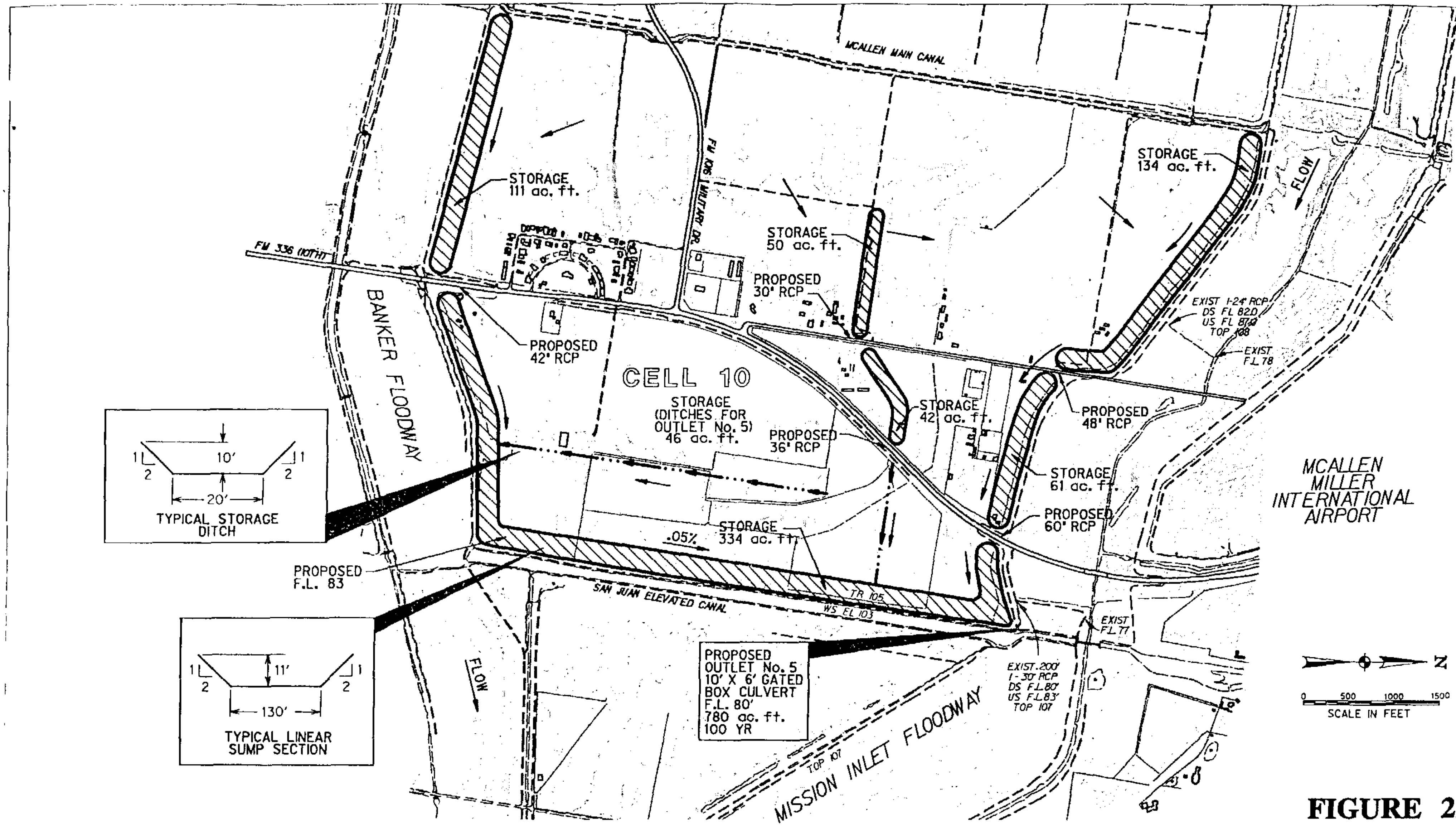

FIGURE 22

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PROPOSED DRAINAGE IMPROVEMENT FOR CELL-10
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

CITY OF McALLEN

CELL10.DGN

A possible configuration of proposed layout of sump areas and storage ditches draining to Outlet No. 5 are illustrated on Figure 22. The estimated construction cost of these improvements is about $5,667,000. An itemized statement of probable cost is provided in Appendix E.

6. **Cell 11 Improvements (Outlet No. 6):**

Cell 11 improvements are bounded by the San Juan elevated canal and the Mission and Banker levees. The total flood storage necessary to alleviate flooding of approximately 6 residential structures, located along Jackson Road, and reclaim about 180 acres of property, inundated by the future (ultimate development) 100-year flood, is approximately 377 acre-feet. Proposed improvements draining to Outlet No. 6 include the excavation of about 607,000 cubic yards of material for sump storage. A flap gated 6' X 4' box culvert outlet structure, with a manually operated emergency backup gate, will also be required at Outlet No. 6 to drain to the Mission Floodway.

A possible configuration of proposed layout of sump areas and storage ditches draining to Outlet No. 6 are illustrated on Figure 23. The estimated construction cost of these improvements is about $2,756,000. An itemized statement of probable cost is provided in Appendix E.

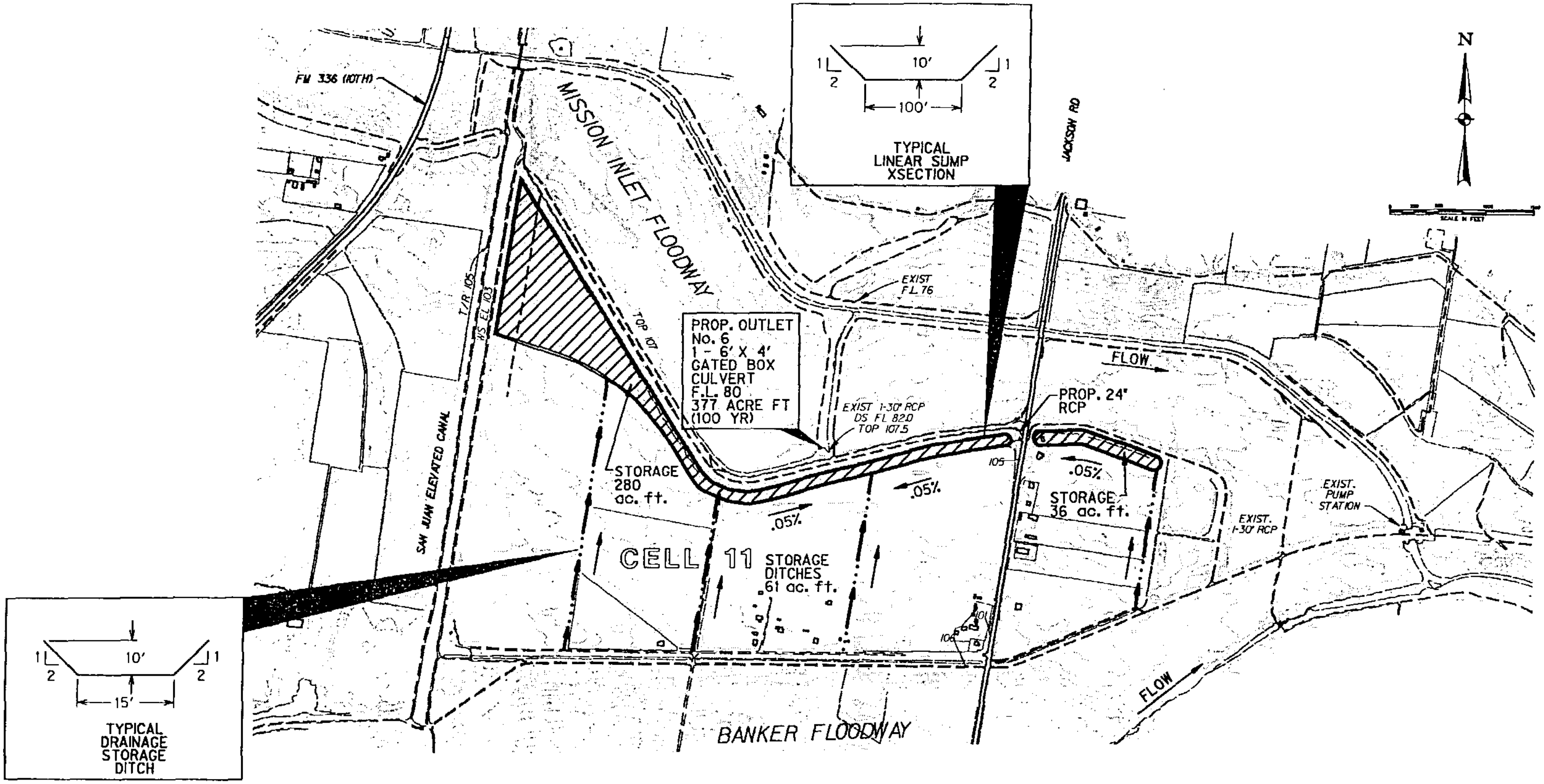

FIGURE 23

PROPOSED DRAINAGE IMPROVEMENTS FOR CELL–11
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN McALLEN AND MISSION, TEXAS

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CELL11.DGN

SECTION V
RECOMENDATIONS

V. RECOMMENDATIONS

A. PRIORITY RECOMMENDED STRUCTURAL IMPROVEMENTS

Based on the results of this study, the need to address imminent flood damages to property and structures, and a review of the various improvement plans (described in detail in Chapter IV), Halff Associates' initial recommendations include implementation of flood damage reduction improvement plans in the following order of priority:

1. Mission Levee Reconstruction at Cimarron Country Club

Modifications of the south Mission levee at Cimarron Country Club are needed to help alleviate flooding to approximately 75 residential structures and to prevent the Mission flood waters from exiting the floodway. Re-directing flood waters around the Cimarron development would include construction of a relief spillway just upstream of Rio Grande Drive and an overflow floodway along the south side of Cimarron. The proposed 340 foot wide relief spillway will convey the computed ultimate 100-year peak flow at about 5 feet depth. Flows will be directed along the south boundary of Cimarron where the south levee will be reconstructed to an elevation of about 108. The proposed overflow floodway could be constructed as a series of linear lakes with a minimum 250 foot bottom width, 3:1 side slopes, and 12 foot depth. A flap gated outlet structure with an emergency manually operated backup gate will be required downstream of Shary Road to prevent back flow into Cimarron. In addition, a new bridge will be required where Shary Road crosses the proposed overflow floodway. The estimated construction cost of these improvements is about $6,371,000.

2. Cells 3 to 9 Improvements (Outlet No. 4):

Approximately 1,470 acre-feet of flood storage is required to alleviate flooding of approximately 1,155 residential, warehouse and commercial structures, located in Balboa Acres and the Foreign Trade Zone, currently inundated by the future 100-year flood. Proposed improvements draining to Outlet No. 4 include the excavation of about 2.4 million cubic yards of material for sump storage and a proposed 10' X 10' box culvert outlet structure. In addition, a flap gate with manually operated emergency backup gate will be required at the outfall to Outlet 4. The estimated construction cost of these improvements is about $10,147,000.

B. OTHER RECOMMENDED STRUCTURAL IMPROVEMENTS

1. Raising the Mission Levee

Halff Associates recommend the Cities consider raising the existing levee, in accordance with FEMA criteria, at the all locations where the computed future 100-year flood will overtop the Mission Levee. According to FEMA "Riverine levees must provide a minimum freeboard of three feet above the water surface level of the base flood. An additional one foot above the minimum is required within 100 feet in either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. An additional one-half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required." (Reference 20).

2. Mission Floodway Emergency Floodway

In order to prevent the Mission Levee from breaching, during the 100-year event, an adequate emergency spillway is needed. A proposed 800 foot length rock lined emergency spillway will be required to convey the future 100-year flood, assuming gates closed. In addition, about 3,000 linear feet of the existing levee will be raised to elevation 105 feet. Note, the purpose of these improvements is to protect the levee from breaching, not to alleviate flooding of properties. The estimated construction cost of this improved spillway is about $2,033,000.

C. GENERAL WATERSHED RECOMMENDATIONS

1. To minimize land erosion and the subsequent sediment loading and siltation in the channels, the Cities should consider requiring large construction projects to be phased to limit the land area that is bare at any one time. Vegetation should be left undisturbed wherever possible. Graded areas should be replanted as soon as possible, and mulches should be used during periods that are not suitable for replanting. Hay bales and/or silt fences should be properly located and included in general construction plans and specifications.

2. Halff Associates recommends that the Cities inspect all existing and future channels periodically to identify potential stream obstructions before they occur. Periodic inspections should identify City controlled floodway areas in which siltation has decreased the flood-storage capacity of the channel and culverts.

3. Halff Associates recommend the Cities replace all gated outlet structures to the Mission Floodway with operable flap gates and emergency backup gates. Periodic inspections of these structures is also recommended.

4. City flood plain zoning maps should be revised to correspond to the revised 100-year flood delineation at the appropriate time.

5. Stream crossings that are hazardous during floods with a return period of 100 years or less, should be marked with a active or passive flood warning system. Passive warning systems are feasible on lightly travelled streets where motorists are familiar with the area and at crossings with minor flooding. Active flood warning systems are necessary on heavily travelled thoroughfares. Guardrails should be installed at hazardous crossings subject to flooding. Guardrails are also useful in indicating the edge of the trafficable road surface to pedestrians and motorists, where flood waters may mask the location of the road surface.

6. The Cities should continue with its present policy of monitoring new development and requiring developers to submit a detailed drainage study of existing (pre-development) and post-development conditions with corresponding hydrologic and/or hydraulic computer models. Halff Associates also recommends the City require an analysis for a full range of flood frequency events (minimum of 2-, 5-, 10-, 25-, 50-, and 100-year flood events), this especially important in the development of an effective detention pond design.

7. The Cities should encourage homeowners subject to flooding to participate in the National Flood Insurance Program. Although flood insurance does not prevent damages from occurring, the purchase of flood insurance could provide some monetary relief from expensive flood damages.

D. UPDATING HYDROLOGIC AND HYDRAULIC COMPUTER MODELS

Included in this report are the computer data diskettes containing the hydrologic and hydraulic computer models used in the production of this report. These baseline models will enable the City Engineering staff to predict effects of anticipated changes in land use and/or watershed characteristics upon flood levels using an IBM or compatible Personal Computer. Halff Associates recommends that the Cities require developers to provide updated "as-built" hydrologic and hydraulic computer models as channel and/or flood plain conditions are modified.

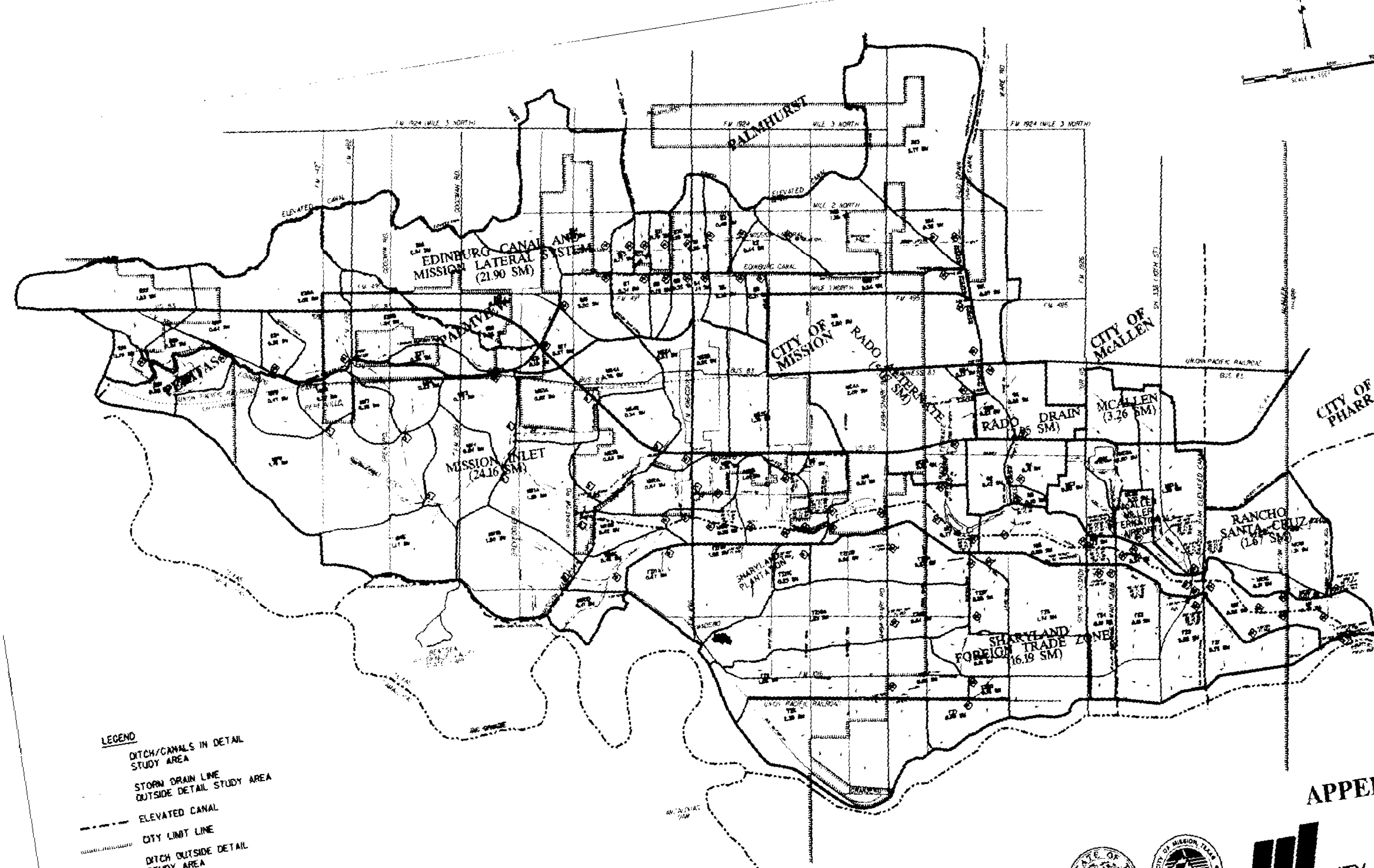
Generally, the HEC-1 hydrologic computer model used in this report should be applicable for a fully developed watershed, provided development occurs as predicted by the future land use maps of the cities within the watershed. Halff Associates recommends the City consider updating the hydrologic and hydraulic computer models prepared for this study a minimum of every five (5) years.

E. FLOOD PLAIN MANAGEMENT POLICIES

Halff Associates recommends that the Cities consider adopting a flood plain management policy that would require all new developments within the Sharyland/Foreign Trade Zone provide a minimum of 0.8 acre-feet of flood storage for every one acre of development.

It is further recommended that the Cities formally adopt the flood levels shown in this report for their flood plain management program.

APPENDIX A
Drainage Area Map



LEGEND

- DITCH/CANALS IN DETAIL STUDY AREA
- STORM DRAIN LINE OUTSIDE DETAIL STUDY AREA
- ELEVATED CANAL
- CITY LIMIT LINE
- DITCH OUTSIDE DETAIL STUDY AREA
- ROAD
- LIMITS OF DETAIL STUDY
- RIVERS & FLOODWAYS
- DRAINAGE SYSTEM DIVIDE

APPENDIX A

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DETAIL DRAINAGE AREA MAP

FLOOD PROTECTION PLANNING STUDY

FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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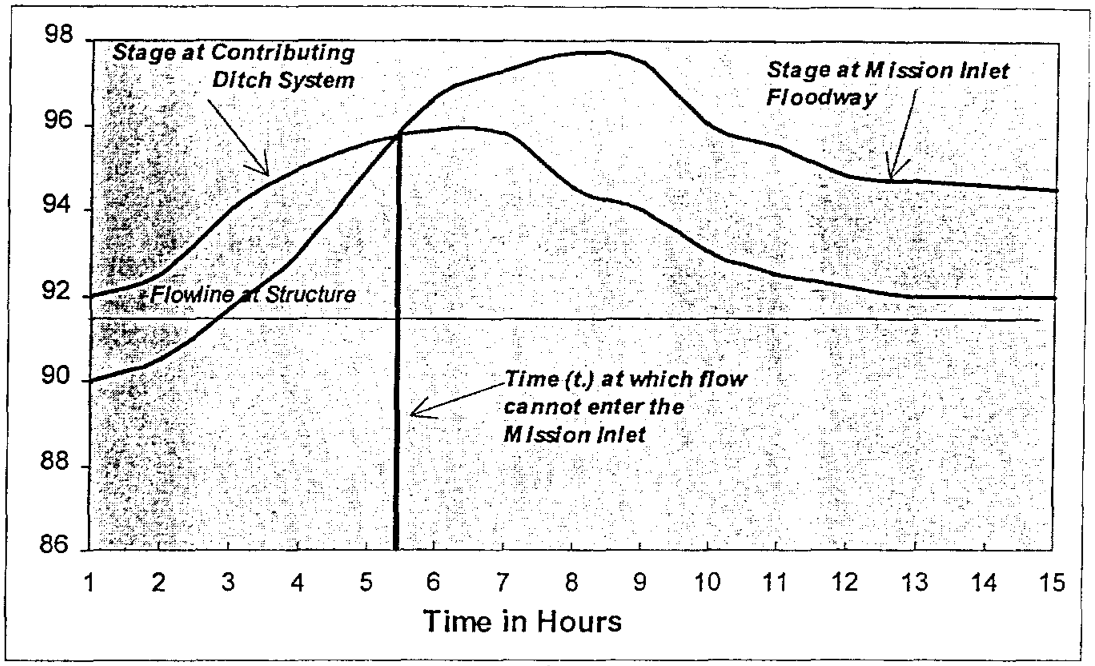
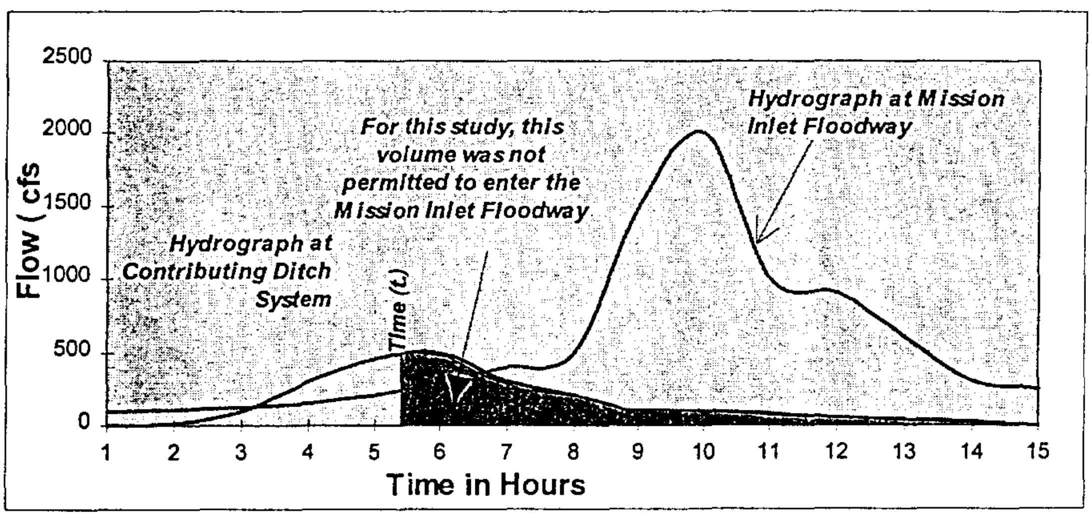
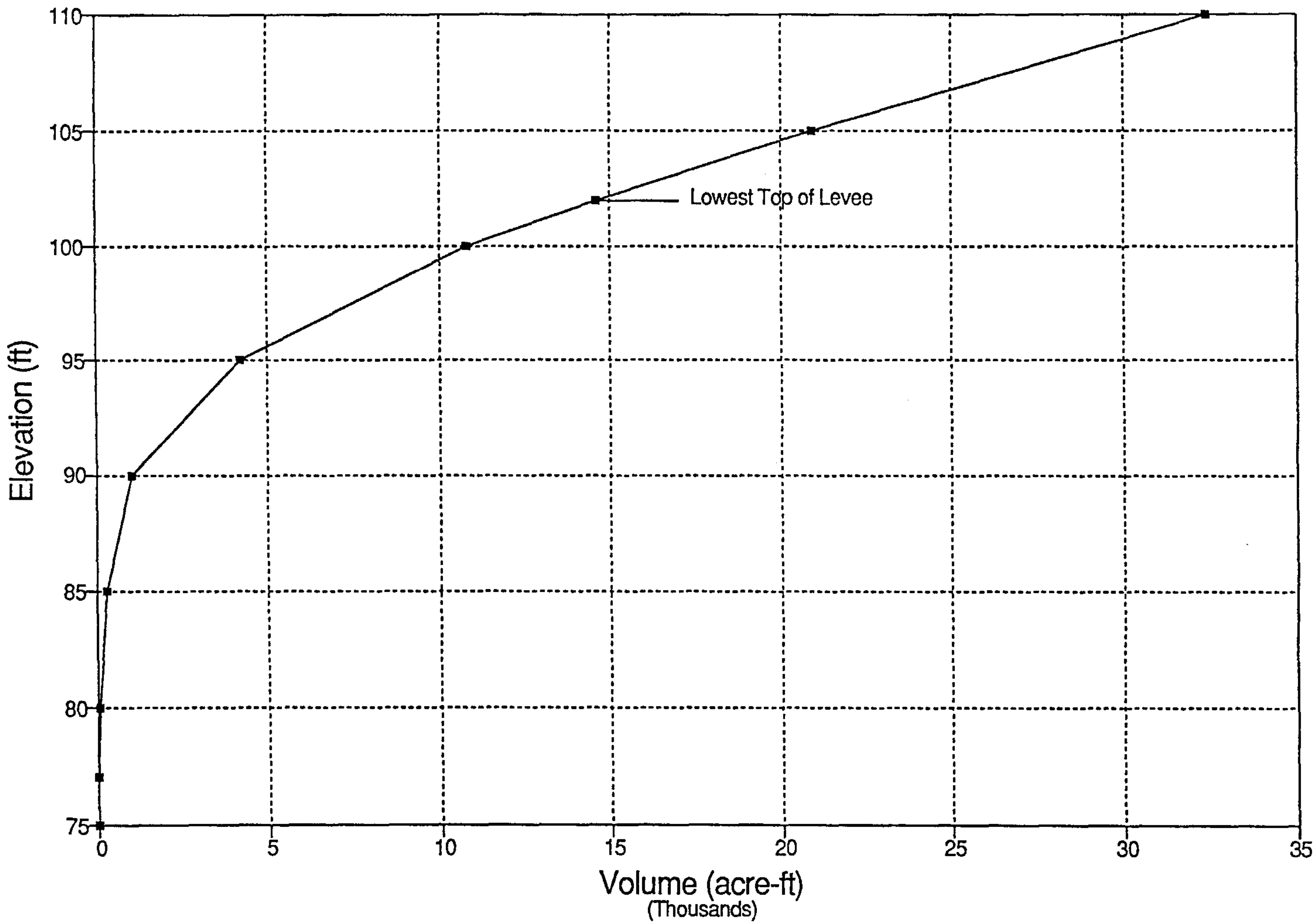
APPENDIX B
Elevation-Storage Tables

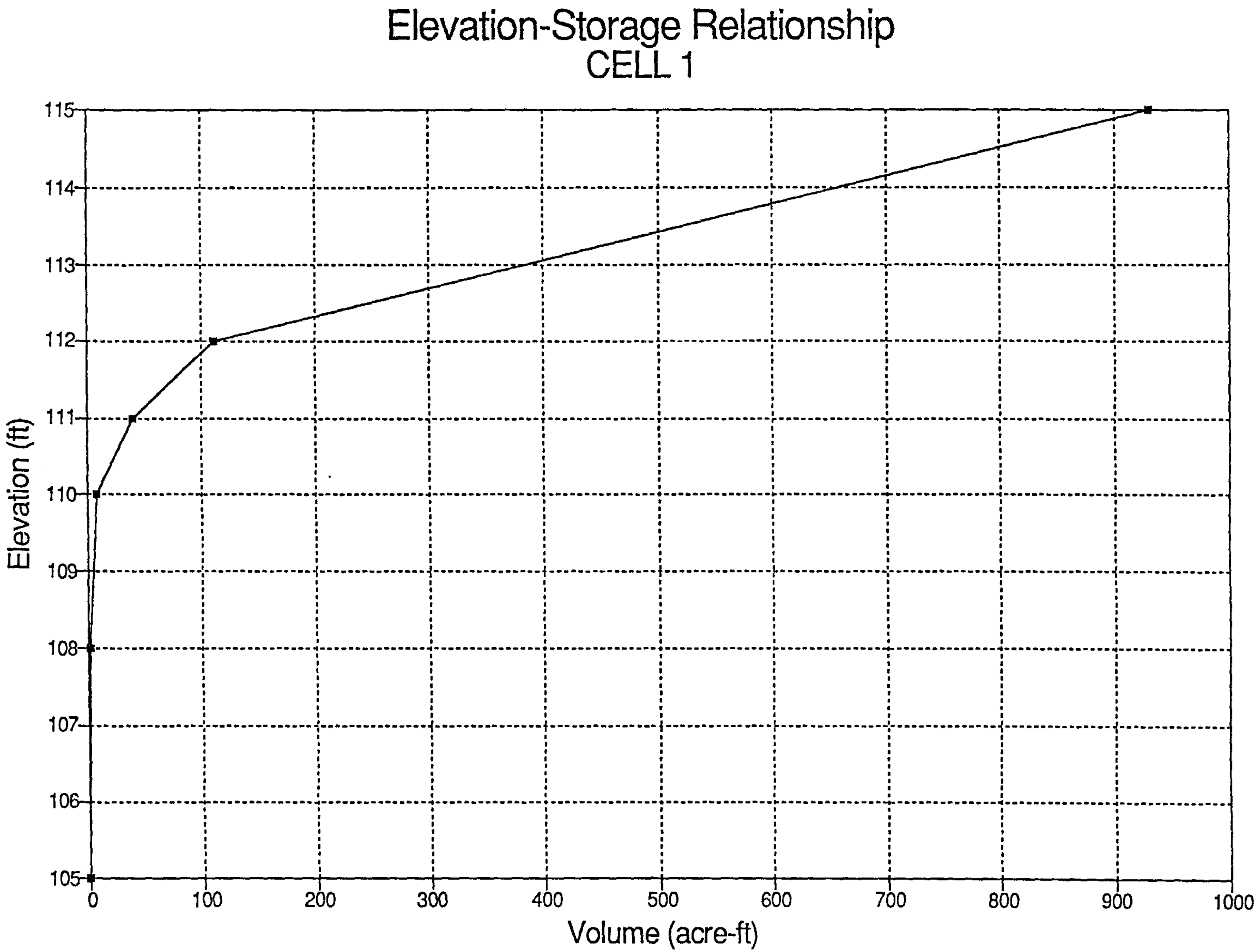


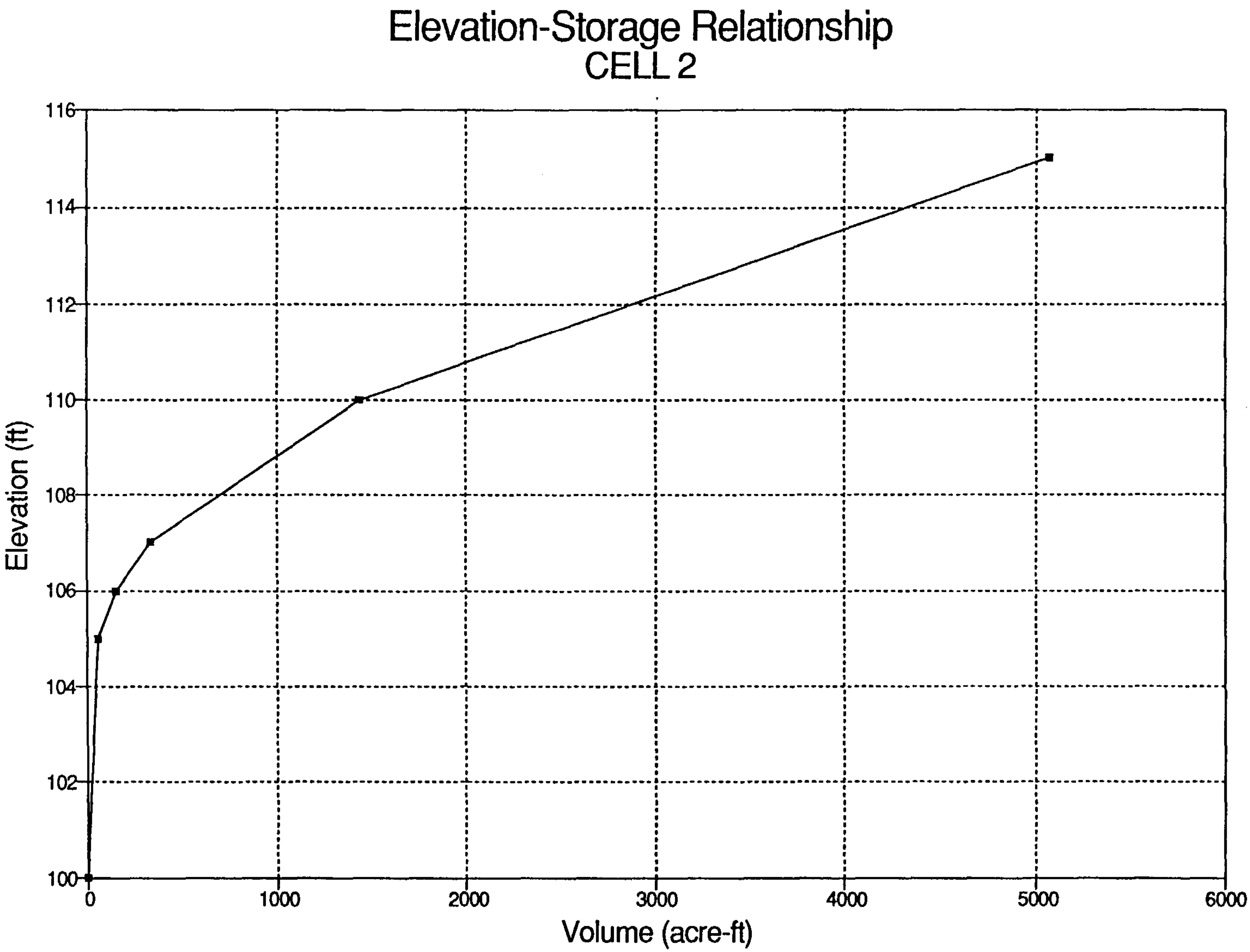


Regulated Flows of Contributing Ditch Systems to the Mission Inlet Floodway

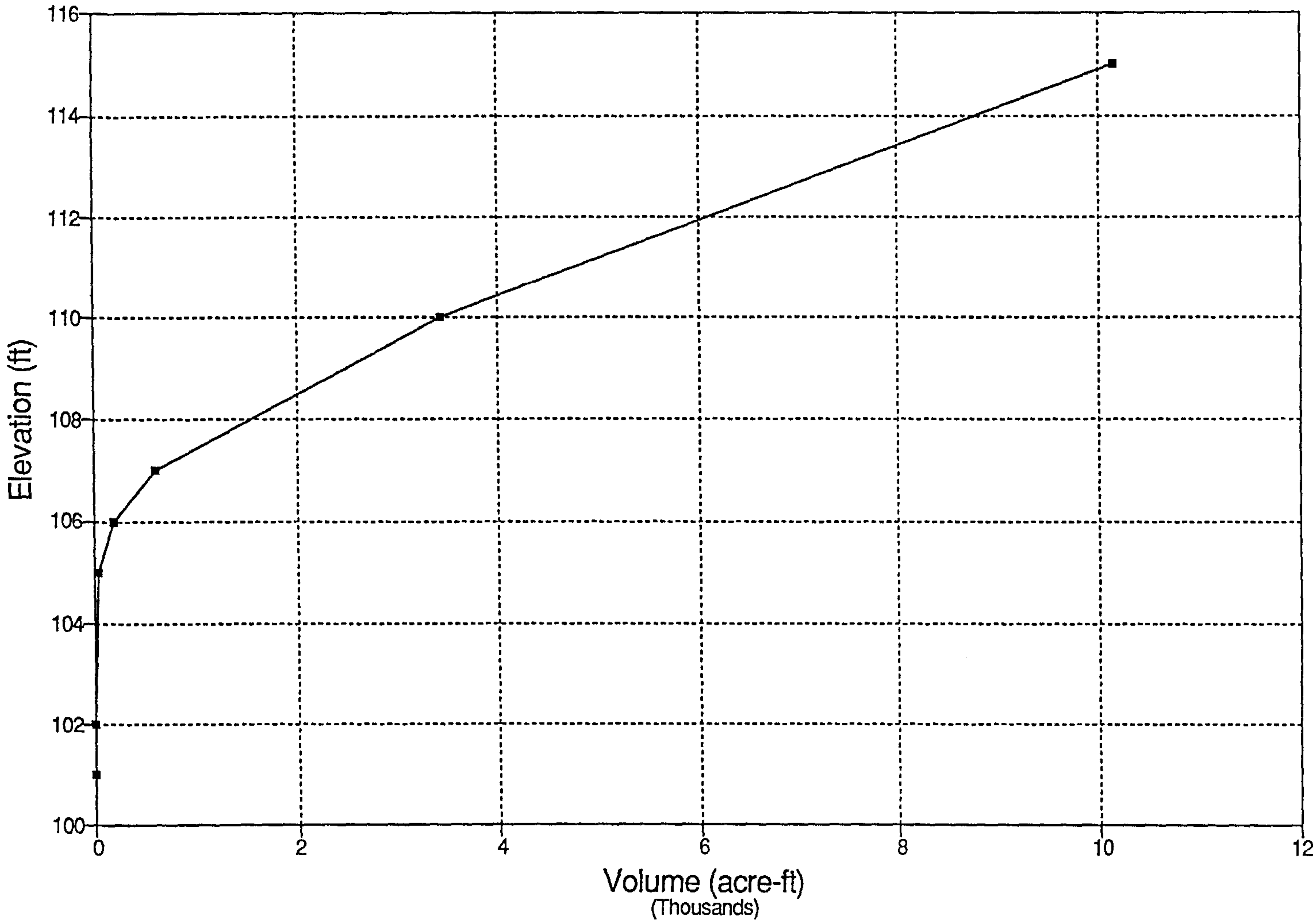
Elevation-Storage Relationship
Mission Inlet Fldwy-Total (Cells 12-17)

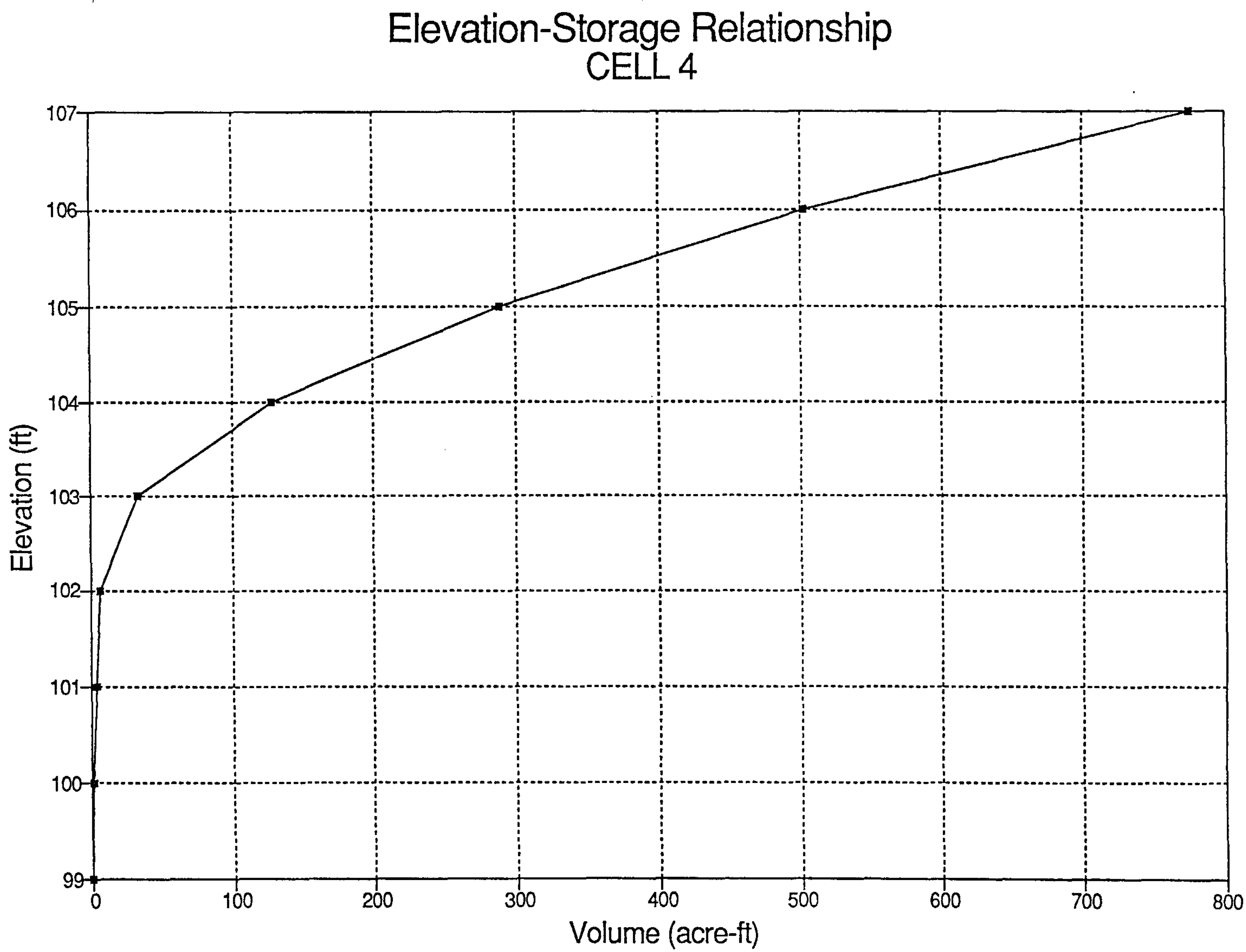



Elevation-Storage Relationship
CELL 1
Elevation (ft)
115
114
113
112
111
110
109
108
107
106
105
0
100
200
300
400
500
600
700
800
900
1000
Volume (acre-ft)


Elevation-Storage Relationship
CELL 2
Elevation (ft)
116
114
112
110
108
106
104
102
100
0
1000
2000
3000
4000
5000
6000
Volume (acre-ft)

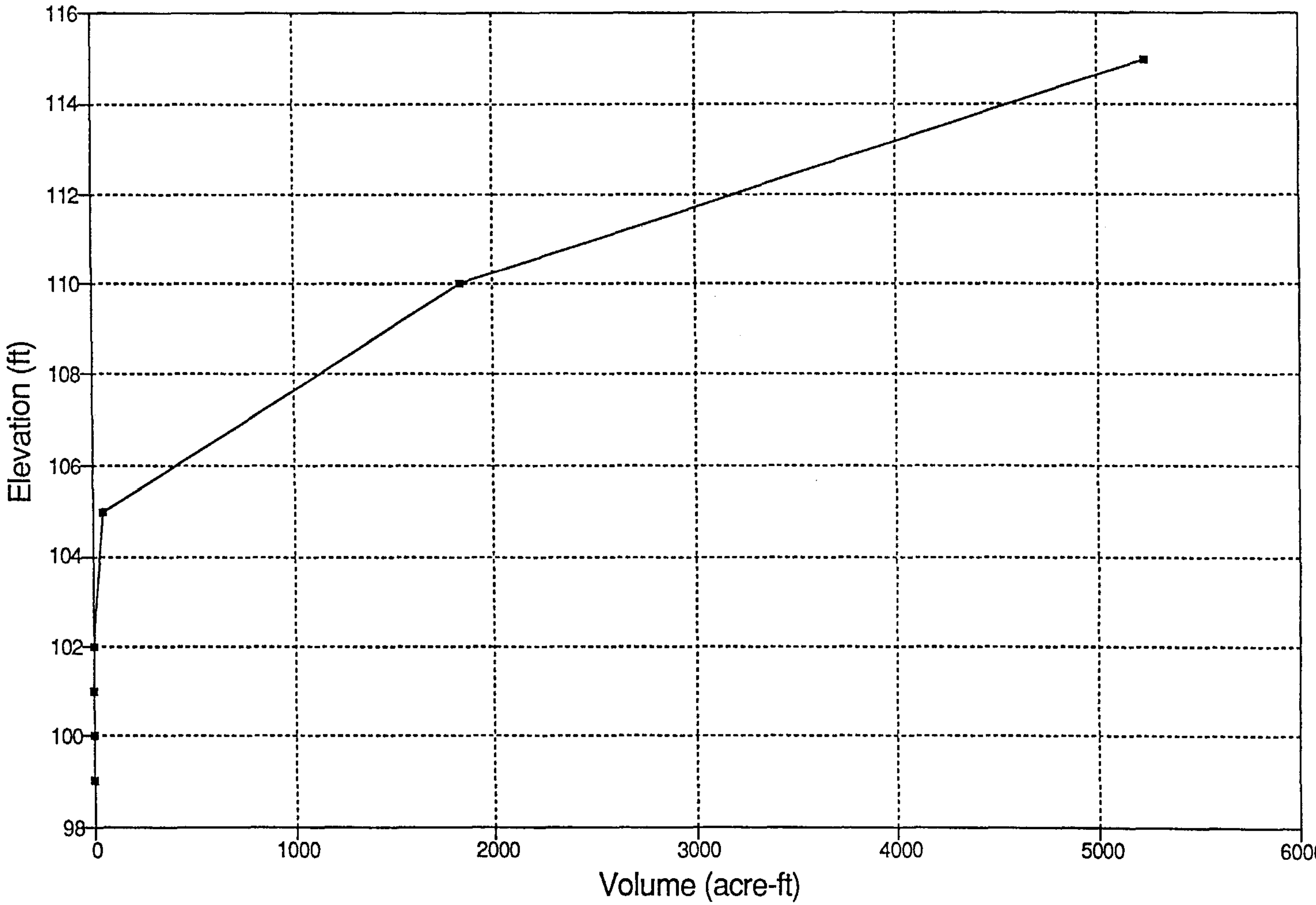
Elevation-Storage Relationship
CELL 3

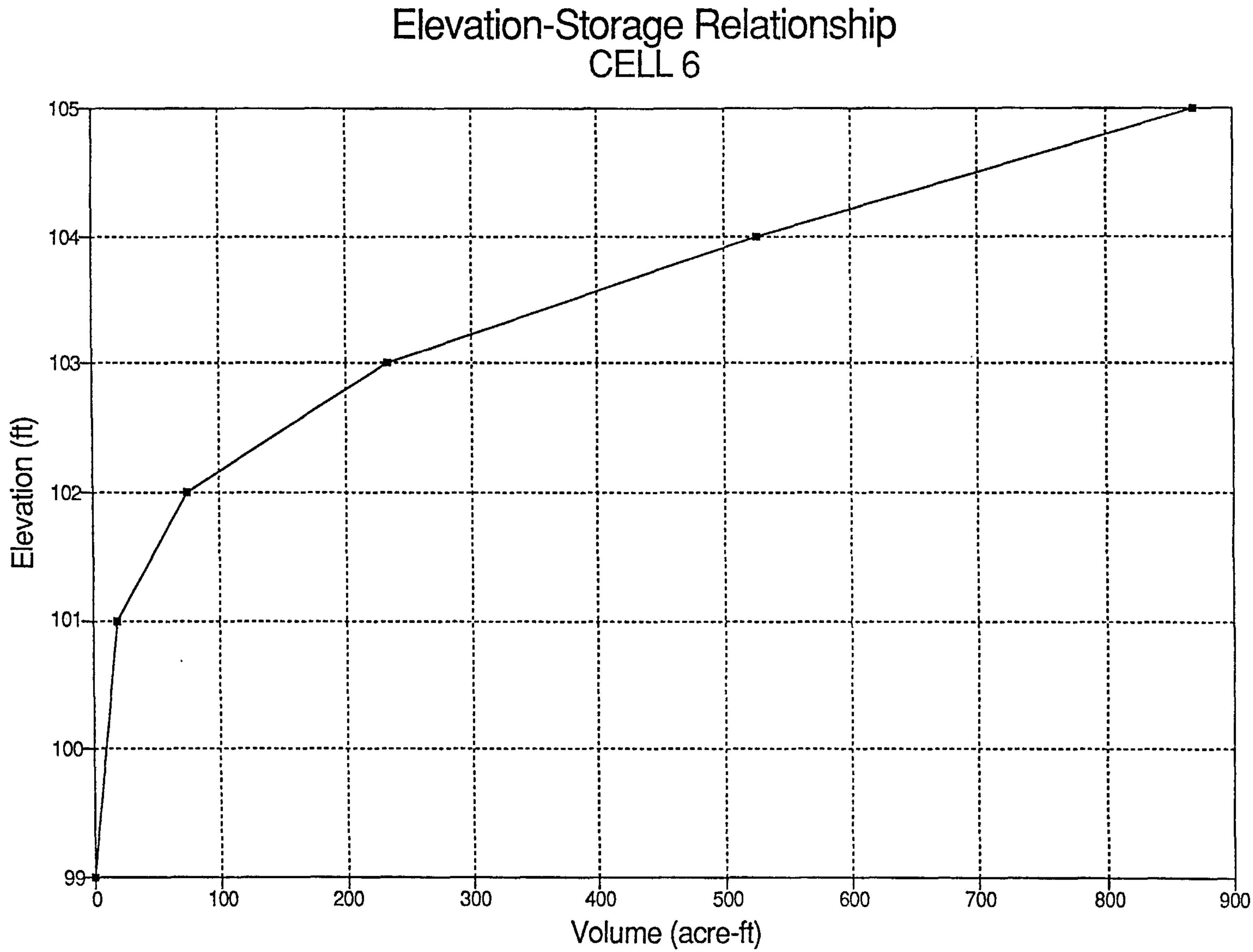




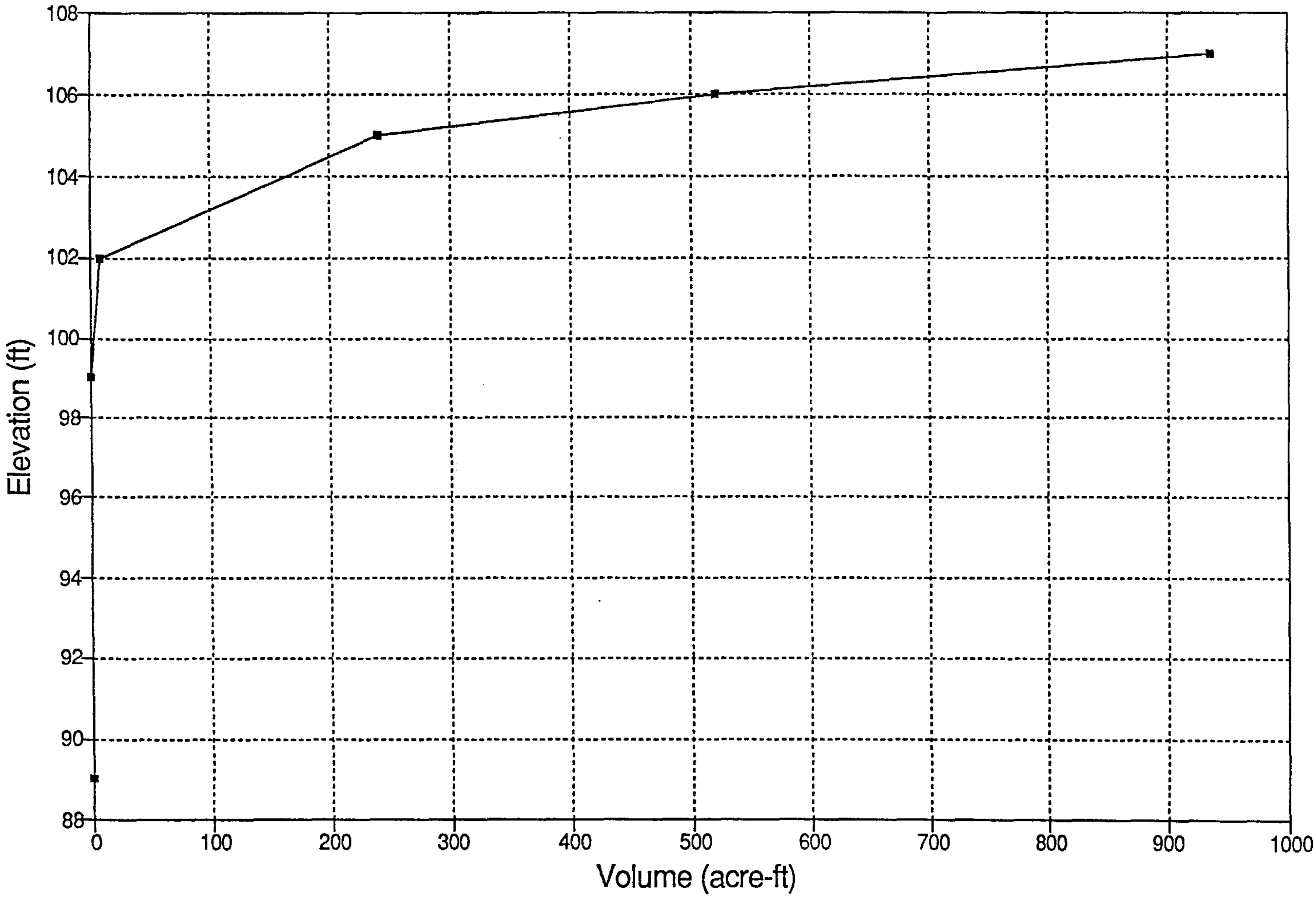
Elevation-Storage Relationship
CELL 4
Elevation (ft)
107
106
105
104
103
102
101
100
99
0
100
200
300
400
500
600
700
800
Volume (acre-ft)

Elevation-Storage Relationship
CELL 5

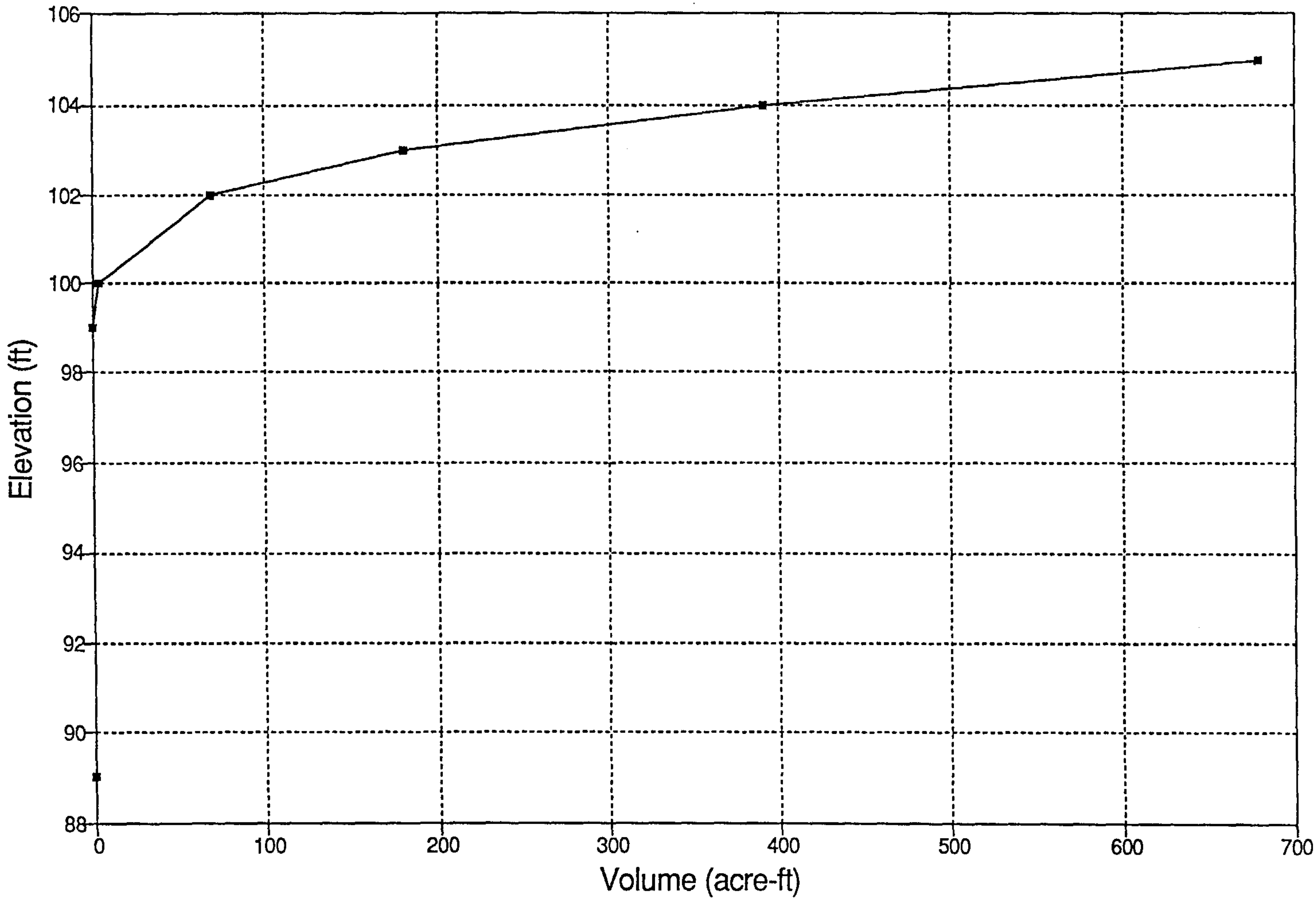



Elevation-Storage Relationship
CELL 6
Elevation (ft)
105
104
103
102
101
100
99
0
100
200
300
400
500
600
700
800
900
Volume (acre-ft)

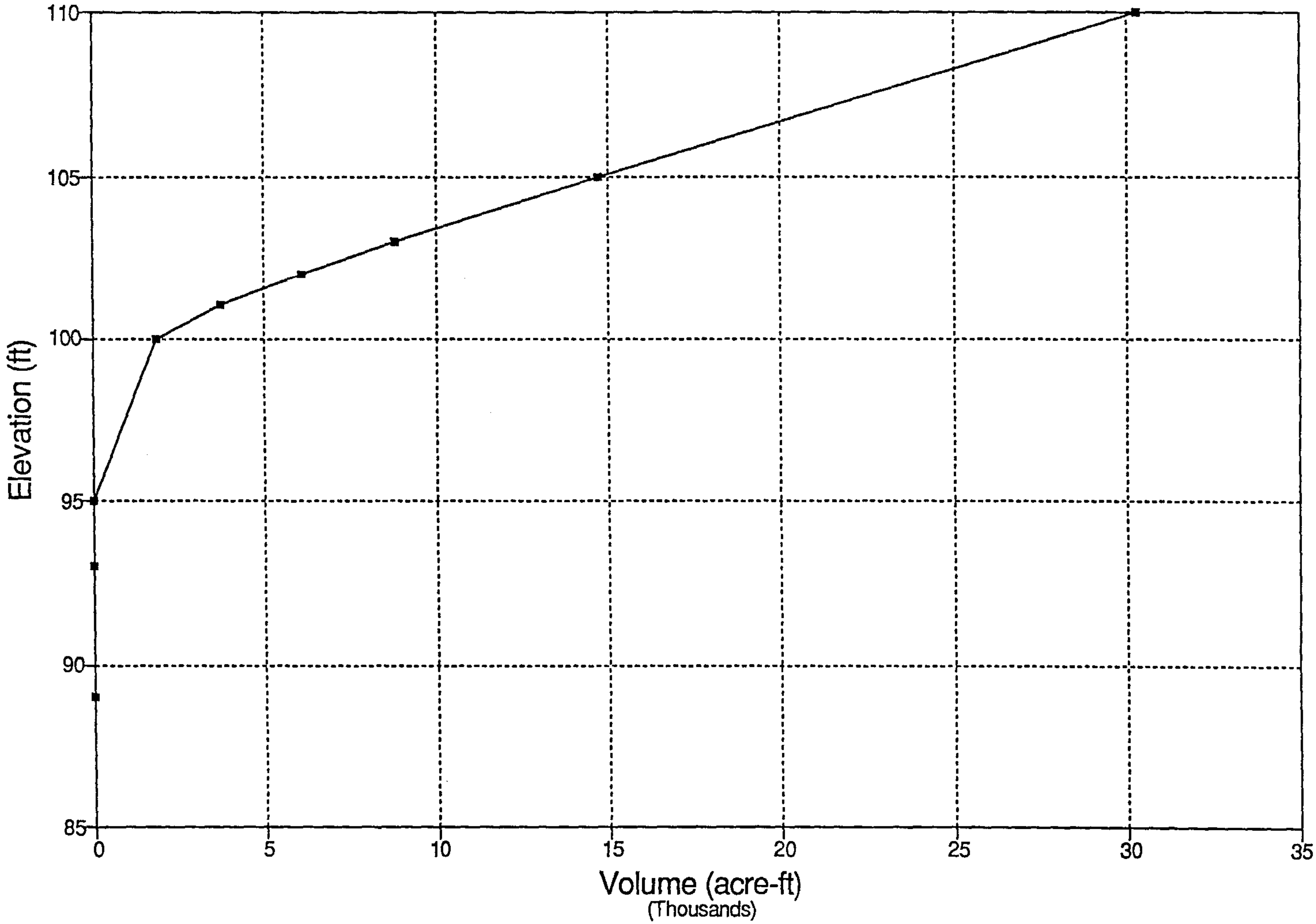
Elevation-Storage Relationship
CELL 7

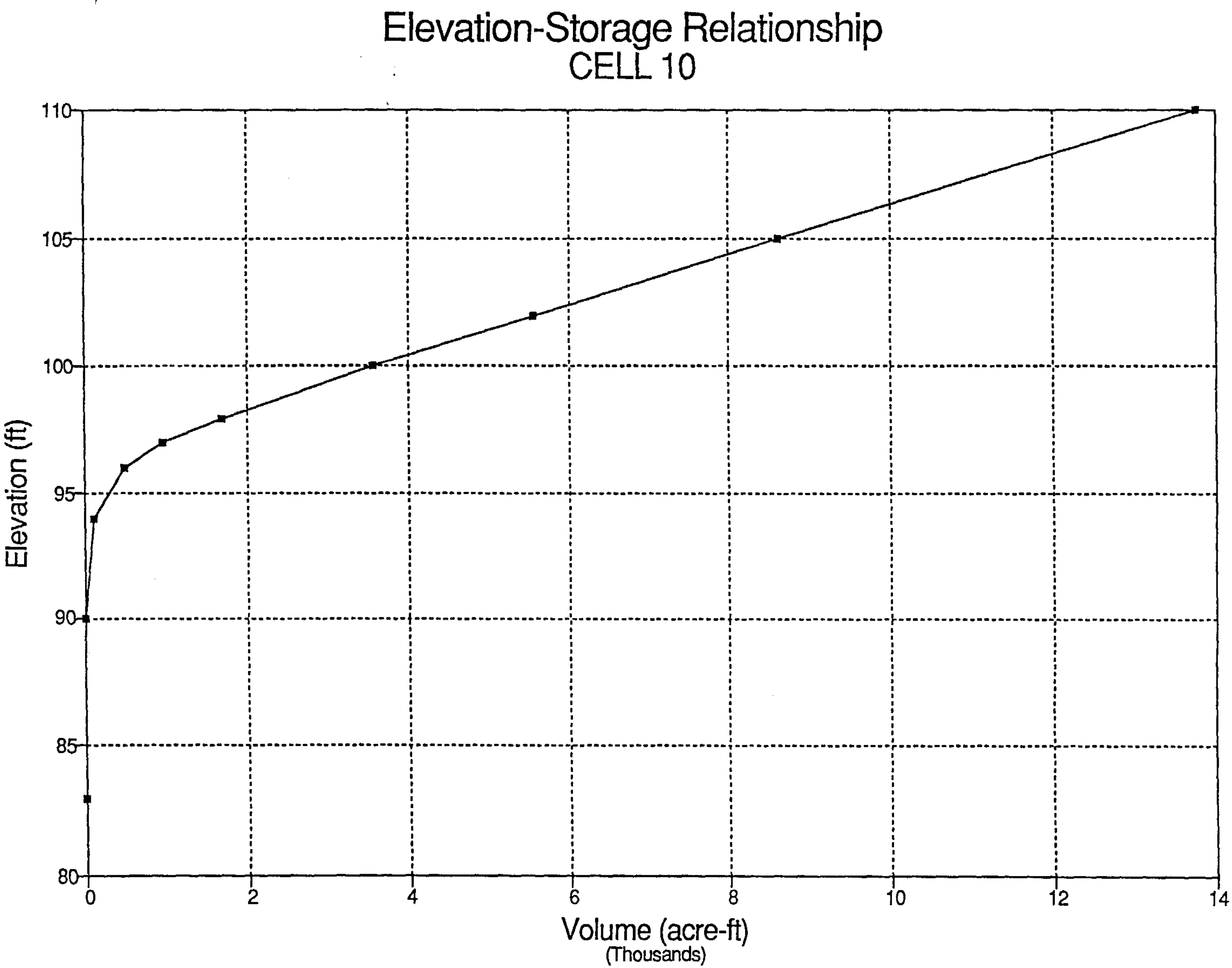


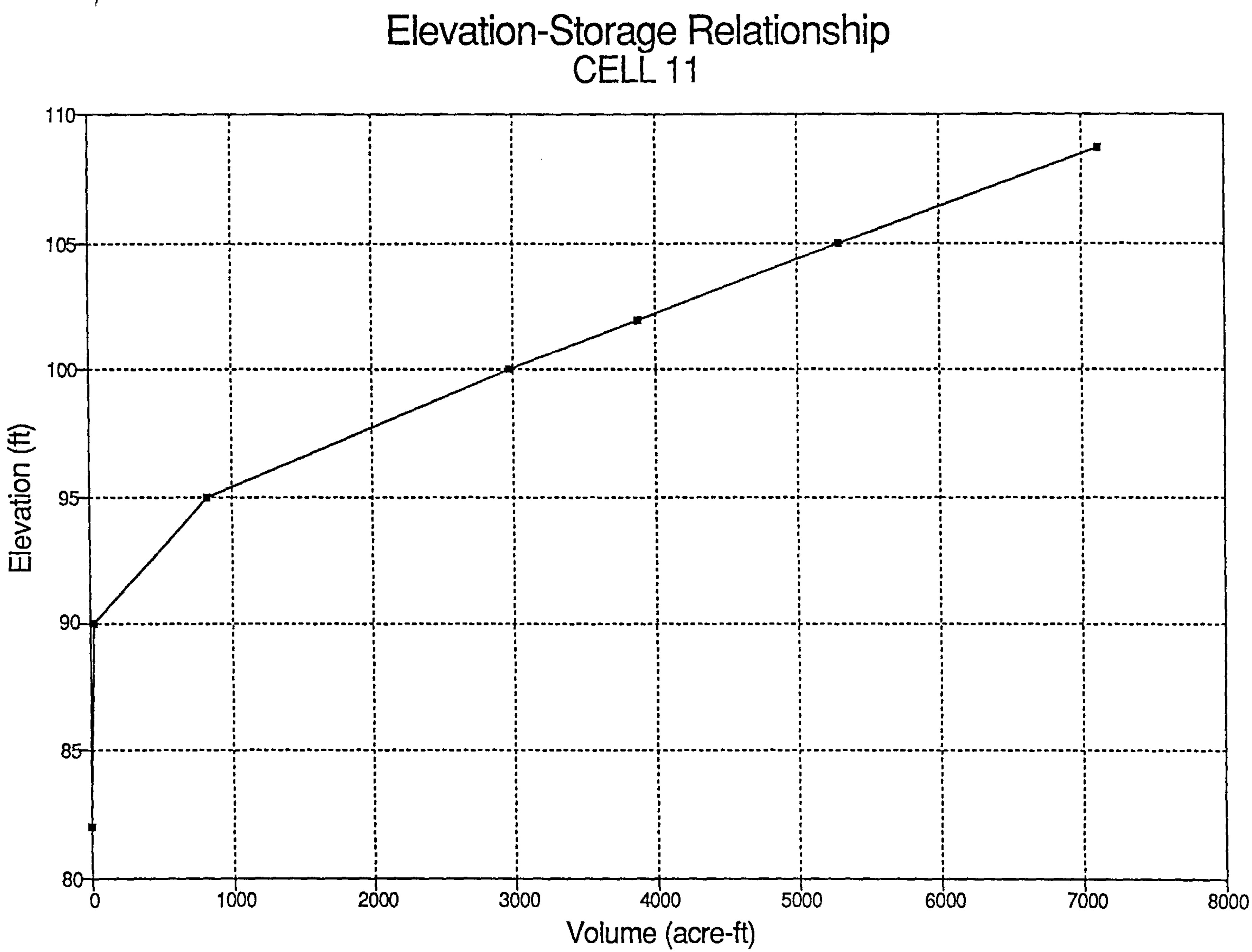
Elevation-Storage Relationship
CELL 8

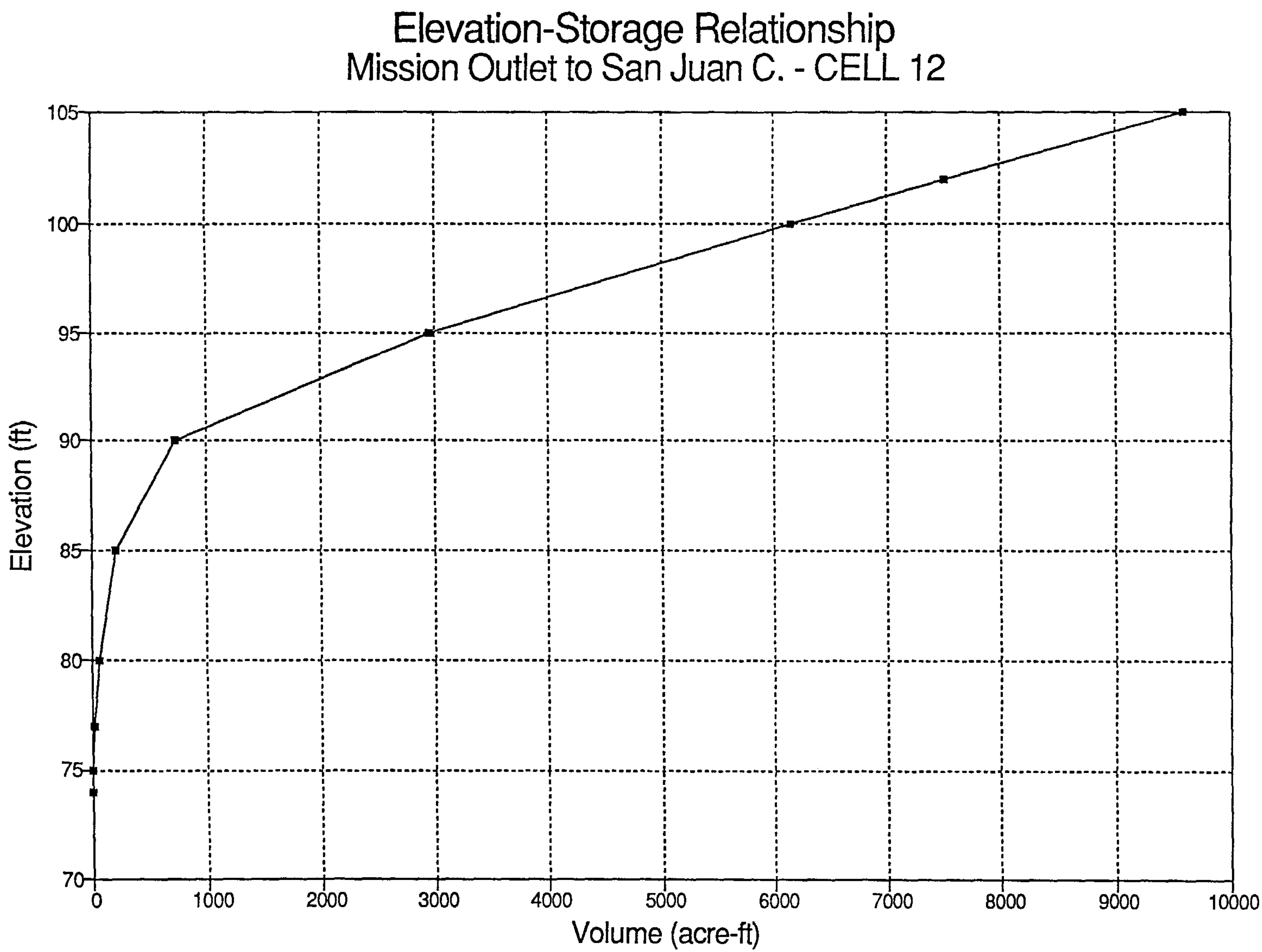


Elevation-Storage Relationship
CELL 9

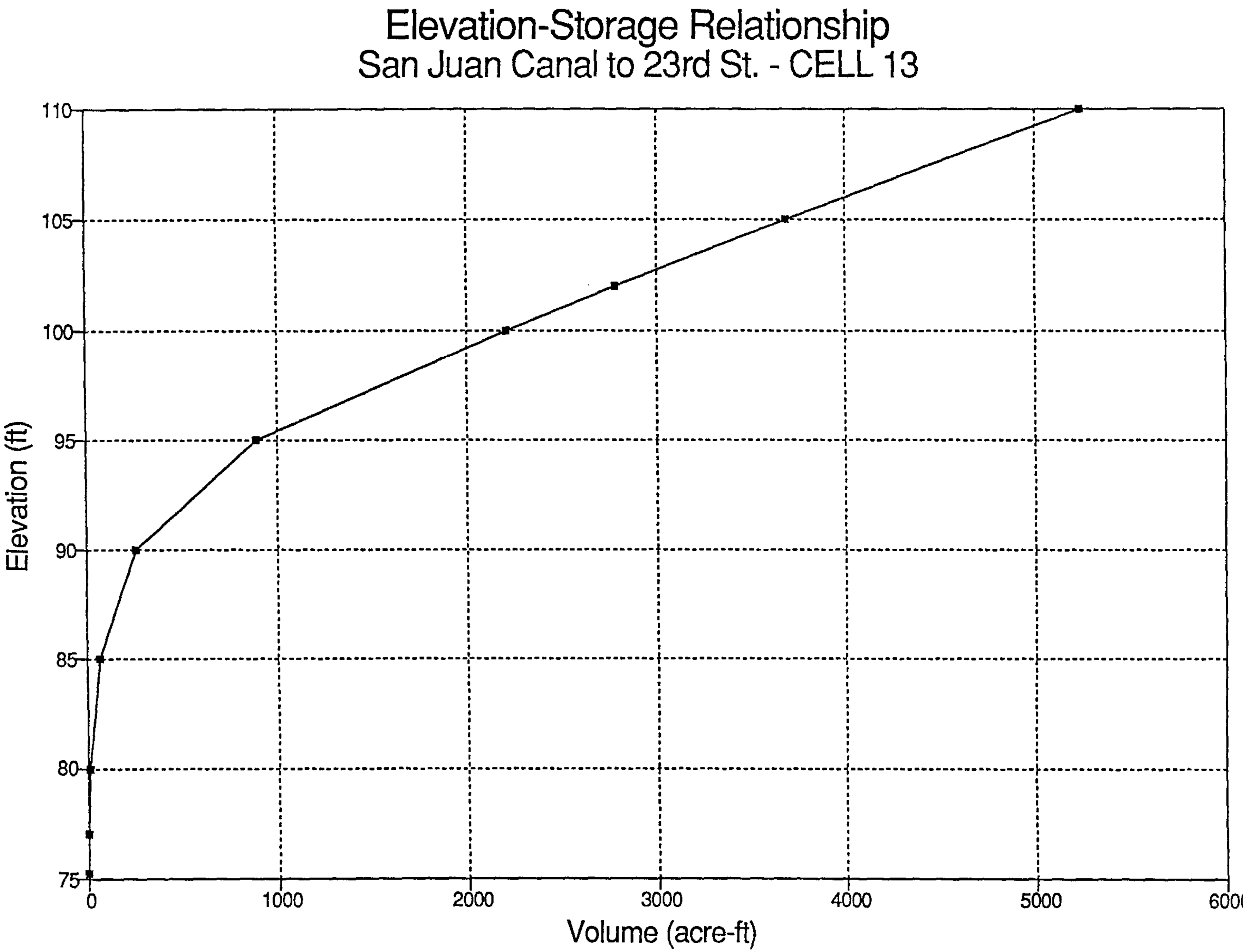



Elevation-Storage Relationship
CELL 10
Elevation (ft)
110
105
100
95
90
85
80
0
2
4
6
8
10
12
14
Volume (acre-ft)
(Thousands)

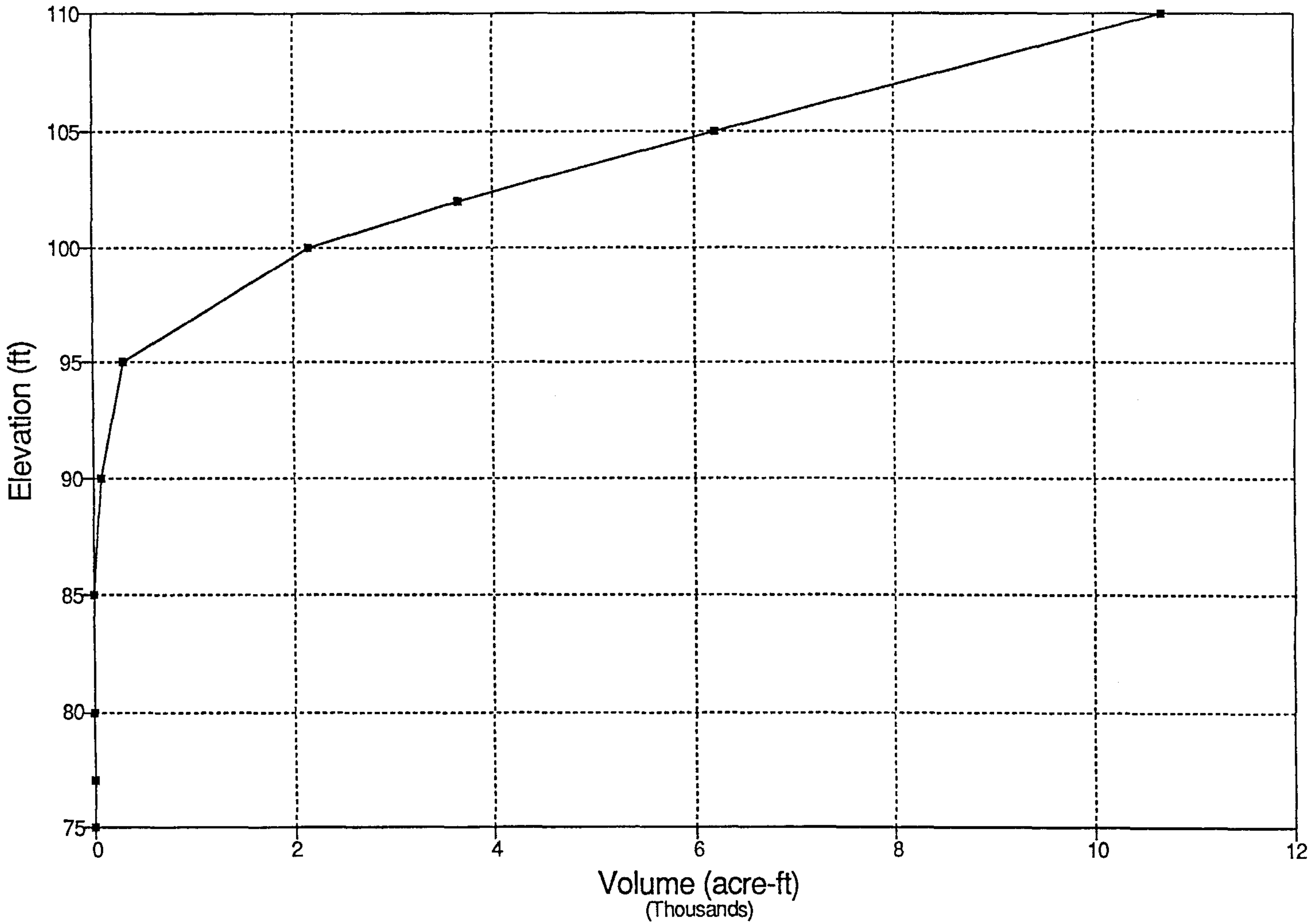

Elevation-Storage Relationship
CELL 11
Elevation (ft)
110
105
100
95
90
85
80
0
1000
2000
3000
4000
5000
6000
7000
8000
Volume (acre-ft)

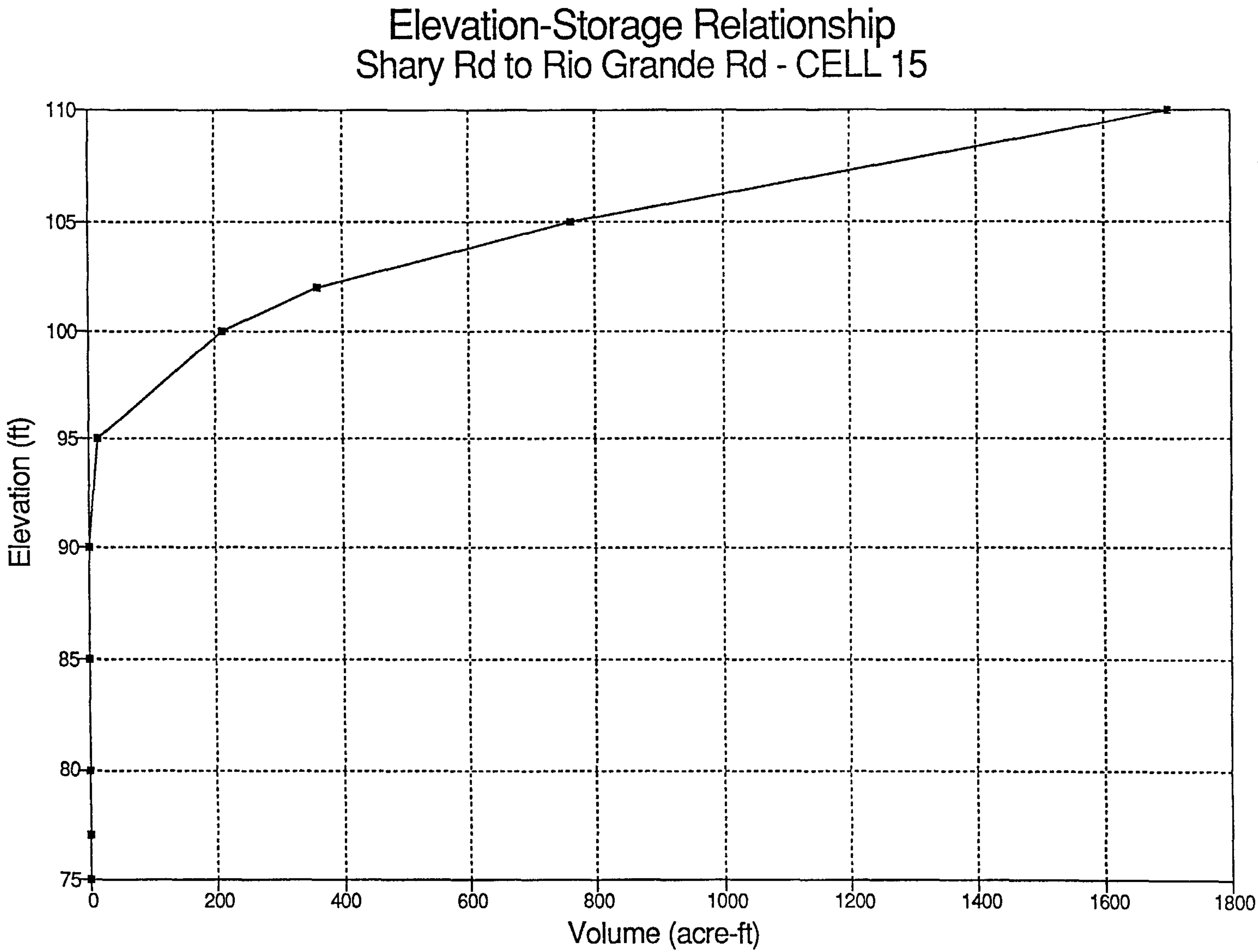


Elevation-Storage Relationship
Mission Outlet to San Juan C. - CELL 12
Elevation (ft)
105
100
95
90
85
80
75
70
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Volume (acre-ft)

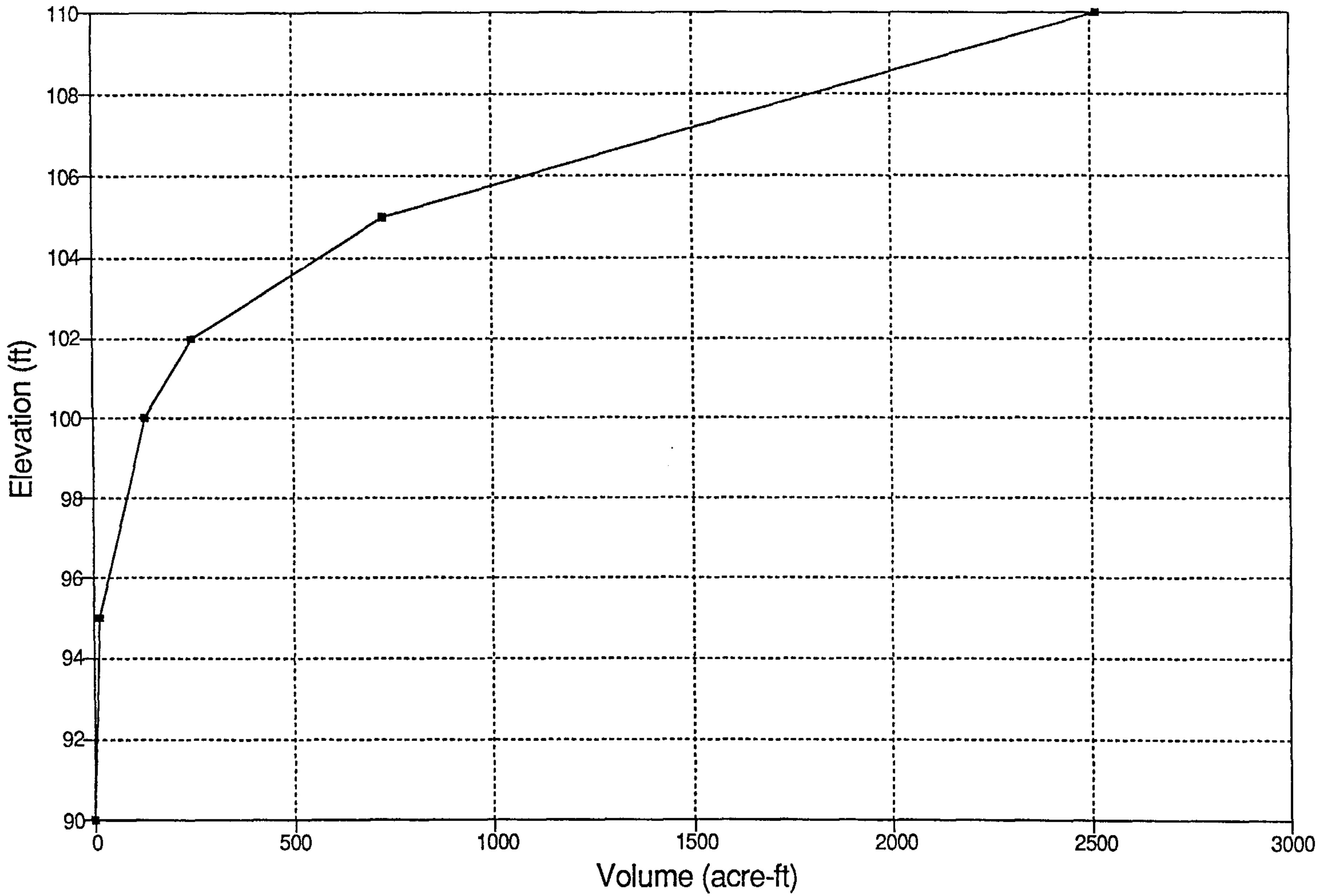

Elevation-Storage Relationship
San Juan Canal to 23rd St. - CELL 13
110
105
100
95
90
85
80
75
Elevation (ft)
0
1000
2000
3000
4000
5000
6000
Volume (acre-ft)

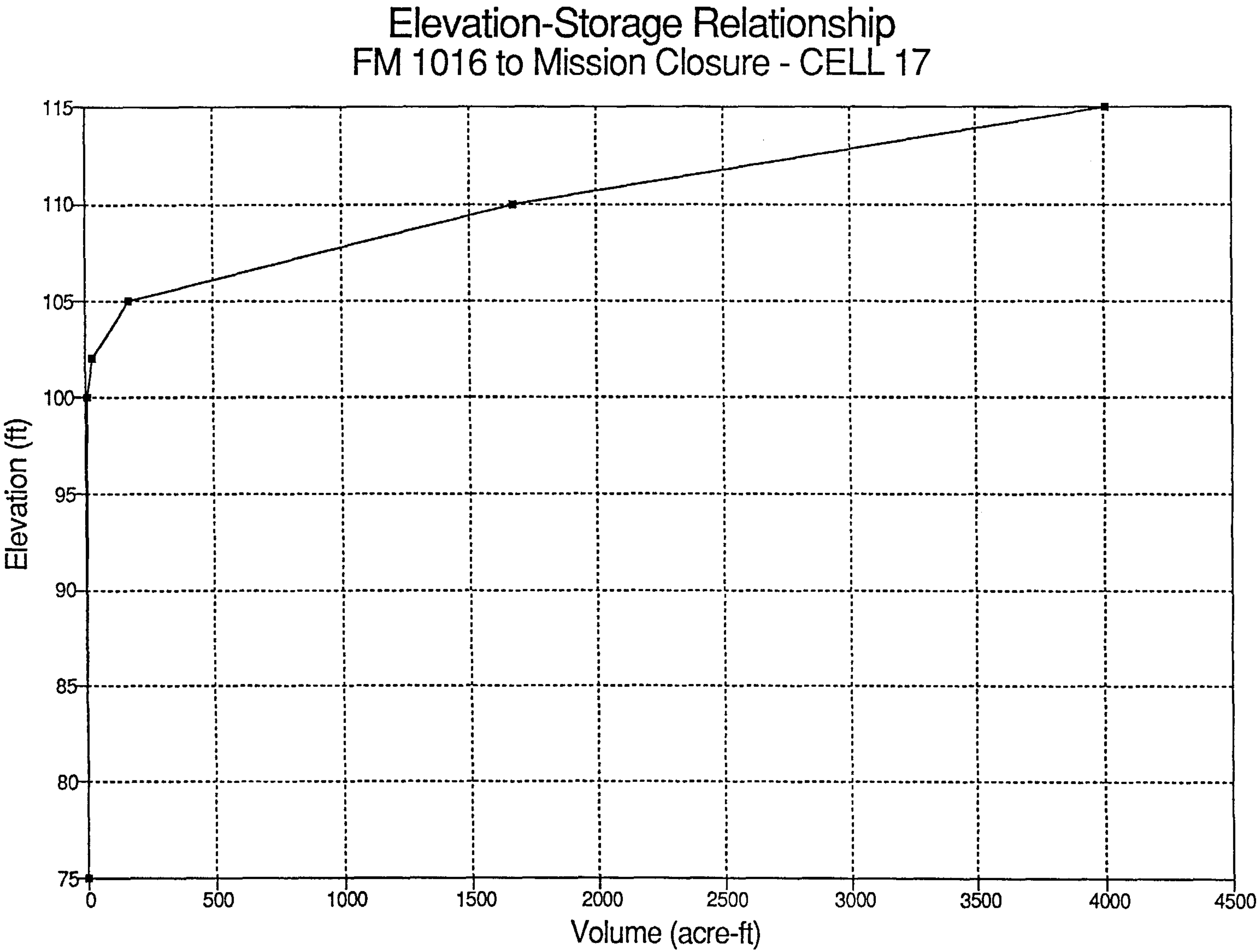
Elevation-Storage Relationship
23rd St. to Shary Rd. - CELL 14




Elevation-Storage Relationship
Shary Rd to Rio Grande Rd - CELL 15
Elevation (ft)
110
105
100
95
90
85
80
75
0
200
400
600
800
1000
1200
1400
1600
1800
Volume (acre-ft)

Elevation-Storage Relationship
Rio Grande Rd to FM 1016 - CELL 16



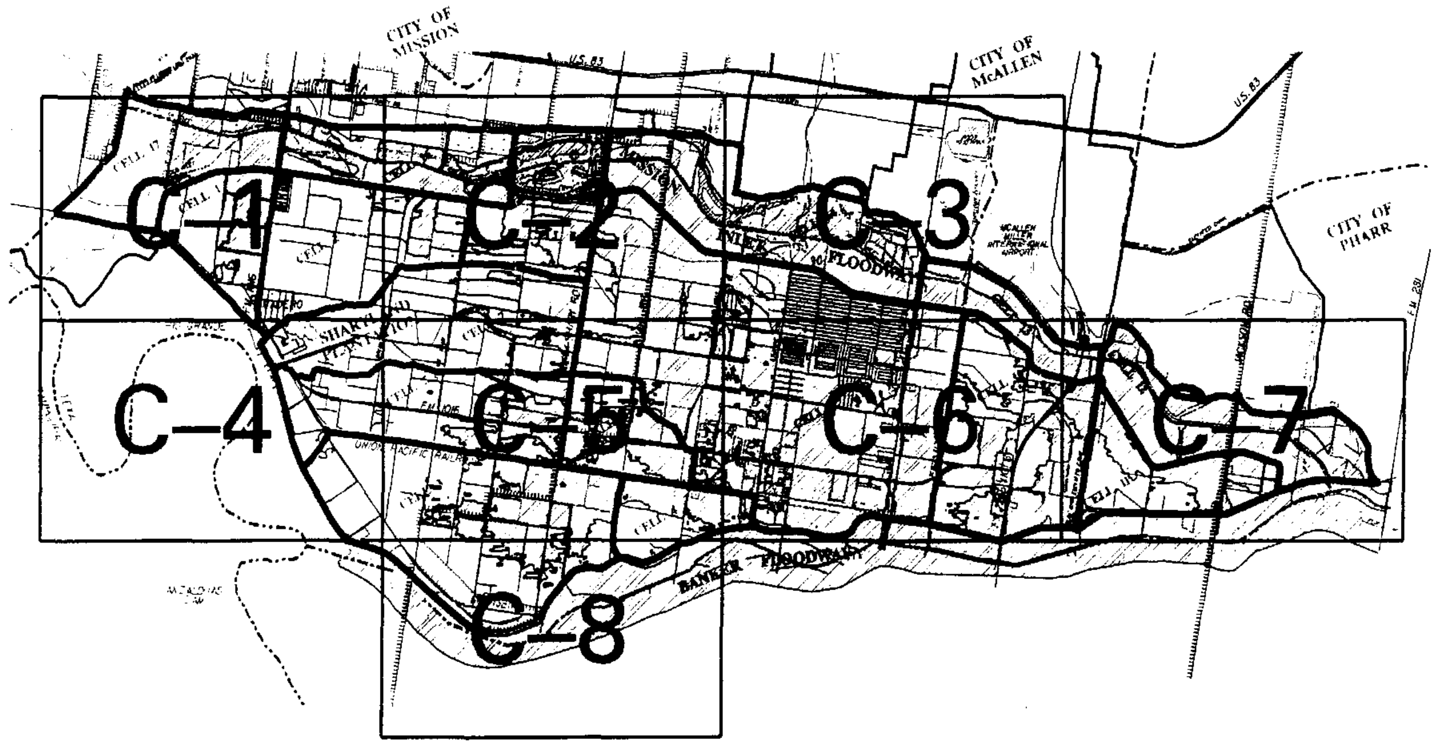


Elevation-Storage Relationship
FM 1016 to Mission Closure - CELL 17
Elevation (ft)
115
110
105
100
95
90
85
80
75
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Volume (acre-ft)

APPENDIX C
Flood Plain Maps

INDEX OF SHEETS

DESCRIPTION	SHEET No.
FLOOD PLAIN MAP	C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8
MISSION INLET FLOOD PROFILE - 10, 25, 50 AND 100 YEAR EVENTS FULLY URBANIZED CONDITIONS (GATES CLOSED)	C-9
MISSION INLET FLOOD PROFILE - 10, 25, 50 AND 100 YEAR EVENTS EXISTING CONDITIONS (GATES CLOSED)	C-10



FLOOD PLAIN KEY MAP

APPENDIX C

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ENGINEERS • ARCHITECTS • SCIENTISTS • PLANNERS • SURVEYORS

FLOOD PLAIN MAPS AND FLOOD PROFILES

FLOOD PROTECTION PLANNING STUDY

FOR SOUTHERN MCALLEN AND MISSION, TEXAS

CITY OF McALLEN

N 16595700

GENERAL NOTES:

1. TOPOGRAPHY FLOWN MARCH, 1995 BY WILLIAM STACKHOUSE, SAN ANTONIO, TX.
2. FLOOD PLAIN LIMITS BASED ON EXISTING (1995) TOPOGRAPHY WITH FUTURE FULLY URBANIZED WATERSHED.
3. FLOOD ELEVATIONS FOR THE MISSION INLET FLOODWAY ARE BASED ON ASSUMED ULTIMATE LAND USE CONDITIONS WITH GATES CLOSED.
4. BASE FLOOD ELEVATIONS FOR BANKER FLOODWAY ARE BASED ON THE IBWC ALLOWABLE DIVERSION FLOW (Q=106,300 CFS).

LEGEND

FLOOD ELEVATIONS

CELL 2

	EXISTING	FUTURE
100 YR.	105.6	105.6
25 YR.	105.3	105.3
10 YR.	105.1	105.1

100 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

25 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

10 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

★ LEVEE OVERTOPPED BY 100 YEAR FLOOD

C-1	C-2	C-3	
C-4	C-5	C-6	C-7
	C-8		

N

SCALE IN FEET

N 16586700

SHEET C-1

FLOOD PLAIN MAP

FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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CITY OF McALLEN

N 16595700

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LEGEND

FLOOD ELEVATIONS

CELL 2

	EXISTING	FUTURE
100 YR.	105.6	105.6
25 YR.	105.3	105.3
10 YR.	105.1	105.1

100 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

25 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

10 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

★ LEVEE OVERTOPPED BY 100 YEAR FLOOD

C-1	C-2	C-3	
C-4	C-5	C-6	C-7
	C-8		

N

SCALE IN FEET

N 16586700

N 16586700

E 1044000

E 1058000

SHEET C-2

FLOOD PLAIN MAP
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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CITY OF McALLEN

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LEGEND

FLOOD ELEVATIONS

CELL 2

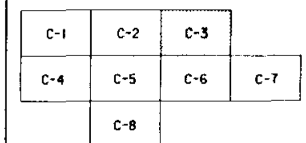
	EXISTING	FUTURE
100 YR.	105.6	105.6
25 YR.	105.3	105.3
10 YR.	105.1	105.1

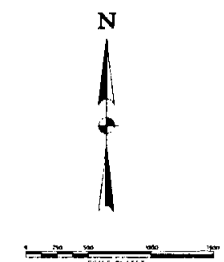
100 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

25 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

10 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

★ LEVEE OVERTOPPED BY 100 YEAR FLOOD





SHEET C-3

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FLOOD PLAIN MAP
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

CITY OF McALLEN

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LEGEND

FLOOD ELEVATIONS

CELL 2

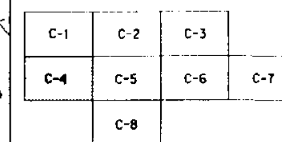
	EXISTING	FUTURE
100 YR.	105.6	105.6
25 YR.	105.3	105.3
10 YR.	105.1	105.1

100 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

25 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

10 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

★ LEVEE OVERTOPPED BY 100 YEAR FLOOD



N

SCALE IN FEET

SHEET C-4

FLOOD PLAIN MAP

FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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CITY OF McALLEN

FLOOD PLAIN MAP

FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

CITY OF McALLEN

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LEGEND

FLOOD ELEVATIONS

CELL 2

	EXISTING	FUTURE
100 YR.	105.6	105.6
25 YR.	105.3	105.3
10 YR.	105.1	105.1

100 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

25 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

10 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

★ LEVEE OVERTOPPED BY 100 YEAR FLOOD

C-1	C-2	C-3	
C-4	C-5	C-6	C-7
	C-8		

N

SCALE IN FEET

SHEET C-6

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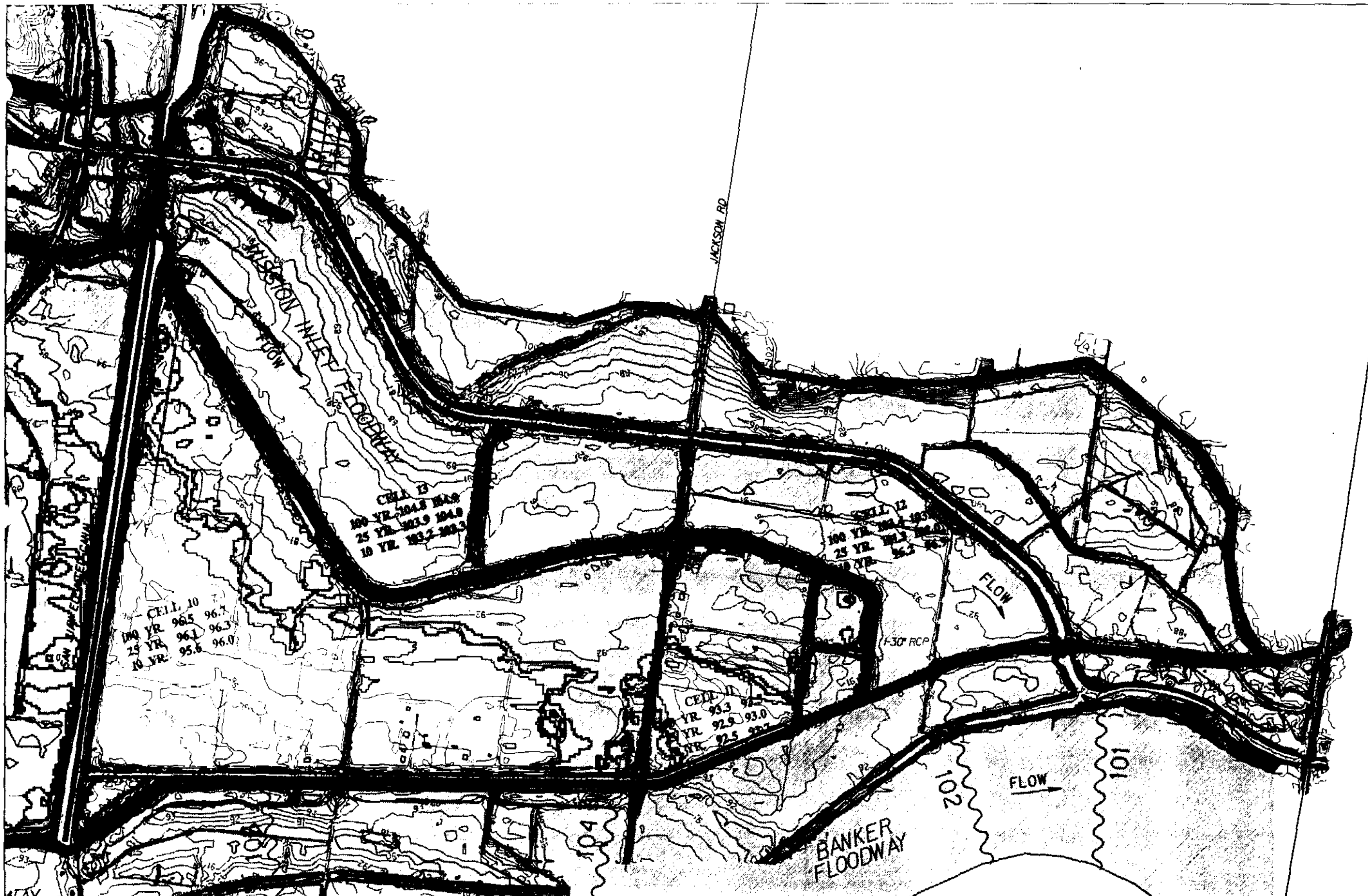
FLOOD PLAIN MAP
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

CITY OF McALLEN



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LEGEND

FLOOD ELEVATIONS

CELL 2

	EXISTING	FUTURE
100 YR.	105.6	105.6
25 YR.	105.3	105.3
10 YR.	105.1	105.1

100 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

25 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

10 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

★ LEVEE OVERTOPPED BY 100 YEAR FLOOD

C-1	C-2	C-3	
C-4	C-5	C-6	C-7
	C-8		

N

SCALE IN FEET

SHEET C-7

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FLOOD PLAIN MAP
FLOOD PROTECTION PLANNING STUDY FOR SOUTHERN MCALLEN AND MISSION, TEXAS

CITY OF McALLEN

N 16586700

GENERAL NOTES:

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LEGEND

FLOOD ELEVATIONS

CELL 2

	EXISTING	FUTURE
100 YR.	105.6	105.6
25 YR.	105.3	105.3
10 YR.	105.1	105.1

100 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

25 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

10 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

★ LEVEE OVERTOPPED BY 100 YEAR FLOOD

C-1	C-2	C-3	
C-4	C-5	C-6	C-7
	C-8		

N

0 250 500 1000 1500
SCALE IN FEET

N 16577700

E 1086000

N 16586700

E 1072000

SHEET C-7

CITY OF MISSION, TEXAS
FOUNDED IN 1908

CITY OF McALLEN

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C7.DGN AVO 14191
c7.dgn Dec. 19, 1995 07:31:38

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LEGEND

FLOOD ELEVATIONS

CELL 2

	EXISTING	FUTURE
100 YR.	105.6	105.6
25 YR.	105.3	105.3
10 YR.	105.1	105.1

100 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

25 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

10 YEAR ULTIMATE DEVELOPMENT FLOOD LIMITS

★ LEVEE OVERTOPPED BY 100 YEAR FLOOD

C-1	C-2	C-3	
C-4	C-5	C-6	C-7
	C-8		

N

SCALE IN FEET

SHEET C-8

FLOOD PLAIN MAP
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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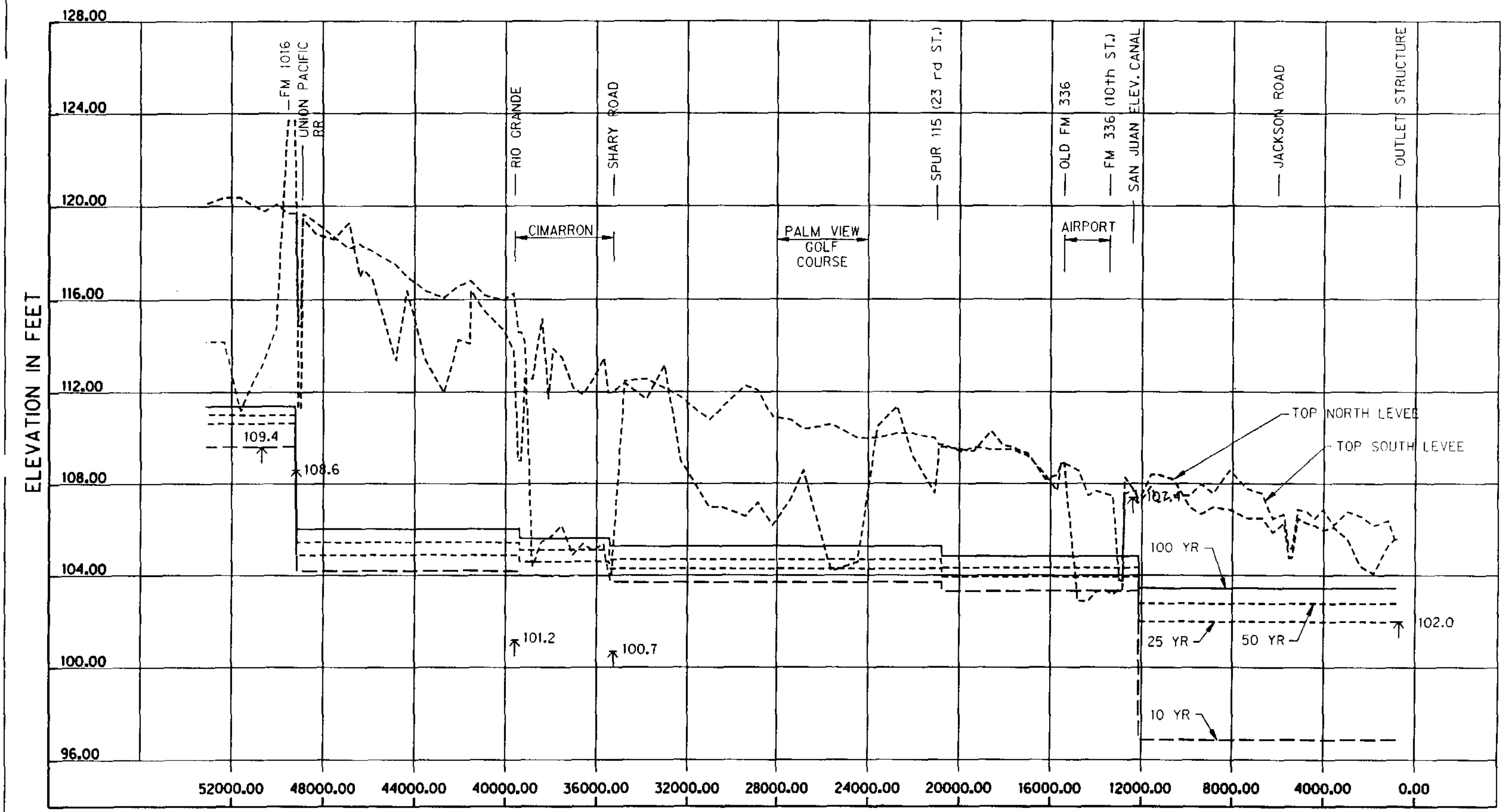
CITY OF McALLEN



LEGEND

↑ TOP OF ROAD

▽ WATER SURFACE

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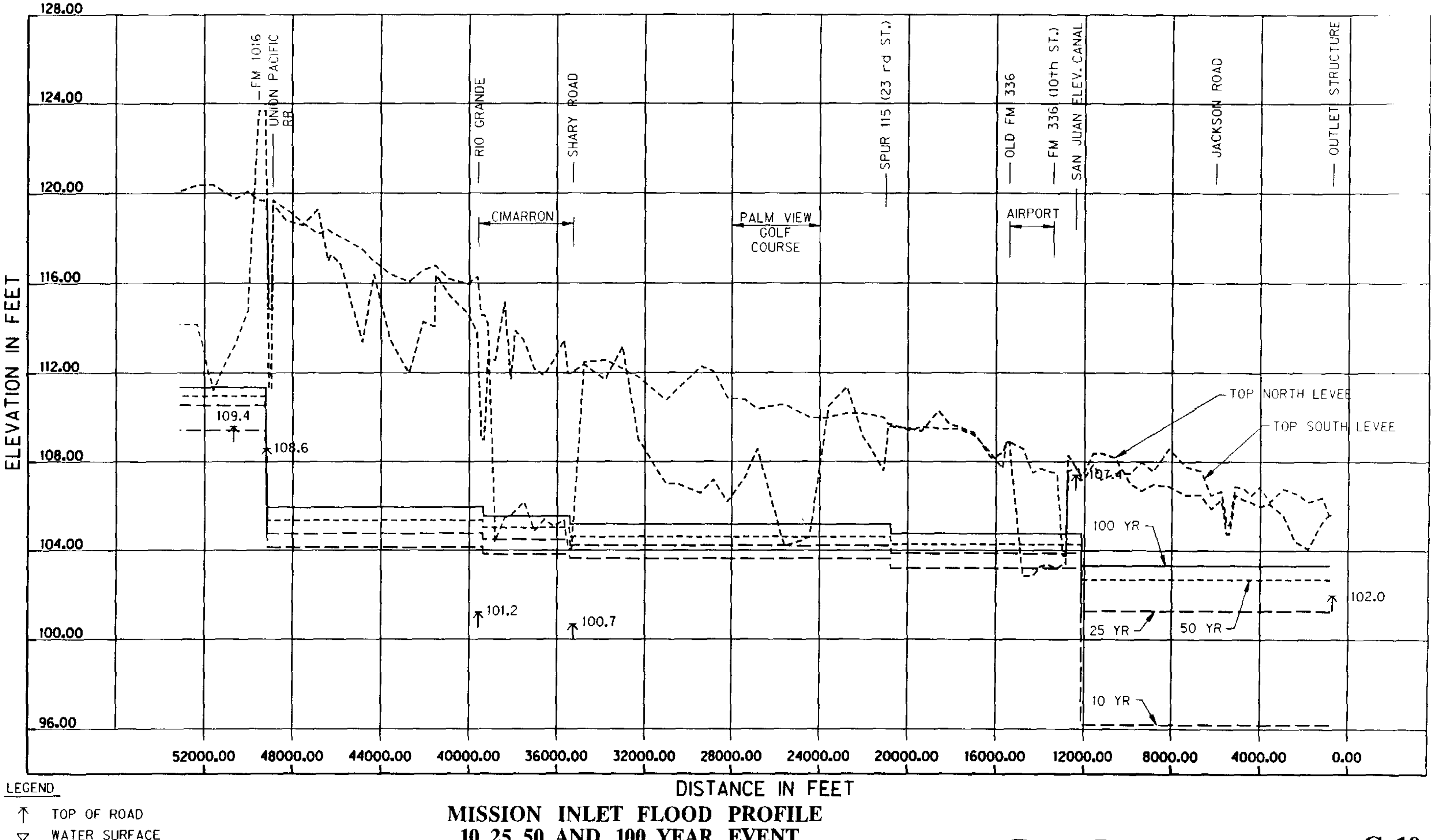
MISSION INLET FLOOD PROFILE
10, 25, 50 AND 100 YEAR EVENT
FULLY URBANIZED CONDITIONS (GATES CLOSED)
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

C–9

CITY OF McALLEN



MISSION INLET FLOOD PROFILE
10, 25, 50 AND 100 YEAR EVENT
EXISTING CONDITIONS (GATES CLOSED)

FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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CITY OF McALLEN

C-10

APPENDIX D
SCS Curve Number Computations

HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
817-847-1422

CLIENT: City of McAllen

PROJECT: McAllen Drainage Study

**COMPARISON OF EXISTING VS FULLY DEVELOPED
SCS CURVE NUMBER**

Area Number	Area (sq. mi.)	Existing Conditions CN	Area Number	Area (sq. mi.)	Fully Urbanized CN	Difference
MI-1	0.49	74.9	MI-1	0.49	74.9	0.0
MI-2	0.62	74.9	MI-2	0.62	74.9	0.0
MI-4	0.34	77.0	MI-4	0.34	77.0	0.0
MI-5	0.13	77.0	MI-5	0.13	77.0	0.0
MI-6	0.80	78.1	MI-6	0.80	78.1	0.0
MI-7	0.77	83.8	MI-7	0.77	83.8	0.0
MI-8	0.57	81.1	MI-8	0.57	81.1	0.0
MI-9A	0.39	84.4	MI-9A	0.39	88.0	3.7
MI-9B	1.01	76.1	MI-9B	1.01	83.6	7.5
MI-9C	0.29	83.0	MI-9C	0.29	83.0	0.0
MI-10A	0.54	83.2	MI-10A	0.54	83.2	0.0
MI-10B	0.42	77.0	MI-10B	0.42	77.0	0.0
MI-10C	0.35	84.0	MI-10C	0.35	84.0	0.0
MI-10D	0.54	78.0	MI-10D	0.54	78.0	0.0
MI-11A	1.25	77.9	MI-11A	1.25	81.2	3.3
MI-11B	1.50	77.0	MI-11B	1.50	77.0	0.0
MI-13	0.73	76.5	MI-13	0.73	80.4	3.9
MI-14	0.94	80.2	MI-14	0.94	82.6	2.4
MI-15	1.17	82.4	MI-15	1.17	82.4	0.0
MI-16	0.62	71.8	MI-16	0.62	78.1	6.3
MI-17	0.36	82.6	MI-17	0.36	83.3	0.7
MI-18	3.19	82.4	MI-18	3.19	82.4	0.0
MI-19	0.47	83.0	MI-19	0.47	83.0	0.0
MI-20	0.37	81.0	MI-20	0.37	85.3	4.4
MS-1	0.37	72.6	MS-1	0.37	80.3	7.7
MS-2A	0.53	88.5	MS-2A	0.53	88.5	0.0
MS-2B	0.82	80.1	MS-2B	0.82	80.1	0.0
MS-2C	1.39	79.8	MS-2C	1.39	79.8	0.0
MS-3A	0.82	82.0	MS-3A	0.82	84.3	2.3
MS-3B	0.68	75.7	MS-3B	0.68	78.8	3.1
MS-4A	0.70	79.1	MS-4A	0.70	79.1	0.0
MS-4B	0.54	78.1	MS-4B	0.54	78.1	0.0
MC-1A	1.39	85.1	MC-1A	1.39	88.3	3.2
MC-1B	1.52	72.5	MC-1B	1.51	78.2	5.7
MC-1C	0.21	74.8	MC-1C	0.21	79.4	4.6
MC-1D	0.07	66.2	MC-1D	0.07	76.3	10.2
MC-2A	0.82	85.6	MC-2A	0.82	85.6	0.0
MC-2B	0.37	90.6	MC-2B	0.37	90.6	0.0
MC-3	0.60	80.2	MC-3	0.60	81.2	1.0

HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
817-847-1422

CLIENT: City of McAllen

PROJECT: McAllen Drainage Study

COMPARISON OF EXISTING VS FULLY DEVELOPED SCS CURVE NUMBER

Area Number	Area (sq. mi.)	Existing Conditions CN	Area Number	Area (sq. mi.)	Fully Urbanized CN	Difference
MC-4A	2.02	74.8	MC-4A	2.02	82.7	7.8
MC-4B	0.42	80.3	MC-4B	0.42	84.5	4.2
R-2	0.42	78.8	R-2	0.42	79.8	1.0
R-3	0.10	75.3	R-3	0.10	75.3	0.0
R-4	0.41	81.0	R-4	0.41	81.0	0.0
R-5A	0.13	73.7	R-5A	0.13	78.3	4.6
R-5B	0.23	72.2	R-5B	0.23	72.2	0.0
R-6	0.82	73.9	R-6	0.82	77.9	4.0
R-9	2.50	75.8	R-9	2.50	78.7	2.9
R-10	0.64	73.6	R-10	0.64	78.7	5.1
R-11	0.97	77.7	R-11	0.97	78.7	1.0
R-13	2.77	69.9	R-13	2.77	76.5	6.5
R-14	0.32	66.8	R-14	0.32	76.3	9.5
R-15	1.85	74.1	R-15	1.85	74.7	0.6
E1	0.26	73.6	E1	0.26	73.6	0.0
E2	0.49	72.1	E2	0.49	73.2	1.1
E3	0.44	69.4	E3	0.44	70.3	0.9
E4	0.14	77.2	E4	0.14	77.2	0.0
E5	0.35	71.5	E5	0.35	71.5	0.0
E6	0.21	74.9	E6	0.21	74.9	0.0
E7	0.34	76.1	E7	0.34	76.1	0.0
E8	0.19	76.0	E8	0.19	76.0	0.0
E9	0.22	84.5	E9	0.22	84.5	0.0
E10	0.25	78.0	E10	0.25	78.0	0.0
E11	0.19	56.0	E11	0.19	76.3	20.3
E12	0.15	61.4	E12	0.15	76.8	15.4
E13	0.17	57.0	E13	0.17	76.8	19.8
E14	2.52	74.9	E14	2.52	75.2	0.3
E15	0.50	73.3	E15	0.50	76.0	2.7
E16	2.24	70.1	E16	2.24	71.6	1.4
E17	0.27	76.5	E17	0.27	76.5	0.0
E18	0.56	74.3	E18	0.56	74.3	0.0
E19	0.36	79.1	E19	0.36	79.3	0.2
E20A	2.05	76.9	E20A	2.05	76.9	0.0
E20B	1.24	75.8	E20B	1.24	76.0	0.2
E21	0.10	82.4	E21	0.10	82.4	0.0
E22	1.53	81.2	E22	1.53	83.3	2.1
E23	0.52	76.6	E23	0.52	82.9	6.3
E24	0.28	81.7	E24	0.28	81.7	0.0
E25	0.25	73.7	E25	0.25	81.5	7.8

HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
817-847-1422

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PROJECT: McAllen Drainage Study

COMPARISON OF EXISTING VS FULLY DEVELOPED SCS CURVE NUMBER

Area Number	Area (sq. mi.)	Existing Conditions CN	Area Number	Area (sq. mi.)	Fully Urbanized CN	Difference
E26	0.24	84.4	E26	0.24	84.4	0.0
E27	0.26	76.3	E27	0.26	76.3	0.0
ES1	0.51	82.7	ES1	0.51	82.7	0.0
Total	**59.1**		Total	**59.1**		
TZ-1	0.75	81.7	TZ-1	0.75	87.8	6.1
TZ-2	0.68	83.2	TZ-2	0.68	92.9	9.7
TZ-3	0.91	81.2	TZ-3	0.91	89.5	8.2
TZ-4	0.61	79.8	TZ-4	0.61	88.8	9.0
TZ-5	1.74	82.7	TZ-5	1.74	85.0	2.3
TZ-6A	0.57	83.0	TZ-6A	0.57	89.6	6.6
TZ-6B	0.64	84.0	TZ-6B	0.64	92.5	8.5
TZ-6C	0.58	84.5	TZ-6C	0.58	92.6	8.1
TZ-6D	0.18	88.8	TZ-6D	0.18	91.5	2.7
TZ-6E	0.51	84.7	TZ-6E	0.51	92.8	8.1
TZ-6F	0.55	76.8	TZ-6F	0.55	89.8	13.0
TZ-7	0.69	77.2	TZ-7	0.69	90.5	13.3
TZ-8	2.36	79.4	TZ-8	2.36	89.1	9.7
TZ-9	1.06	80.0	TZ-9	1.06	91.3	11.3
TZ-10A	1.83	82.8	TZ-10A	1.83	88.0	5.1
TZ-10B	0.59	83.2	TZ-10B	0.59	86.8	3.6
TZ-11A	0.67	80.3	TZ-11A	0.67	82.6	2.3
TZ-11B	1.03	80.0	TZ-11B	1.03	81.4	1.4
TZ-11C	0.23	84.5	TZ-11C	0.23	86.2	1.7
Total	**16.18**			**16.18**		

HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
817-847-1422

CLIENT: City of McAllen

PROJECT: McAllen Drainage Study

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FILE: MASTER
EMP: ES,DW,MM
CH

MISSION FLOODWAY DRAINAGE AREA- FULLY DEVELOPED
LAND USE FOR AREA NUMBER

SUMMARY

Area Number	Drainage Area (sq. mi.)	Future Contitions CN	Residential-1	Residential-2	Warehouse / Industrial	Commercial / Office	Mixed Landuse	Agricultural	Public / Schools	Park / Cementeries	Undeveloped	Soil B	Soil C	Soil D
MI-1	0.49	74.9	0	0		0		0	0	0	314	31	0	282
MI-2	0.62	74.9	0	0	0	0		0	0	0	397	40	0	357
MI-4	0.34	77.0	0	0	0	0		0	0	0	217	0	0	217
MI-5	0.13	77.0	0	0	0	0		0	0	0	83	0	0	83
MI-6	0.80	78.1	0	0	0	0		0	0	269	243	26	0	486
MI-7	0.77	83.8	237	0	0	0		256	0	0	0	99	0	394
MI-8	0.57	81.1	363	0	0	0		0	0	0	0	195	0	168
MI-9A	0.39	88.0	62	0	89	23		76	0	0	0	62	0	187
MI-9B	1.01	83.6	275	0	65	65		242	0	0	0	323	0	323
MI-9C	0.29	83.0	0	0	0	0		186	0	0	0	37	0	149
MI-10A	0.54	83.2	0	0	0	4		342	0	0	0	69	0	277
MI-10B	0.42	77.0	0	0	0	0		269	0	0	0	215	0	54
MI-10C	0.35	84.0	0	0	0	0		224	0	0	0	22	0	202
MI-10D	0.54	78.0	0	0	0	0		346	0	0	0	242	0	104
MI-11A	1.25	81.2	640	0	0	0		160	0	0	0	400	0	400
MI-11B	1.50	77.0	0	0	0	0		960	0	0	0	768	0	192
MI-13	0.73	80.4	449	0	0	0		19	0	0	0	280	0	187
MI-14	0.94	82.6	247	0	0	0		355	0	0	0	180	0	421
MI-15	1.17	82.4	15	0	0	0		734	0	0	0	150	150	449
MI-16	0.62	78.1	321	64	0	0		12	0	0	0	298	20	79
MI-17	0.36	83.3	0	98	0	0		133	0	0	0	35	0	196
MI-18	3.19	82.4	149	63	0	0		1,830	0	0	0	510	102	1,429
MI-19	0.47	83.0	32	194	0	0		75	0	0	0	45	15	241
MI-20	0.37	85.3	158	79	0	0		0	0	0	0	0	47	189
MS-1	0.37	80.3	188	0	0	49		0	0	0	0	213	0	24
MS-2A	0.53	88.5	51	0	0	237		0	51	0	0	170	0	170
MS-2B	0.82	80.1	346	0	0	131		0	0	0	0	472	0	52
MS-2C	1.39	79.8	632	0	0	178		0	80	0	0	801	0	89
MS-3A	0.82	84.3	333	0	192	0		0	0	0	0	367	0	157
MS-3B	0.68	78.8	337	0	39	20		0	21	0	0	392	0	44
MS-4A	0.70	79.1	341	0	0	86		0		0	0	426	0	22
MS-4B	0.54	78.1	321	0	0	0		0	24	0	0	276	0	69
MC-1A	1.39	88.3	80	0	160	569		0	80	0	0	801	0	89
MC-1B	1.51	78.2	851	0	0	48		0	0	68	0	773	0	193
MC-1C	0.21	79.4	134	0	0	0		0	0	0	0	94	0	40
MC-1D	0.07	76.3	45	0	0	0		0	0	0	0	45	0	0
MC-2A	0.82	85.6	173	0	302	0		0	14	35	0	236	0	288
MC-2B	0.37	90.6	0	0	237	0		0	0	0	0	180	0	57

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MISSION FLOODWAY DRAINAGE AREA- FULLY DEVELOPED
LAND USE FOR AREA NUMBER

SUMMARY

Area Number	Drainage Area (sq. mi.)	Future Contitions CN	Residential-1	Residential-2	Warehouse / Industrial	Commercial / Office	Mixed Landuse	Agricultural	Public / Schools	Park / Cementeries	Undeveloped	Soil B	Soil C	Soil D
MC-3	0.60	81.2	150	0	77	61		0	31	65	0	307	0	77
MC-4A	2.02	82.7	931	0	0	362		0	0	0	0	1,034	0	259
MC-4B	0.42	84.5	170	0	0	99		0	0	0	0	180	0	89
R-2	0.42	79.8	172	0	0	59		0	0	38	172	215	0	54
R-3	0.10	75.3	0	0	0	0		0	0	64	0	19	0	45
R-4	0.41	81.0	167	0	0	59		0	0	36	0	197	0	66
R-5A	0.13	78.3	40	0	0	23		0	0	20	0	75	0	8
R-5B	0.23	72.2	49	0	0	21		0	0	77	0	140	0	7
R-6	0.82	77.9	378	0	0	42		0	42	63	0	420	0	105
R-9	2.50	78.7	1,200	0	0	320		0	0	80	0	1,600	0	0
R-10	0.64	78.7	307	0	0	82		0	0	21	0	410	0	0
R-11	0.97	78.7	515	0	0	53		0	53	0	0	528	0	93
R-13	2.77	76.5	461	576	0	160		452	124	0	0	1,596	0	177
R-14	0.32	76.3	205	0	0	0		0	0	0	0	205	0	0
R-15	1.85	74.7	426	616	0	0		142	0	0	0	1,066	0	118
E1	0.26	73.6	83	0	0	17		17	0	50	83	166	0	0
E2	0.49	73.2	53	130	0	0		61	70	0	0	304	0	9
E3	0.44	70.3	0	253	0	0		0	0	28	0	282	0	0
E4	0.14	77.2	47	0	0	21		0	0	21	0	85	0	5
E5	0.35	71.5	146	0	0	0		0	0	78	0	224	0	0
E6	0.21	74.9	121	0	0	0		0	0	13	0	134	0	0
E7	0.34	76.1	187	0	0	0		0	31	0	0	207	0	11
E8	0.19	76.0	116	0	0	0		0	6	0	0	122	0	0
E9	0.22	84.5	28	0	0	85		0	28	0	0	141	0	0
E10	0.25	78.0	128	0	0	0		32	0	0	0	128	0	32
E11	0.19	76.3	122	0	0	0		0	0	0	0	122	122	0
E12	0.15	76.8	96	0	0	0		0	0	0	0	91	91	5
E13	0.17	76.8	109	0	0	0		0	0	0	0	103	103	5
E14	2.52	75.2	667	474	0	0		473	0	0	0	1,452	1,452	32
E15	0.50	76.0	305	0	0	0		0	0	16	0	310	0	10
E16	2.24	71.6	100	1,334	0	0		0	0	0	0	1,434	0	0
E17	0.27	76.5	138	0	0	17		0	0	17	0	173	0	0
E18	0.56	74.3	39	274	0	45		0	0	0	0	358	0	0
E19	0.36	79.3	185	0	0	45		0	0	0	0	230	0	0
E20A	2.05	76.9	784	164	0	56		203	0	105	0	1,050	197	66
E20B	1.24	76.0	575	174	0	45		0	0	0	0	794	0	0
E21	0.10	82.4	38	0	0	26		0	0	0	0	64	0	0
E22	1.53	83.3	313	0	0	79		588	0	0	0	0	979	0
E23	0.52	82.9	0	113	0	25		195	0	0	0	15	251	67

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PROJECT: McAllen Drainage Study

MISSION FLOODWAY DRAINAGE AREA- FULLY DEVELOPED
LAND USE FOR AREA NUMBER

SUMMARY

Area Number	Drainage Area (sq. mi.)	Future Contitions CN	Residential-1	Residential-2	Warehouse / Industrial	Commercial / Office	Mixed Landuse	Agricultural	Public / Schools	Park / Cementeries	Undeveloped	Soil B	Soil C	Soil D
E24	0.28	81.7	0	42	0	3		134	0	0	0	10	159	11
E25	0.25	81.5	28	0	0	0		132	0	0	0	24	120	16
E26	0.24	84.4	0	0	0	0		154	0	0	0	0	31	123
E27	0.26	76.3	166	0	0	0		0	0	0	0	166	0	0
ES1	0.51	82.7	22	0	0	0		307	0	0	0	54	88	187
	59.1													
Outside Trade Zone			16544	4648	1160	3213	0	9106	656	1165	1509	25506	3927	10036.86
%			43.8%	12.3%	3.1%	8.5%	0.0%	24.1%	1.7%	3.1%	4.0%	67.5%	10.4%	26.5%
TZ-1	0.75	87.8	240		120	0	0	120	0	0	0	0	0	480
TZ-2	0.68	92.9	22		109	304	0	0	0	0	0	22	0	413
TZ-3	0.91	89.5	247		0	339	0	0	0	0	0	92	0	493
TZ-4	0.61	88.8	273		0	117	0	0	0	0	0	0	0	390
TZ-5	1.74	85.0	668		0	319	0	0	15	0	0	334	0	780
TZ-6A	0.57	89.6	172		193	0	0	0	0	0	0	18	0	347
TZ-6B	0.64	92.5	0		410	0	0	0	0	0	0	41	0	369
TZ-6C	0.58	92.6	0		371	0	0	0	0	0	0	19	0	353
TZ-6D	0.18	91.5	0		115	0	0	0	0	0	0	52	0	63
TZ-6E	0.51	92.8	0		326	0	0	0	0	0	0	0	0	326
TZ-6F	0.55	89.8	88		224	0	0	0	40	0	0	18	0	334
TZ-7	0.69	90.5	0		442	0	0	0	0	0	0	353	0	88
TZ-8	2.36	89.1	140		1,285	0	0	0	0	85	0	453	76	982
TZ-9	1.06	91.3	0		339	0	339	0	0	0	0	237	0	441
TZ-10A	1.83	88.0	586		0	0	586	0	0	0	0	234	0	937
TZ-10B	0.59	86.8	378		0	0	0	0	0	0	0	0	0	378
TZ-11A	0.67	82.6	430		0	0	0	0	0	0	0	172	0	258
TZ-11B	1.03	81.4	659		0	0	0	0	0	0	0	329	33	296
TZ-11C	0.23	86.2	147		0	0	0	0	0	0	0	7	0	140
Trade Zone Subtotal			4047.8		3935	1079	925	120	55	85	0	2381.9	108.5	7867.224
%			39.1%		38.0%	10.4%	8.9%	1.2%	0.5%	0.8%	0.0%	23.0%	1.0%	76.0%
	16.18													
OVERALL			20591	4648	5095	4292	925	9226	711	1250	1509	27888	4035	17904.08
%			42.8%	9.6%	10.6%	8.9%	1.9%	19.2%	1.5%	2.6%	3.1%	57.9%	8.4%	37.2%

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MISSION FLOODWAY DRAINAGE AREA- EXISTING DEVELOPMENT
LAND USE FOR AREA NUMBER

SUMMARY

Area Number	Drainage Area (sq. mi.)	Existing Contitions CN	Residential-1	Residential-2	Warehouse / Industrial	Commercial / Office	Mixed Landuse	Agricultural	Public / Schools	Park / Cementeries	Undeveloped	Soil B	Soil C	Soil D
MI-1	0.49	74.9	0	0		0		0	0	0	314	31	0	282
MI-2	0.62	74.9	0	0	0	0		0	0	0	397	40	0	357
MI-4	0.34	77.0	0	0	0	0		0	0	0	217	0	0	217
MI-5	0.13	77.0	0	0	0	0		0	0	0	83	0	0	83
MI-6	0.80	78.1	0	0	0	0		0	0	269	243	26	0	486
MI-7	0.77	83.8	237	0	0	0		256	0	0	0	99	0	394
MI-8	0.57	81.1	363	0	0	0		0	0	0	0	195	0	168
MI-9A	0.39	84.4	62	0	62	23		39	0	0	64	62	0	187
MI-9B	1.01	76.1	107	0	0	0		333	0	0	207	323	0	323
MI-9C	0.29	83.0	0	0	0	0		186	0	0	0	37	0	149
MI-10A	0.54	83.2	0	0	0	4		342	0	0	0	69	0	277
MI-10B	0.42	77.0	0	0	0	0		269	0	0	0	215	0	54
MI-10C	0.35	84.0	0	0	0	0		224	0	0	0	22	0	202
MI-10D	0.54	78.0	0	0	0	0		346	0	0	0	242	0	104
MI-11A	1.25	77.9	100	0	0	0		580	0	0	120	400	0	400
MI-11B	1.50	77.0	0	0	0	0		960	0	0	0	768	0	192
MI-13	0.73	76.5	262	0	0	0		93	0	0	112	280	0	187
MI-14	0.94	80.2	247	0	0	0		178	0	0	177	180	0	421
MI-15	1.17	82.4	15	0	0	0		734	0	0	0	150	150	449
MI-16	0.62	71.8	111	64	0	0		0	0	0	222	238	0	159
MI-17	0.36	82.6	0	76	0	0		133	0	0	22	35	0	196
MI-18	3.19	82.4	149	63	0	0		1,830	0	0	0	510	102	1,429
MI-19	0.47	83.0	32	194	0	0		75	0	0	0	45	15	241
MI-20	0.37	81.0	125	0	0	0		0	0	76	36	25	34	177
MS-1	0.37	72.6	55	0	0	0		119	21	0	43	213	0	24
MS-2A	0.53	88.5	51	0	0	237		0	51	0	0	170	0	170
MS-2B	0.82	80.1	346	0	0	131		0	0	0	0	472	0	52
MS-2C	1.39	79.8	632	0	0	178		0	80	0	0	801	0	89
MS-3A	0.82	82.0	333	0	100	0		0	0	0	92	276	0	249
MS-3B	0.68	75.7	337	0	0	20		0	21	0	39	392	0	44
MS-4A	0.70	79.1	341	0	0	86		0		0	0	426	0	22
MS-4B	0.54	78.1	321	0	0	0		0	24	0	0	276	0	69
MC-1A	1.39	85.1	80	0	160	489		0	80	0	80	801	0	89
MC-1B	1.52	72.5	348	0	0	0		213	45	68	300	734	45	193
MC-1C	0.21	74.8	0	0	0	0		100	0	0	34	94	0	40
MC-1D	0.07	66.2	22	0	0	0		0	0	0	22	45	0	0
MC-2A	0.82	85.6	173	0	302	0		0	14	35	0	236	0	288
MC-2B	0.37	90.6	0	0	237	0		0	0	0	0	180	0	57

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MISSION FLOODWAY DRAINAGE AREA- EXISTING DEVELOPMENT
LAND USE FOR AREA NUMBER

SUMMARY

Area Number	Drainage Area (sq. mi.)	Existing Contitions CN	Residential-1	Residential-2	Warehouse / Industrial	Commercial / Office	Mixed Landuse	Agricultural	Public / Schools	Park / Cementeries	Undeveloped	Soil B	Soil C	Soil D
MC-3	0.60	80.2	150	0	77	61		0	31	0	65	307	0	77
MC-4A	2.02	74.8	504	0	0	259		52	0	0	478	1,034	0	259
MC-4B	0.42	80.3	0	0	0	91		119	0	59	0	180	0	89
R-2	0.42	78.8	129	0	0	54		54	0	0	129	215	0	54
R-3	0.10	75.3	0	0	0	0		0	0	64	0	19	0	45
R-4	0.41	81.0	167	0	0	59		0	0	36	0	197	0	66
R-5A	0.13	73.7	19	0	0	23		0	0	15	26	75	0	8
R-5B	0.23	72.2	49	0	0	21		0	0	77	0	140	0	7
R-6	0.82	73.9	315	0	0	0		0	42	63	105	420	0	105
R-9	2.50	75.8	960	0	0	240		160	0	80	160	1,600	0	0
R-10	0.64	73.6	328	0	0	0		0	0	82	0	410	0	0
R-11	0.97	77.7	53	0	0	53		463	53	0	0	528	0	93
R-13	2.77	69.9	461	417	0	0		239	124	0	532	1,596	0	177
R-14	0.32	66.8	61	0	0	0		51	0	0	92	205	0	0
R-15	1.85	74.1	426	349	0	0		315	0	0	93	1,066	0	118
E1	0.26	73.6	83	0	0	17		17	0	50	83	166	0	0
E2	0.49	72.1	53	81	0	0		82	70	0	27	304	0	9
E3	0.44	69.4	0	220	0	0		23	0	0	39	282	0	0
E4	0.14	77.2	47	0	0	21		0	0	21	0	85	0	5
E5	0.35	71.5	146	0	0	0		0	0	78	0	224	0	0
E6	0.21	74.9	121	0	0	0		0	0	13	0	134	0	0
E7	0.34	76.1	187	0	0	0		0	31	0	0	207	0	11
E8	0.19	76.0	116	0	0	0		0	6	0	0	122	0	0
E9	0.22	84.5	28	0	0	85		0	28	0	0	141	0	0
E10	0.25	78.0	128	0	0	0		32	0	0	0	128	0	32
E11	0.19	56.0	0	0	0	0		0	0	0	122	122	122	0
E12	0.15	61.4	23	0	0	0		0	0	0	73	91	91	5
E13	0.17	57.0	0	0	0	0		0	0	0	109	103	103	5
E14	2.52	74.9	253	474	0	0		887	0	0	0	1,452	1,452	32
E15	0.50	73.3	207	0	0	0		65	0	16	33	320	0	0
E16	2.24	70.1	0	1,334	0	0		0	0	0	100	1,434	0	0
E17	0.27	76.5	138	0	0	17		0	0	17	0	173	0	0
E18	0.56	74.3	39	274	0	45		0	0	0	0	358	0	0
E19	0.36	79.1	151	0	0	45		34	0	0	0	230	0	0
E20A	2.05	76.9	784	164	0	56		203	0	105	0	1,050	197	66
E20B	1.24	75.8	448	175	0	45		126	0	0	0	794	0	0
E21	0.10	82.4	38	0	0	26		0	0	0	0	64	0	0
E22	1.53	81.2	294	0	0	0		588	0	0	98	0	979	0
E23	0.52	76.6	0	113	0	25		114	0	0	81	96	171	67

HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
817-847-1422

CLIENT: City of McAllen

PROJECT: McAllen Drainage Study

DATE: 12/95
AVO: 14191
FILE: ASTER
EMP: W,MM
CH

MISSION FLOODWAY DRAINAGE AREA- EXISTING DEVELOPMENT
LAND USE FOR AREA NUMBER

SUMMARY

Area Number	Drainage Area (sq. mi.)	Existing Contitions CN	Residential-1	Residential-2	Warehouse / Industrial	Commercial / Office	Mixed Landuse	Agricultural	Public / Schools	Park / Cementeries	Undeveloped	Soil B	Soil C	Soil D
E24	0.28	81.7	0	42	0	3		134	0	0	0	10	159	11
E25	0.25	73.7	28	0	0	0		23	0	0	109	24	120	16
E26	0.24	84.4	0	0	0	0		154	0	0	0	0	31	123
E27	0.26	76.3	166	0	0	0		0	0	0	0	166	0	0
ES1	0.51	82.7	22	0	0	0		307	0	0	0	54	88	187
	59.1													
Outside Trade Zone			11969	4037.3	938	2413	0	11249	722	1224.5	5379	25431.7	3857.7	10186.7
%			31.7%	10.7%	2.5%	6.4%	0.0%	29.8%	1.9%	3.2%	14.2%	67.3%	10.2%	26.9%
TZ-1	0.75	81.7	4		0	0	0	279	0	0	197	0	0	480
TZ-2	0.68	83.2	26		0	0	0	334	0	0	74	22	0	413
TZ-3	0.91	81.2	28		0	10	0	389	0	0	155	87	0	495
TZ-4	0.61	79.8	0		0	24	0	86	0	0	280	0	0	390
TZ-5	1.74	82.7	473		77	90	0	312	15	0	147	334	0	780
TZ-6A	0.57	83.0	0		0	0	0	299	0	0	66	18	0	347
TZ-6B	0.64	84.0	0		0	0	0	410	0	0	0	41	0	369
TZ-6C	0.58	84.5	0		0	0	0	371	0	0	0	19	0	353
TZ-6D	0.18	88.8	0		94	0	0	21	0	0	0	52	0	63
TZ-6E	0.51	84.7	0		91	0	0	134	0	0	102	0	0	326
TZ-6F	0.55	76.8	0		0	0	0	0	40	0	312	18	0	334
TZ-7	0.69	77.2	0		6	0	0	436	0	0	0	353	0	88
TZ-8	2.36	79.4	83		0	2	0	1,209	0	0	217	453	76	982
TZ-9	1.06	80.0	10		15	0	0	592	0	0	61	237	0	441
TZ-10A	1.83	82.8	26		0	0	0	1,129	0	0	17	234	0	937
TZ-10B	0.59	83.2	0		0	0	0	292	0	0	86	0	0	378
TZ-11A	0.67	80.3	0		0	0	0	392	0	0	37	172	0	258
TZ-11B	1.03	80.0	55		0	0	0	604	0	0	0	329	33	296
TZ-11C	0.23	84.5	0		0	0	0	147	0	0	0	7	0	140
Trade Zone Subtotal			705.1		283	125.9	0	7434.3	54.5	0	1751	2376.72	108.46	7869.111
%			6.8%		2.7%	1.2%	0.0%	71.8%	0.5%	0.0%	16.9%	23.0%	1.0%	76.0%
	16.18													
OVERALL			12674	4037.3	1221	2539	0	18684	776	1224.5	7130	27808.4	3966.2	18055.81
%			26.3%	8.4%	2.5%	5.3%	0.0%	38.8%	1.6%	2.5%	14.8%	57.7%	8.2%	37.5%

APPENDIX E
Preliminary Estimates of Probable Construction Cost

ALBERT H. HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817)847-1422

CLIENT: City of McAllen

PAGE: COST-M1
DATE: 12/95
BY: es/mam/chm

PROJECT: Flood Protection Planning Study
for Southern McAllen and Mission
Emergency Spillway at Mission Outlet levee

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Compacted Select Fill	14,000	CY	$10.00	$140,000
2	Rock Riprap	11,450	CY	$90.00	$1,030,500
3	Grouted Rock Rip rap	10,080	SY	$50.00	$504,000
4	Seeding	20,000	SY	$1.00	$20,000
5		0	SY	$0.00	$0
6		0	CY	$0.00	$0
7		0	EA	$0.00	$0
8		0	EA	$0.00	$0
9		0	EA	$0.00	$0
10		0	LF	$0.00	$0
11		0	SY	$0.00	$0
	Subtotal				$1,694,500
	20 % contingency				$338,900
	TOTAL				$2,033,000

Note: Estimate does not include Engineering, Adminstration, Surveying, or Legal fees

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

ALBERT H. HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817)847-1422

CLIENT: City of McAllen

PAGE: COST-M2
DATE: 12/95
BY: es/mam/chm

PROJECT: Flood Protection Planning Study
for Southern McAllen and Mission
Relief Storage for 100-Year Gates Closed

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	Compacted Select Fill-Mission outlet levee	17,500	CY	$5.00	$87,500
2	Rock Riprap	5,050	CY	$90.00	$454,500
3	Grouted Rock Rip rap	2,200	SY	$50.00	$110,000
4	Triple-10' x 10' Reinforced Conc. Box Culvert (150 ft)	435	CY	$400.00	$174,000
5	Flap Gates 10' x 10'	3	EA	$20,000.00	$60,000
6	Excavation	1,600,100	CY	$3.00	$4,800,300
7		0	EA	$0.00	$0
8		0	EA	$0.00	$0
9		0	EA	$0.00	$0
10		0	LF	$0.00	$0
11		0	SY	$0.00	$0
	Subtotal				$5,686,300
	5 % Utlity Adjustment				$284,315
	20 % contingency				$1,137,260
	TOTAL				$7,108,000

This estimate does not include ROW acquisition
Note: Estimate does not include Engineering, Adminstration, Surveying, or Legal fees

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4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817)847-1422

CLIENT: City of McAllen

PAGE: COST-CIM
DATE: 12/95
BY: es/mam/chm

PROJECT: Flood Protection Planning Study
for Southern McAllen and Mission
Reconstruction of the South Levee at Cimarron

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	ROW Preparation	65	AC	$1,000.00	$65,000
2	Compacted Select Fill-Levee	77,400	CY	$5.00	$387,000
3	Excavation	864,400	CY	$3.00	$2,593,200
4	Salvage Topsoil	33,600	CY	$2.00	$67,200
5	Seeding	314,600	SY	$1.00	$314,600
6	Rock Riprap	2,445	CY	$90.00	$220,050
7	Grouted Rock Rip rap	2,990	SY	$50.00	$149,500
8	Five-10' x 10' Reinforced Conc. Box Culvert (50 ft)	260	CY	$400.00	$104,000
9	Flap Gates 10' x 10'	5	EA	$20,000.00	$100,000
10	Bridge at Shary Road	1	LS	$900,000.00	$900,000
11		0	EA	$0.00	$0
12		0	EA	$0.00	$0
13		0	EA	$0.00	$0
14		0	LF	$0.00	$0
15		0	SY	$0.00	$0
	Subtotal				$4,900,550
	10% Utility Adjustments				$490,055
	20 % contingency				$980,110
	TOTAL				$6,371,000

This estimate does not include ROW acquisition
Note: Estimate does not include Engineering, Adminstration, Surveying, or Legal fees

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ALBERT H. HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817)847-1422

CLIENT: City of McAllen

PROJECT: Flood Protection Planning Study
for Southern McAllen and Mission
Drainage Improvements for Cell-1 (Outlet No. 1)

PAGE: COST-C1
DATE: 12/95
BY: es/mam/chm

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	ROW Preparation	25	AC	$1,000.00	$25,000
2	Excavation	508,000	CY	$3.00	$1,524,000
3	Levee Excavation for CBC installation	1,390	CY	$10.00	$13,900
4	Salvage Topsoil	13,600	CY	$2.00	$27,200
5	Seeding	121,000	SY	$1.00	$121,000
6	Sigle-6' x 4' Reinforced Conc. Box Culvert (150 ft)	77	CY	$400.00	$30,800
7	Flap Gates 6' x 4'	1	EA	$11,000.00	$11,000
8	Compacted Select Fill-Mission Levee	9,800	CY	$5.00	$49,000
9		0	EA	$0.00	$0
10		0	LF	$0.00	$0
11		0	SY	$0.00	$0
	Subtotal				$1,801,900
	5 % Utility Adjustment				$90,095
	20 % contingency				$360,380
	TOTAL				$2,252,000

Note: Estimate does not include Engineering, Adminstration, Surveying, or Legal fees

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ALBERT H. HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817)847-1422

CLIENT: City of McAllen

PAGE: COST-C2
DATE: 12/95
BY: es/mam/chm

PROJECT: Flood Protection Planning Study
for Southern McAllen and Mission
Drainage Improvements for Cell-2 (Outlet No. 2)

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	ROW Preparation	45	AC	$1,000.00	$45,000
2	Excavation	947,500	CY	$3.00	$2,842,500
3	Levee Excavation for CBC installation	5,780	CY	$10.00	$57,800
4	Salvage Topsoil	23,900	CY	$2.00	$47,800
5	Seeding	215,400	SY	$1.00	$215,400
6	Sigle-8' x 5' Reinforced Conc. Box Culvert (150 ft)	127	CY	$400.00	$50,800
7	Flap Gates	1	EA	$15,000.00	$15,000
8		0	EA	$0.00	$0
9		0	EA	$0.00	$0
10		0	LF	$0.00	$0
11		0	SY	$0.00	$0
	Subtotal				$3,274,300
	5 % Utility Adjustment				$163,715
	20 % contingency				$654,860
	TOTAL				$4,093,000

Note: Estimate does not include Engineering, Adminstration, Surveying, or Legal fees

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ALBERT H. HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817)847-1422

CLIENT: City of McAllen

PAGE: COST-C9B
DATE: 12/95
BY: es/mam/chm

PROJECT: Flood Protection Planning Study
for Southern McAllen and Mission
Drainage Improvements for Cells 3-9 (Outlet No. 3)

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	ROW Preparation	320	AC	$1,000.00	$320,000
2	Excavation	7,732,700	CY	$3.00	$23,198,100
3	Levee Excavation for CBC installation	4,430	CY	$10.00	$44,300
4	Salvage Topsoil	172,100	CY	$2.00	$344,200
5	Seeding	1,548,800	SY	$1.00	$1,548,800
6	Double-10' x 10' Reinforced Conc. Box Culvert (150 ft)	331	CY	$400.00	$132,400
7	Flap Gates- 10' x 10'	2	EA	$20,000.00	$40,000
8	Flap Gates- 4 x 4	5	EA	$10,000.00	$50,000
9	36" Class III R.C.P.	200	LF	$53.00	$10,600
10		0	LF	$0.00	$0
11		0	SY	$0.00	$0
	Subtotal				$25,688,400
	2 % Utility Adjustment				$513,768
	20 % contingency				$5,137,680
	TOTAL				$31,340,000

Note: Estimate does not include Engineering, Adminstration, Surveying, or Legal fees

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

ALBERT H. HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817)847-1422

CLIENT: City of McAllen

PAGE: COST-C9A
DATE: 12/95
BY: es/mam/chm

PROJECT: Flood Protection Planning Study
for Southern McAllen and Mission
Drainage Improvements for Cells 3-9 (Outlet No. 4)

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	ROW Preparation	104	AC	$1,000.00	$104,000
2	Excavation	2,371,600	CY	$3.00	$7,114,800
3	Levee Excavation for CBC installation	3,950	CY	$10.00	$39,500
4	Salvage Topsoil	70,350	CY	$2.00	$140,700
5	Seeding	502,400	SY	$1.00	$502,400
6	Single-10' x 10' Reinforced Conc. Box Culvert (150 ft)	238	CY	$400.00	$95,200
7	Flap Gates 10 x 10	1	EA	$20,000.00	$20,000
8	42" Class III R.C.P.	400	LF	$80.00	$32,000
9	Single-10' x 5' Reinforced Conc. Box Culvert (200 ft)	172	CY	$400.00	$68,800
10		0	LF	$0.00	$0
11		0	SY	$0.00	$0
	Subtotal				$8,117,400
	5 % Utility Adjustment				$405,870
	20 % contingency				$1,623,480
	TOTAL				$10,147,000

Note: Estimate does not include Engineering, Adminstration, Surveying, or Legal fees

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

ALBERT H. HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817)847-1422

CLIENT: City of McAllen

PROJECT: Flood Protection Planning Study
for Southern McAllen and Mission
Drainage Improvements for Cell-10 (Outlet No. 5)

PAGE: COST-C10
DATE: 12/95
BY: es/mam/chm

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	ROW Preparation	75	AC	$1,000.00	$75,000
2	Excavation	1,256,900	CY	$3.00	$3,770,700
3	Levee Excavation for CBC installation	8,500	CY	$10.00	$85,000
4	Salvage Topsoil	41,000	CY	$2.00	$82,000
5	Seeding	367,800	SY	$1.00	$367,800
6	Single-10' x 6' Reinforced Conc. Box Culvert (200 ft)	267	CY	$400.00	$106,800
7	Flap Gates 10 x 6	1	EA	$18,000.00	$18,000
8	30" Class III R.C.P.	100	LF	$42.00	$4,200
9	36" Class III R.C.P.	100	LF	$53.00	$5,300
10	48" Class III R.C.P.	100	LF	$80.00	$8,000
11	60" Class III R.C.P.	100	LF	$108.00	$10,800
	Subtotal				$4,533,600
	5 % Utility Adjustment				$226,680
	20 % contingency				$906,720
	TOTAL				$5,667,000

Note: Estimate does not include Engineering, Adminstration, Surveying, or Legal fees

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

ALBERT H. HALFF ASSOCIATES, INC.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817)847-1422

CLIENT: City of McAllen

PAGE: COST-C11
DATE: 12/95
BY: es/mam/chm

PROJECT: Flood Protection Planning Study
for Southern McAllen and Mission
Drainage Improvements for Cell-11 (Outlet No. 6)

STATEMENT OF PROBABLE COST

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
1	ROW Preparation	41	AC	$1,000.00	$41,000
2	Excavation	606,700	CY	$3.00	$1,820,100
3	Levee Excavation for CBC installation	4,270	CY	$10.00	$42,700
4	Salvage Topsoil	22,050	CY	$2.00	$44,100
5	Seeding	198,400	SY	$1.00	$198,400
6	Sigle-6' x 4' Reinforced Conc. Box Culvert (200 ft)	107	CY	$400.00	$42,800
7	Flap Gates 6 x 4	1	EA	$12,000.00	$12,000
8	24" Class III R.C.P.	100	LF	$34.00	$3,400
9	36" Class III R.C.P.	0	LF	$53.00	$0
10	48" Class III R.C.P.	0	LF	$80.00	$0
11	60" Class III R.C.P.	0	LF	$108.00	$0
	Subtotal				$2,204,500
	5 % Utility Adjustment				$110,225
	20 % contingency				$440,900
	TOTAL				$2,756,000

Note: Estimate does not include Engineering, Adminstration, Surveying, or Legal fees

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

APPENDIX F
Computer Files of Hydrologic and Hydraulic Models
(Computer Diskette)

APPENDIX G
References

APPENDIX G
REFERENCES

1. Soil Survey of Hidalgo County, Texas, United State Department of Agriculture Soil Conservation Service, June 1981.

2. Flood Insurance Study, Hidalgo County, Texas, Federal Emergency Management Agency, July 2, 1980.

3. Report of Hurricane Beulah, U.S. Army Corps of Engineers, Galveston District, September, 1968.

4. Flood Insurance Study, City of McAllen, Texas, Hidalgo County, Federal Emergency Management Agency, December 15, 1980.

5. HEC-1 Flood Hydrograph Package, U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California, September 1990.

6. Lower Rio Grande Basin, Texas Flood Control and Major Drainage Project, Phase 1 - General Design Memorandum Main Report and Final Environmental Impact Statement with Appendices 1-8, U.S. Army Corps of Engineers, Galveston District, August, 1982.

7. Draft Report - Mission Inlet Pilot Channel Improvements, Phase V Engineering Inc. in cooperation with Furlong Engineering, Inc., May 1991

8. SCS National Engineering Handbook, Section 4, Hydrology, United States Department of Agriculture Soil Conservation Service, 1969.

9. Hidalgo County Drainage Plan, Melden and Hunt, Inc. and Sigler, Winston, Greenwood and Associates, Inc., March 14, 1985.

10. Technical Paper No. 40, Rainfall Frequency Atlas of the United States, National Weather Service, May 1961.

11. Technical Memorandum HYDRO-35, National Oceanic and Atmospheric Administration, June, 1977.

12. HEC-2 Water Surface Profiles, U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California, May 1991.

13. Status of Conveying Capacity of the Lower Rio Grande Flood Control Project, International Boundary & Water Commission United States and Mexico, United States Section, El Paso, Texas, June 1992

14. Engineering Report, Mission Floodway Closure, International Boundary & Water Commission United States and Mexico, United States Section, El Paso, Texas, July 1972

APPENDIX G
REFERENCES (Continued)

15. Flood Insurance Study, City of Mission, Texas, Hidalgo County, Federal Emergency Management Agency, November 20, 1991.

16. Happy Trails Flood Study, L.L. Rodriguez and Associates, Inc., February 1985.

17. Preliminary Engineering Report for the Relocation of the Water District No. 3 Siphon and Drainage Improvements to the South 18th Street and Balboa Acres Drainage Systems, L.L. Rodriguez and Associates, Inc., November 1983

18. Master Drainage Plan for Mission Inlet and South Rado Drain-Hidalgo County Drainage District No. 1, Melden and Hunt, Inc. and Sigler, Winston, Greenwood and Associates 1985

19. Rado Drain Alternative Study for Hidalgo County Drainage District. No. 1

20. National Flood Insurance Program and Related Regulations, Federal Emergency Management Agency.

APPENDIX H
Survey Control Data

ANZALDUAS PANEL POINT
GPS ADJUSTMENT SUMMARY

Panel Points for aerial photogrammetry were placed as indicated on layout provided by Robert Stackhouse Aerial Company. Panels were placed as 4'x4' chevrons with 1/2-inch iron rods set flush with the ground at the interior corner of each panel. Panels were made with 1' wide white plastic sheets held in place by nails and shiners.

Static GPS observations were performed on March 8, 9, and 10, 1995 by Halff Associates personnel using Trimble 4000ST receivers. GPS observations were reduced using Trimnet software. The GPS network was adjusted and WGS-84 ellipsoid heights were computed using GEOLAB software. The GPS network was constrained horizontally to NGS first order triangulation station "HICKLEY" NAD 83 coordinate values.

The GPS network was constrained vertically to IBWC benchmarks as follows:

AL01 direct GPS observation of IBWC BM No. 266 AL-PH.
BM02 direct GPS observation of IBWC brass disk on south side of the Anzalduas wier.
AL07 level loop to IBWC brass disk on Structure No. 300.
AL08 level loop to IBWC brass disk on Structure No. 301.
AL21 level loop to IBWC brass disk on Structure No. 316.
AL28 level loop to IBWC brass disk on Structure No. 323.

All panel points were adjusted by least squares computations using the six IBWC benchmarks described above.

Surface coordinates were computed using a combined scale factor of 0.99999588.

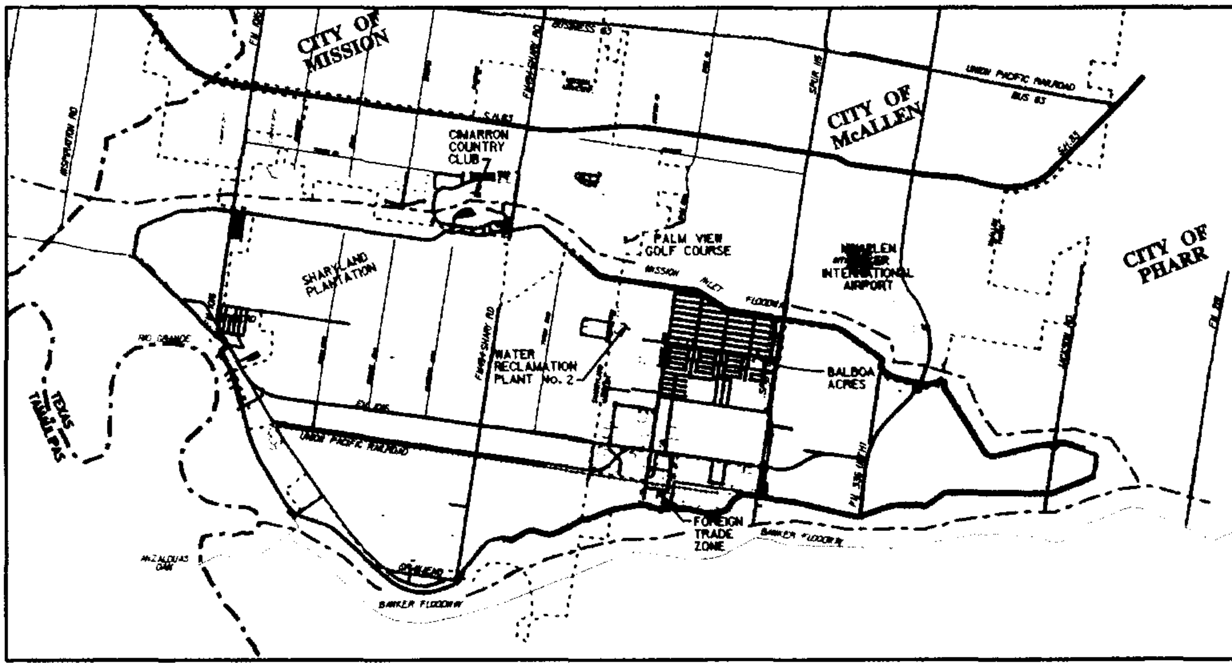
Conversion factor from meters to U.S. survey feet = 0.304800609601 meters/foot.

FLOOD PROTECTION PLANNING STUDY FOR SOUTHERN McALLEN AND MISSION, TEXAS
ALL COORD[illegible]TE VALUES ARE NAD83 - TEXAS SOUTH ZONE 4205
ADJUSTED HORIZONTALLY FROM TRIANGULATION STATION "HICKLEY 2"
ALL ELEVATIONS ARE ADJUSTED VERTICALLY FROM IBWC BENCHMARKS

PANEL POINT	GRID NORTHING (METERS)	PANEL EASTING (METERS)	ELEVATION ABOVE MSL (METERS)	SCALE FACTOR	SURFACE NORTHING (FEET)	SURFACE EASTING (FEET)	ELEVATION ABOVE MSL (METERS)	NATURAL GROUND (METERS)
AL01	5056704.7435	315418.9699	38.4322	0.99999707	16,590,273.8472	1,034,841.3350	38.43	37.37
AL02	5058234.5784	315811.5320	33.3171	0.99999367	16,595,293.0012	1,036,129.2711	33.32	33.32
AL03	5058743.4684	317069.8965	34.0817	0.99999256	16,596,962.5913	1,040,257.7723	34.08	34.08
AL04	5056700.6945	316759.4967	33.7987	0.99999708	16,590,260.5630	1,039,239.3981	33.80	33.80
AL05	5054933.7598	317078.3642	34.3812	1.00000108	16,584,463.5209	1,040,285.5535	34.38	34.38
AL06	5053744.1339	317231.6657	37.2438	1.00000382	16,580,560.5405	1,040,788.5123	37.24	37.24
AL07	5051963.7175	318551.5646	33.4762	1.00000798	16,574,719.2669	1,045,118.8984	33.48	33.48
AL08	5051417.7240	320108.5796	32.0802	1.00000928	16,572,927.9459	1,050,227.2262	32.08	32.08
AL09	5052383.9394	320205.7232	32.2470	1.00000700	16,576,097.9506	1,050,545.9395	32.25	32.25
AL10	5054265.6527	320350.1739	32.1961	1.00000263	16,582,271.5638	1,051,019.8601	32.20	32.20
AL11	5055411.8034	320650.9136	31.3736	1.00000001	16,586,031.9087	1,052,006.5410	31.37	31.37
AL12	5057086.6398	319295.1610	34.9186	0.99999623	16,591,526.7904	1,047,558.5243	34.92	34.92
AL13	5057132.5828	320914.2227	31.0032	0.99999613	16,591,677.5224	1,052,870.4178	31.00	31.00
AL14	5058551.7773	318710.4405	34.7544	0.99999298	16,596,333.6822	1,045,640.1459	34.75	34.75
AL15	5058210.0138	321077.0670	33.8525	0.99999374	16,595,212.4085	1,053,404.6850	33.85	33.85
AL16	5057841.8994	323488.3725	33.3578	0.99999456	16,594,004.6815	1,061,315.8091	33.36	33.36
AL17	5056315.6270	323297.9649	32.0671	0.99999797	16,588,997.2155	1,060,691.1109	32.07	32.07
AL18	5055440.9348	323183.5421	30.2369	0.99999995	16,586,127.4844	1,060,315.7072	30.24	30.24
AL19	5053890.0257	322942.9751	30.3768	1.00000350	16,581,039.1891	1,059,526.4437	30.38	30.38
AL20	5052324.3466	322668.7265	34.6539	1.00000715	16,575,902.4358	1,058,626.6761	34.65	34.06
AL21	5052279.0067	325885.4467	33.8115	1.00000727	16,575,753.6825	1,069,180.2424	33.81	33.81
AL22	5053417.5694	326069.0432	29.1753	1.00000461	16,579,489.1324	1,069,782.5944	29.18	29.18
AL23	5055217.5613	326341.1581	32.4579	1.00000047	16,585,394.6301	1,070,675.3617	32.46	32.46
AL24	5056297.1968	326707.3824	29.7501	0.99999803	16,588,936.7488	1,071,876.8876	29.75	29.75
AL25	5056176.0076	329146.4741	29.5686	0.99999831	16,588,539.1456	1,079,879.1739	29.57	29.57
AL26	5054698.7862	328920.9554	31.7968	1.00000167	16,583,692.6085	1,079,139.2816	31.80	31.80
AL28	5053006.2848	329949.5596	30.0960	1.00000559	16,578,139.7706	1,082,513.9745	30.10	30.10
AL29	5051716.5561	328477.2284	27.6979	1.00000861	16,573,908.3682	1,077,683.4813	27.70	27.70
BM02	5052629.6321	317683.7738	37.4386	1.00000642	16,576,904.0307	1,042,271.8097	37.44	37.44
HICKLEY 2	5053067.4427	322863.0322	34.2781	1.00000541	16,578,340.4203	1,059,264.1633	34.28	34.28
AVERAGE ELEVATION (METERS)			32.7973					
AVERAGE SCALE FACTOR				1.00000103				
SEA LEVEL REDUCTION FACTOR				0.99999485				
COMBINED SCALE FACTOR				0.99999588				

"WORK SESSION"
PRESENTATION OF PRELIMINARY RESULTS

NOVEMBER 21, 1995



FLOOD PROTECTION PLANNING STUDY
FOR
SOUTHERN MCALLEN AND MISSION, TEXAS

STATE OF TEXAS
MICHAEL A. MOYA
68170
REGISTERED
PROFESSIONAL ENGINEER
11/20/95

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Flood Protection Planning Study for Southern McAllen and Mission, Texas

OUTLINE OF PRESENTATION

I. Introduction

II. Study Procedures

III. Results of Baseline Conditions

IV. Conceptual Design Solutions

V. Summary of Findings

Flood Protection Planning Study for Southern McAllen and Mission, Texas

INTRODUCTION

- Project Milestones
- Purpose of Study
- Description of Watershed

Flood Protection Planning Study for Southern McAllen and Mission, Texas

PROJECT MILESTONES

- September 1994 - Application for TWDB Grant
- January 1995 - Notice-to-Proceed
- March 1995 - Aerial Surveys Flown
- September 1995 - Final Mapping Received
- November 1995 - Work Session to Present Preliminary Results

Flood Protection Planning Study for Southern McAllen and Mission, Texas

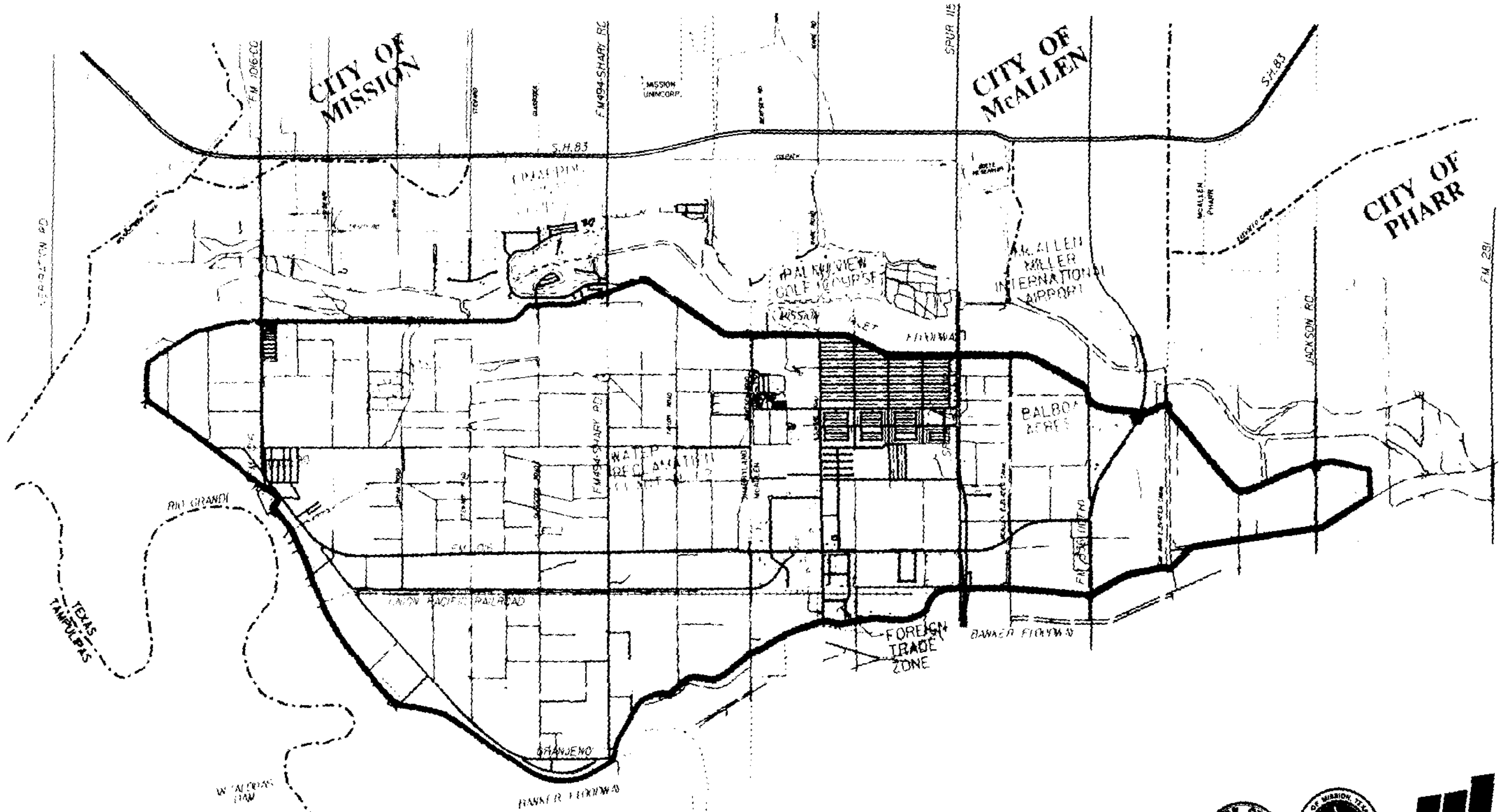
PURPOSE OF STUDY

The purpose of this study is to develop detailed hydrologic and hydraulic computer models to analyze the existing drainage system and evaluate alternative design schemes to help alleviate existing and potential flood damages for the developing areas of southern McAllen and southern Mission, Texas, located between the Old Mission Inlet Floodway and the Banker Floodway.

Flood Protection Planning Study for Southern McAllen and Mission, Texas

DESCRIPTION OF WATERSHED

- Total Contributing Drainage Area is 75 sm.
- Detail Study Area (Sharyland/Trade Zone) is 16 sm.



LEGEND

CITY LIMIT LINE

DITCH

ROAD

STUDY AREA MAP
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN McALLEN AND MISSION, TEXAS

FIGURE 1

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FIGURE 2

DRAINAGE AREA MAP

FLOOD PROTECTION PLANNING STUDY

FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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Flood Protection Planning Study for Southern McAllen and Mission, Texas

STUDY PROCEDURES

- Data Collection
- Study Assumptions
- Hydrologic and Hydraulic Computer Modeling

Flood Protection Planning Study for Southern McAllen and Mission, Texas

DATA COLLECTION

- Aerial Surveys by Williams-Stackhouse Inc.
- Previous Studies - Federal Emergency Management Agency, Corps of Engineers, International Boundary & Water Commission, and Phase V Engineering
- Future Land Use Maps for McAllen and Sharyland
- Hidalgo County Soil Survey
- Record Bridge/Roadway Construction Plans
- Field Observations

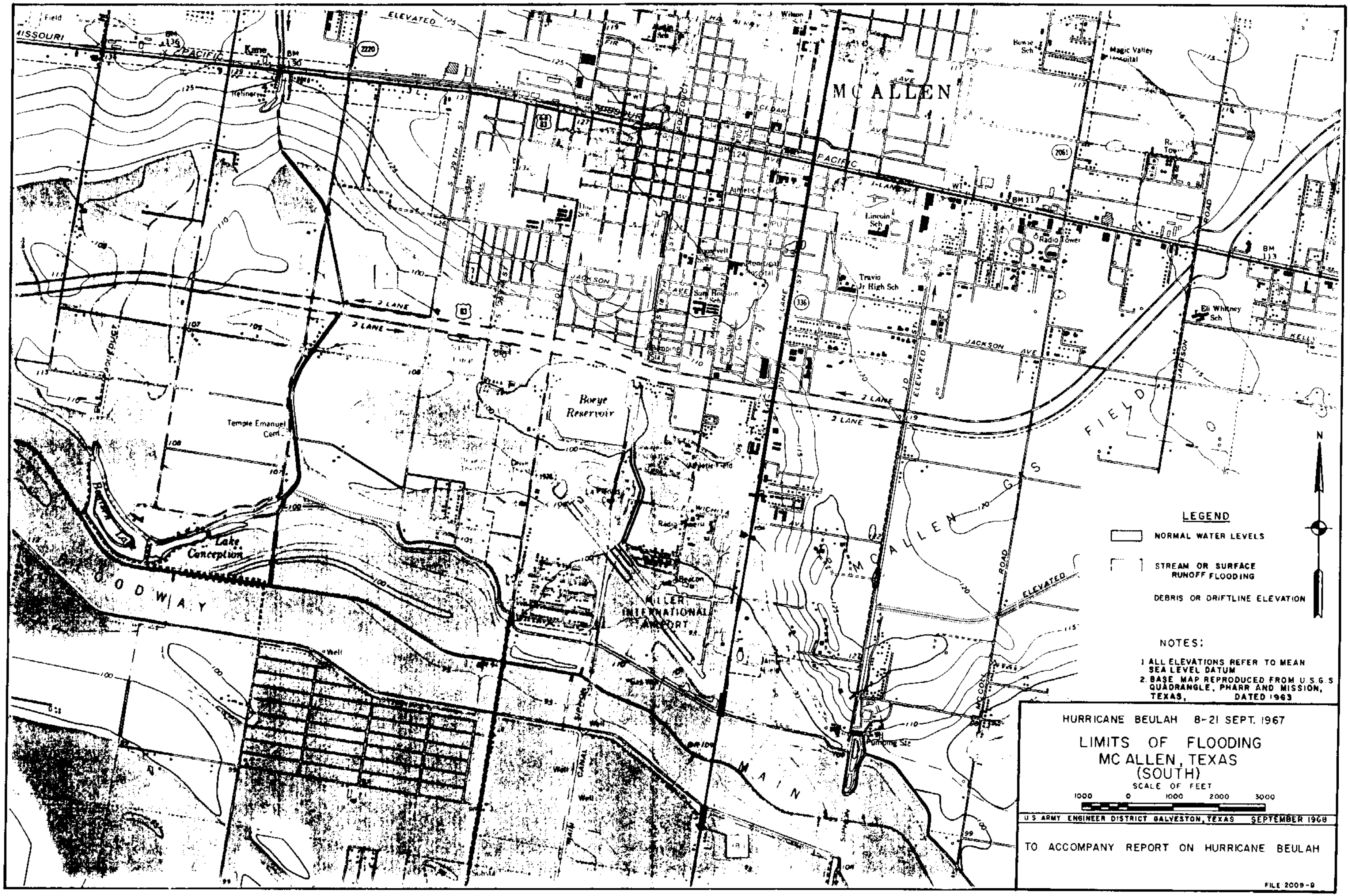
MC ALLEN
MISSOURI PACIFIC
Boeye Reservoir
Lake Conception
Temple Emanuel Cem.
MILLER INTERNATIONAL AIRPORT
FLOODWAY
MAIN
MC ALLEN GAS FIELD
Lincoln Sch
Travis Jr High Sch
Eli Whitney Sch
Magic Valley Hospital
JACKSON AVE
2 LANE
ELEVATED
LEGEND
NORMAL WATER LEVELS
STREAM OR SURFACE RUNOFF FLOODING
DEBRIS OR DRIFTLINE ELEVATION
NOTES:
1. ALL ELEVATIONS REFER TO MEAN SEA LEVEL DATUM
2. BASE MAP REPRODUCED FROM U.S.G.S. QUADRANGLE, PHARR AND MISSION, TEXAS, DATED 1963
HURRICANE BEULAH 8-21 SEPT. 1967
LIMITS OF FLOODING
MC ALLEN, TEXAS
(SOUTH)
SCALE OF FEET
1000 0 1000 2000 3000
U.S. ARMY ENGINEER DISTRICT GALVESTON, TEXAS SEPTEMBER 1968
TO ACCOMPANY REPORT ON HURRICANE BEULAH
FILE 2009-9

PLATE 46

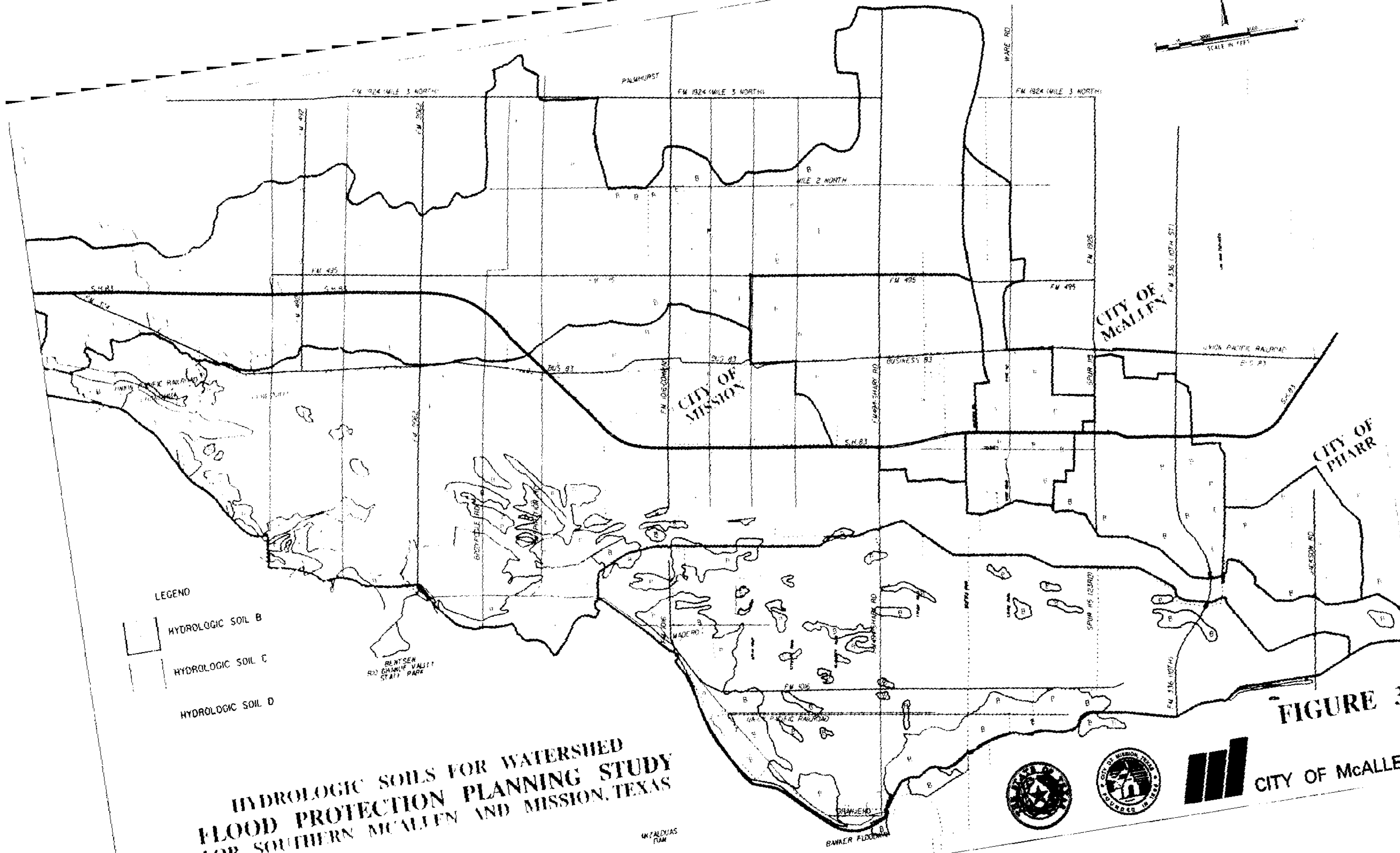

FIGURE 3

HYDROLOGIC SOILS FOR WATERSHED
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN McALLEN AND MISSION, TEXAS

CITY OF McALLEN

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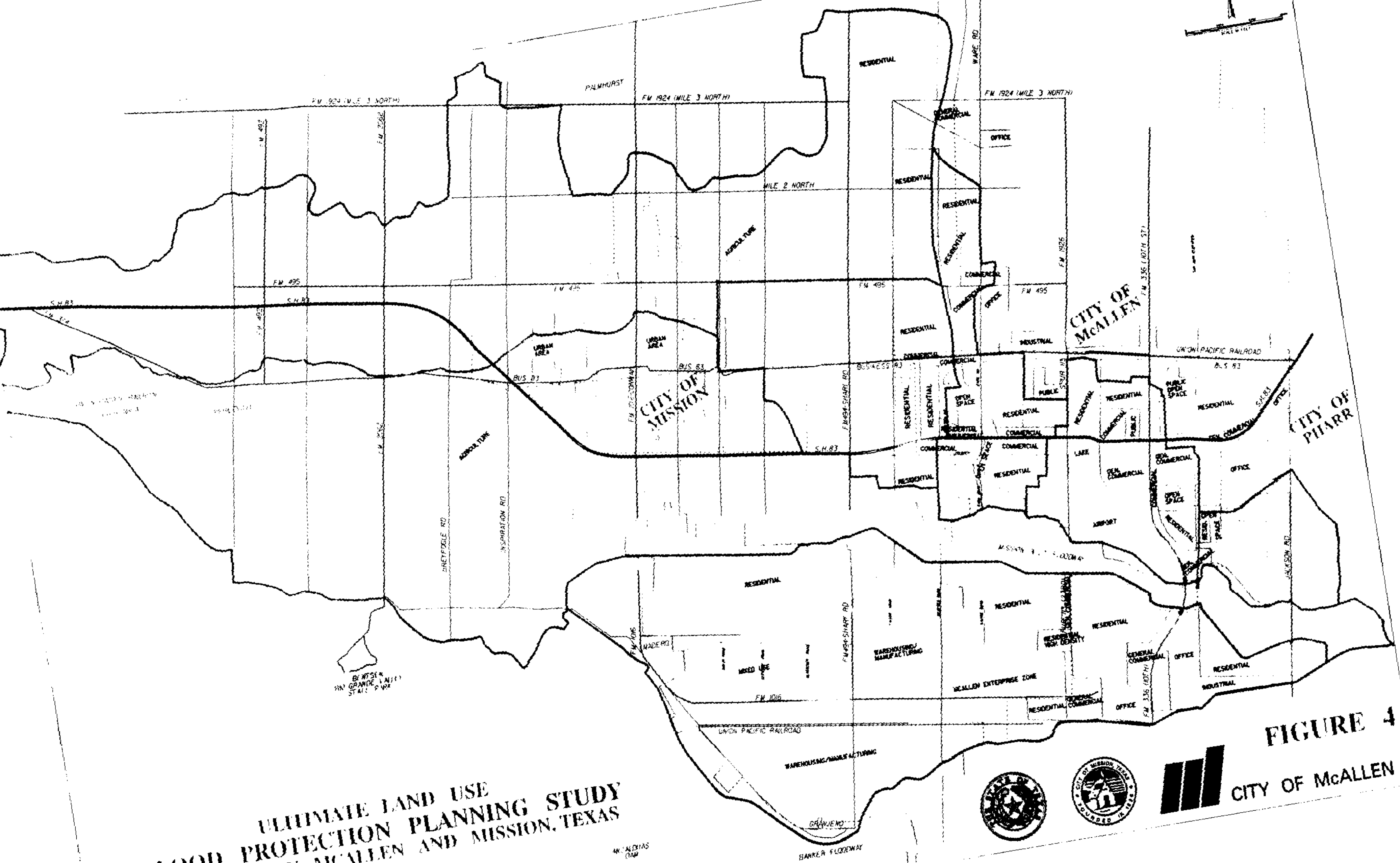

FIGURE 4

ULTIMATE LAND USE

FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN McALLEN AND MISSION, TEXAS

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Flood Protection Planning Study for Southern McAllen and Mission, Texas

STUDY ASSUMPTIONS

- Future Development
- Undeveloped Areas Assigned Agricultural Land Use
- Detail Study Area Modeled as Enclosed System with Eleven Separate Flood Storage Cells
- All Contributing Areas, Except Sharyland/Trade Zone Area, Permitted to Enter Mission Inlet
- Mission Inlet Floodway Modeled as Series of Reservoirs
- Mission Inlet Gates Closed and Banker Floodway Full

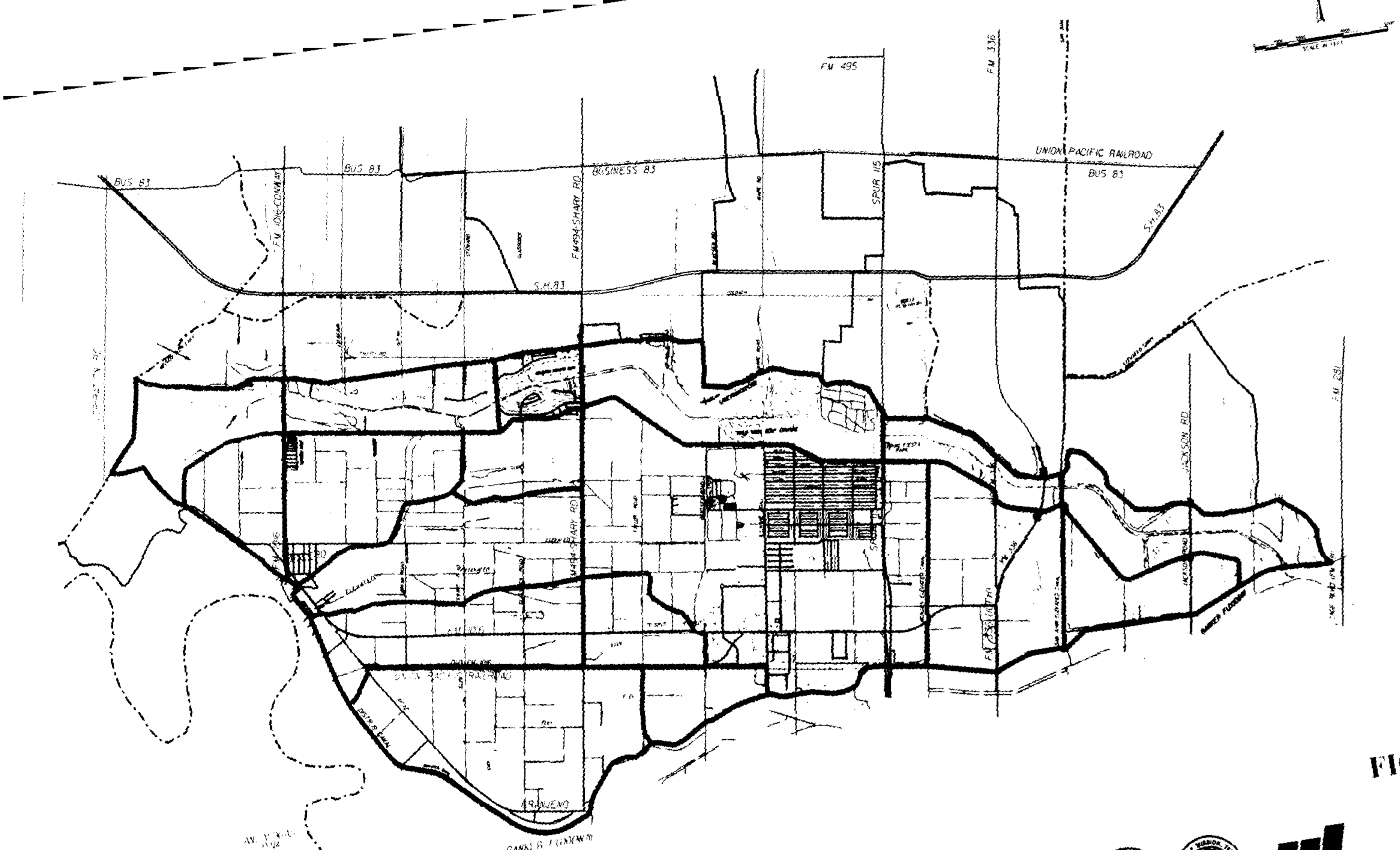

FIGURE 5

DETAIL STUDY AREA - FLOOD STORAGE CELLS
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN McALLEN AND MISSION, TEXAS

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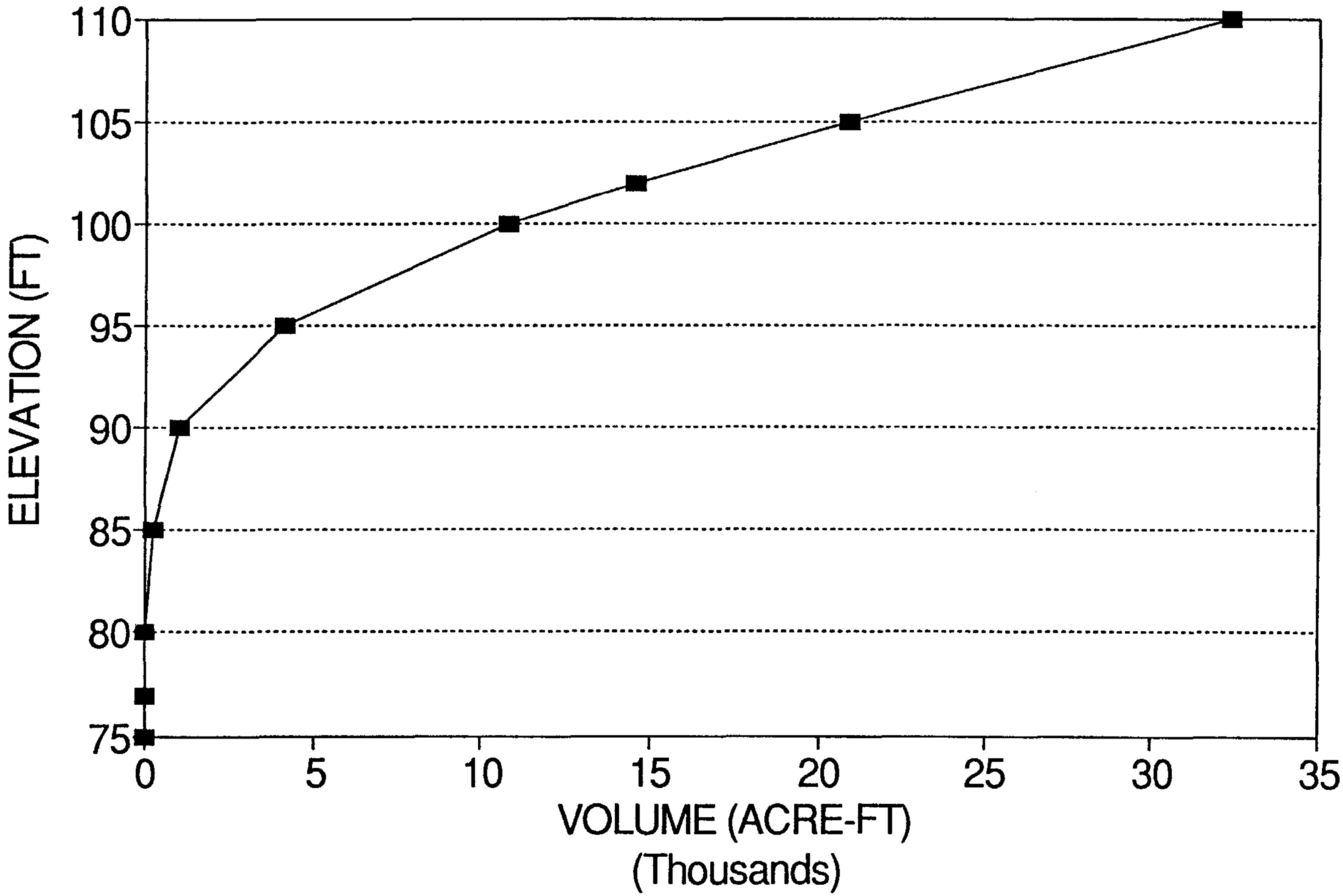
Flood Protection Planning Study for Southern McAllen and Mission, Texas

HYDROLOGIC AND HYDRAULIC COMPUTER MODELING

- HEC-1 Flood Hydrograph Package / HEC-2 Water Surface Profiles
- Soil Conservation Service Loss Rate Method
- Modified Puls Reservoir Flood Routing - Digital Terrain Model (DTM) Utilized to Compute Stage-Storage-Discharge Relationships
- Rainfall Depth/Duration Taken from Technical Paper No. 40 and Technical Memorandum NWS HYDRO-35

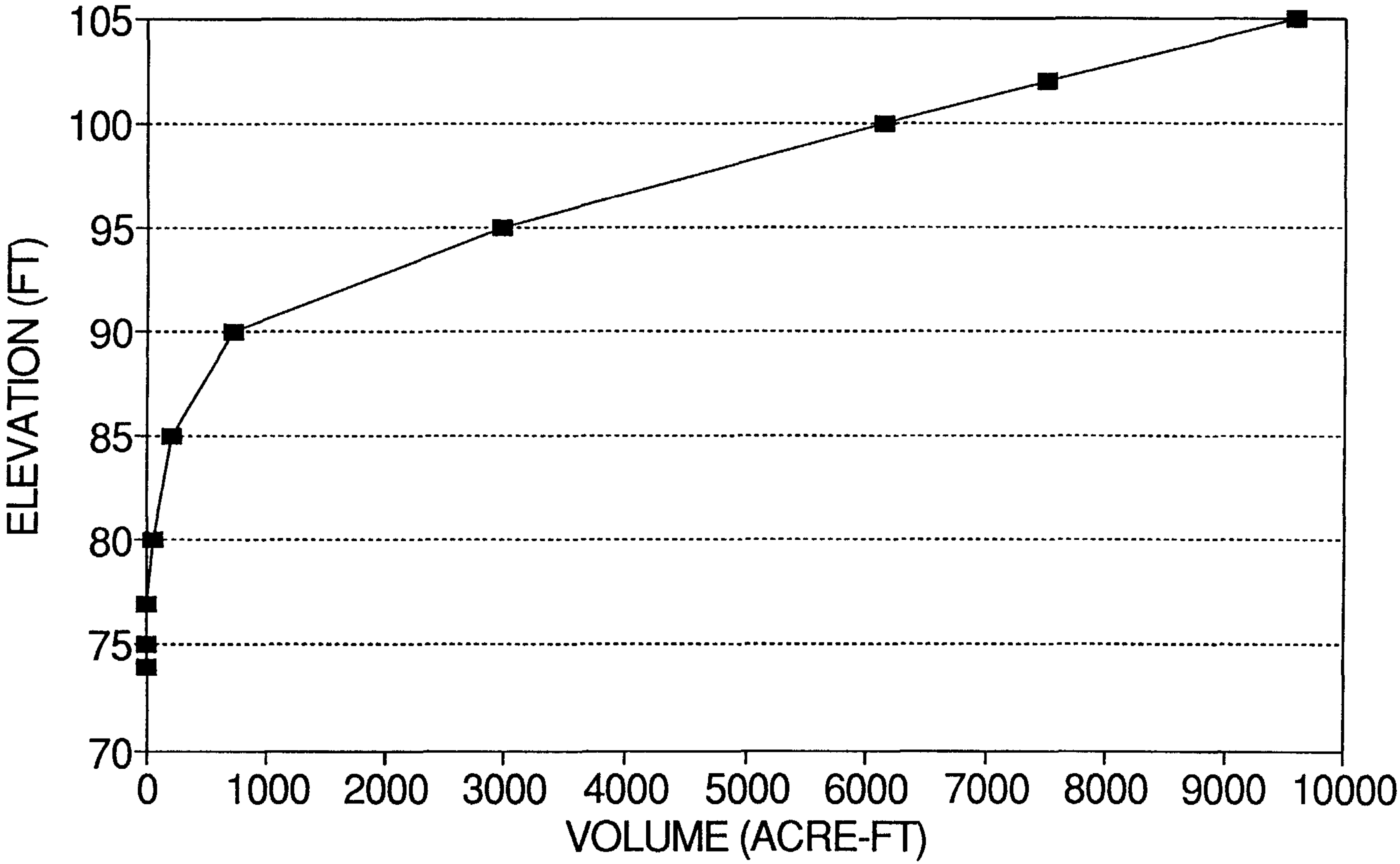
ELEVATION-STORAGE RELATIONSHIP

MISSION PUMP TO MISSION INLET (91-7)



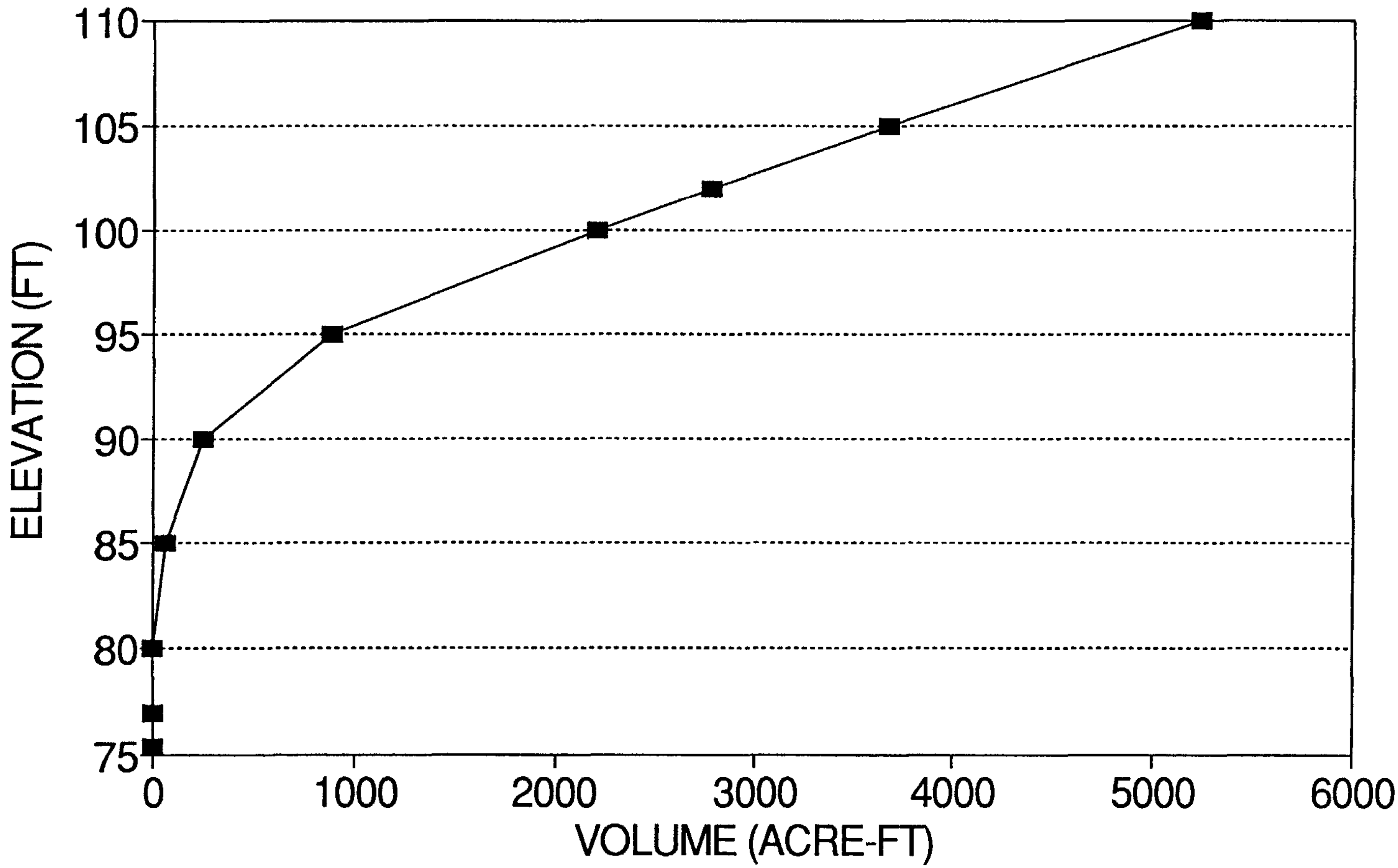
ELEVATION-STORAGE RELATIONSHIP

MISSION PUMP TO SAN JUAN CANAL (91-84)



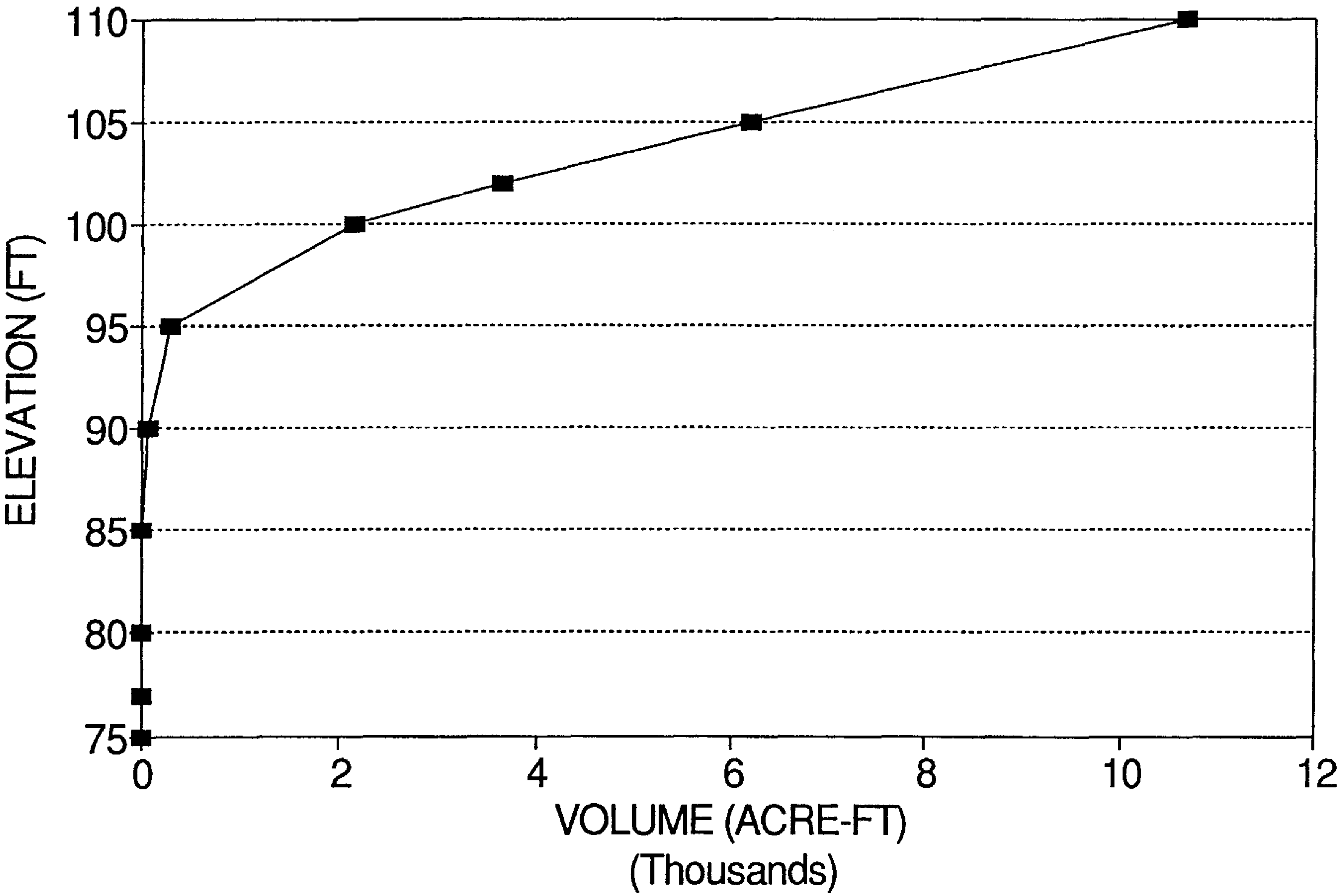
ELEVATION-STORAGE RELATIONSHIP

SAN JUAN CANAL TO 23RD ST (84-74)



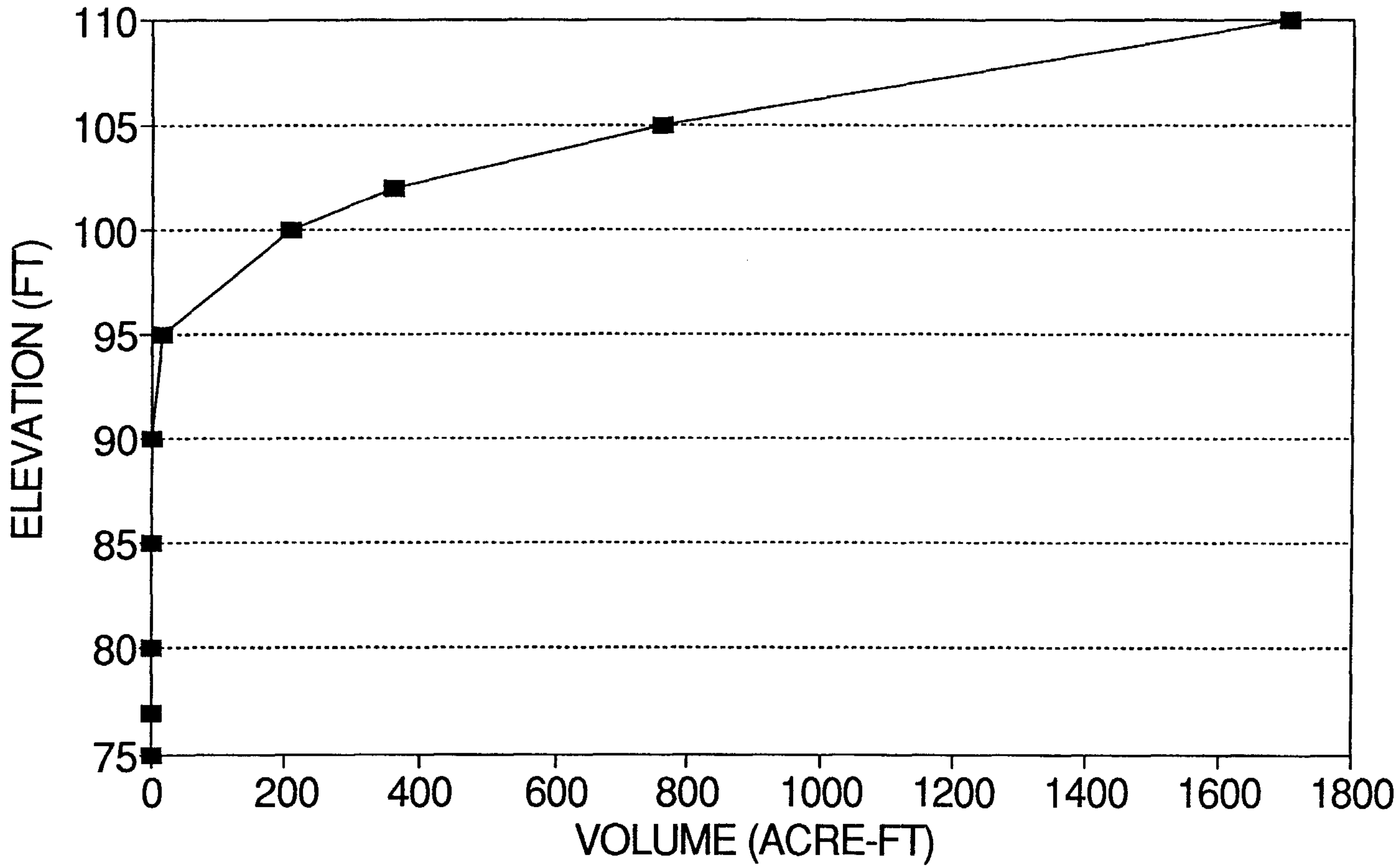
ELEVATION-STORAGE RELATIONSHIP

23RD ST TO SHARY RD (74-26)



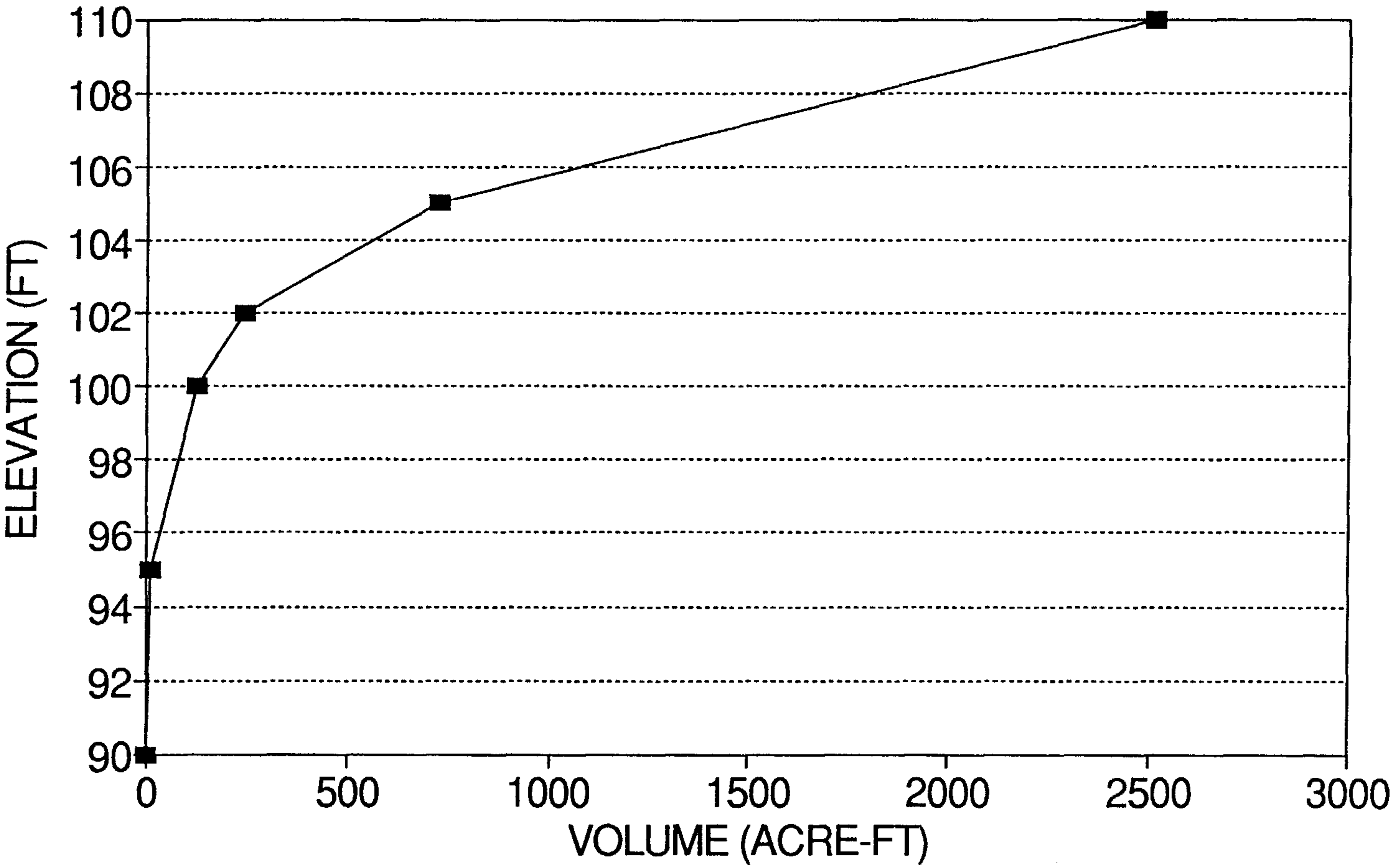
ELEVATION-STORAGE RELATIONSHIP

SHARY RD TO RIO GRANDE RD (26-25)



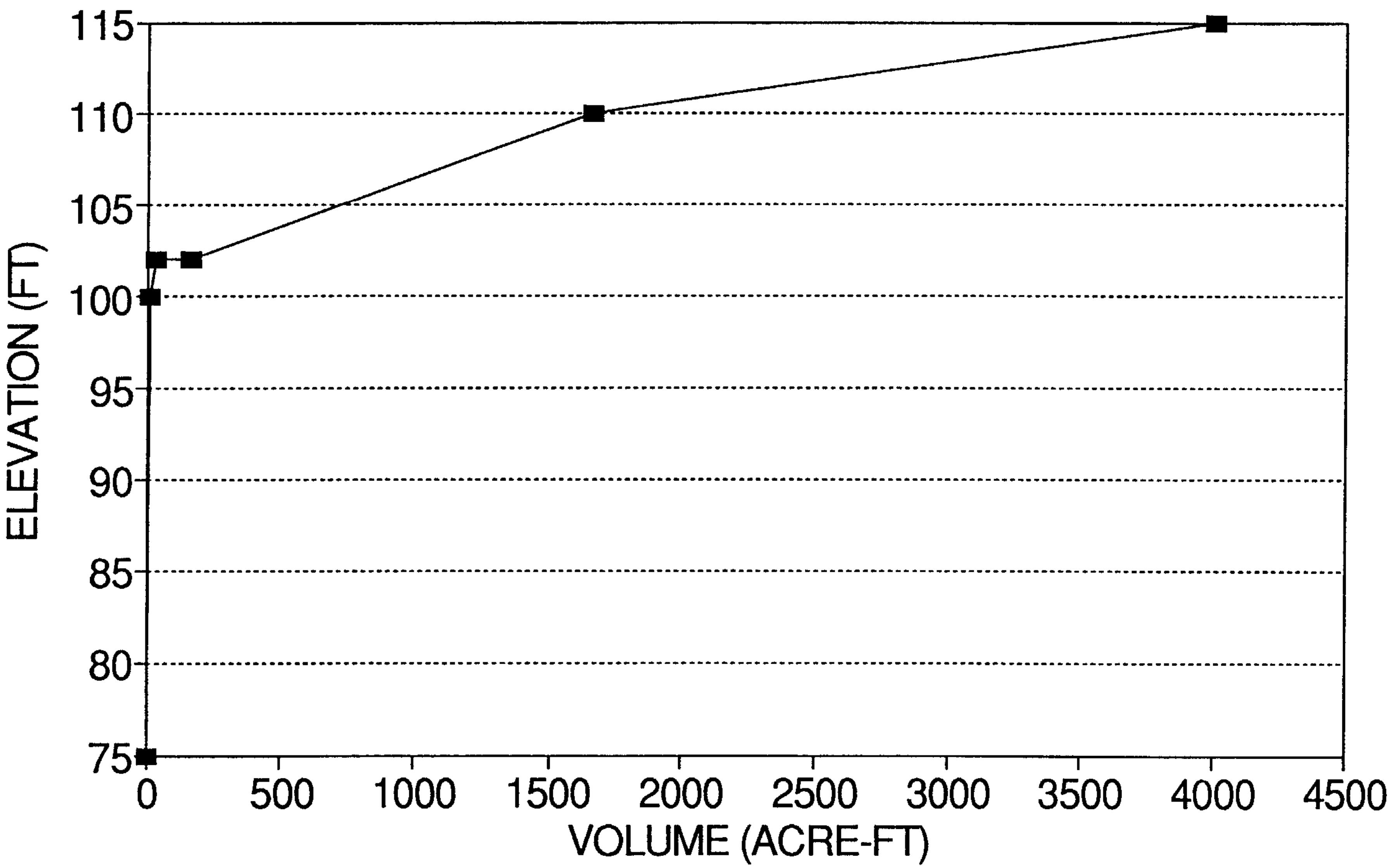
ELEVATION-STORAGE RELATIONSHIP

RIO GRANDE RD TO FM 1016 (25-14)



ELEVATION-STORAGE RELATIONSHIP

FM 1016 TO MISSION INLET (14-7)



Flood Protection Planning Study for Southern McAllen and Mission, Texas

Table 1
Rainfall Depth / Duration for the Hidalgo County Study Area *

Return Period (years)	Point Rainfall Depths (inches) for Hidalgo County Study Area							
	5-min	15-min	60-min	2-hr	3-hour	6-hr	12-hr	24-hr
2-Year	0.50	1.10	2.00	2.60	2.70	3.25	3.70	4.30
5-Year	0.58	1.28	2.57	3.40	3.70	4.40	5.20	6.00
10-Year	0.64	1.42	2.97	3.95	4.30	5.20	6.10	7.10
25-Year	0.74	1.63	3.53	4.60	5.00	6.20	7.20	8.50
50-Year	0.81	1.79	3.97	5.10	5.70	7.00	8.30	9.60
100-Year	0.88	1.95	4.40	5.70	6.30	7.80	9.50	11.00
500-Year	1.7	3.2	5.75	7.25	8.0	9.9	12.0	13.75

* Data taken from Technical Paper No. 40 and Technical Memorandum Hydro-35.

Flood Protection Planning Study for Southern McAllen and Mission, Texas

RESULTS OF BASELINE CONDITIONS

- Computed Peak Flood Discharges at Key Locations
- Flood Elevations for Mission Inlet
- Flood Elevations for Sharyland/Trade Zone
- Single Occurrence Flood Losses
- Peak Storage Requirements
- Sensitivity Analysis

Table 2
Summary of Computed Peak Flood Discharges*
Mission Inlet Floodway Baseline Conditions

Location	Drainage Area (sm)	Computed Peak Flood Discharges			
		10-yr	25-yr	50-yr	100-yr
At Mission Main Canal	12.5	8500	10600	12200	13900
At Mission Inlet	12.5	9600	12200	14200	16400
At FM 1016	16.0	3900	6400	8600	11100
At Rio Grande Rd	22.6	5200	7800	9800	12200
At Shary Rd	23.2	5200	7800	9700	12100
At 23rd Street	64.3	6300	9100	12400	15800
At San Juan Elevated Canal	71.9	5500	8900	12200	16300
At Jackson Road	73.6	5500	9000	12300	16500
Note: Baseline condition peak discharges are based on fully urbanized watershed with existing (1995) topography.					

Table 3
Summary of Computed Peak Flood Discharges*
Major Contributing Ditch Systems Baseline Conditions

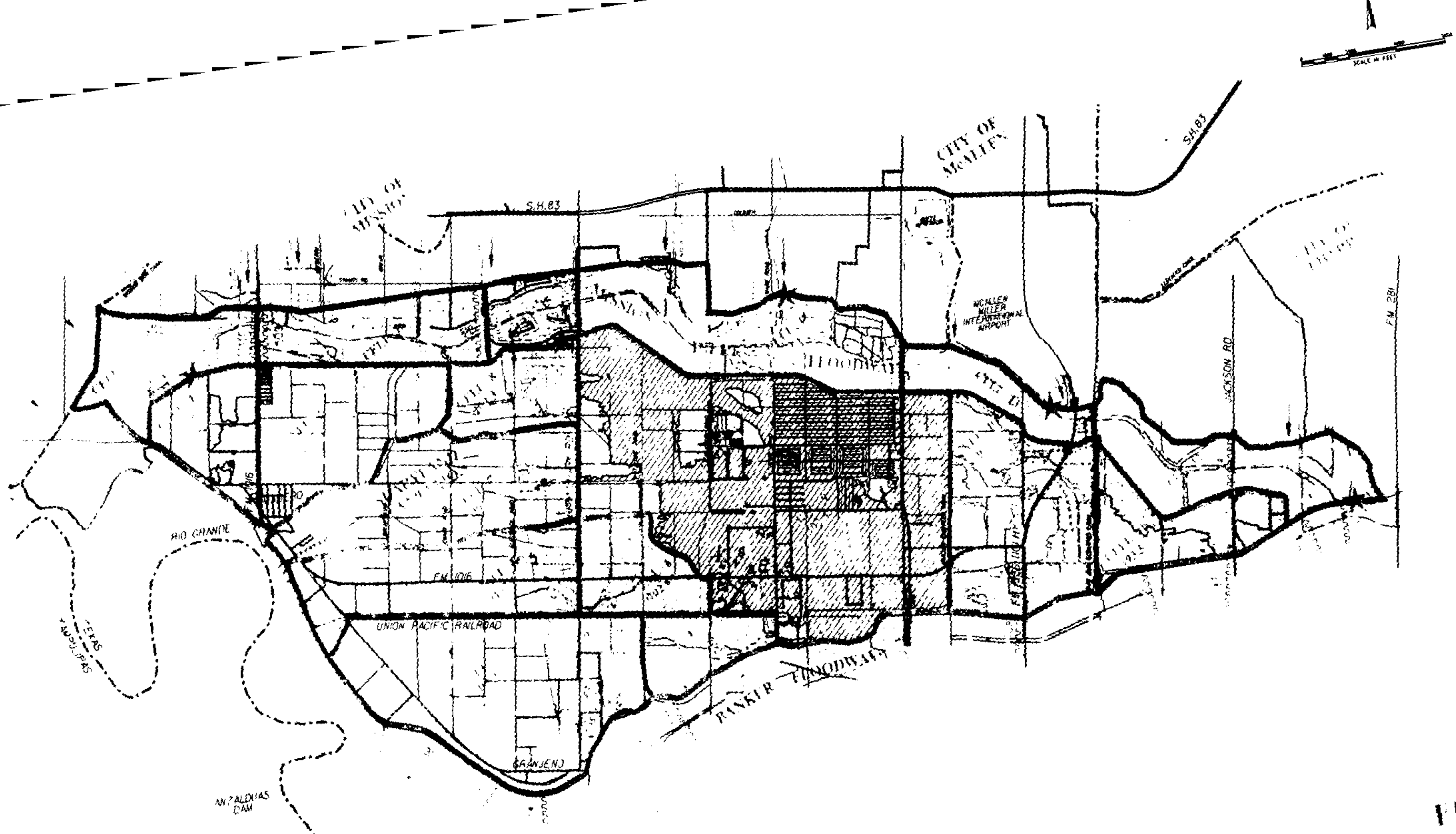
Location	Drainage Area (sm)	Computed Peak Flood Discharges			
		10-yr	25-yr	50-yr	100-yr
Rado Alternate	20.2	1980	2960	3440	4030
Old Rado Alternate	3.0	700	880	1030	1200
23rd Street Ditch	1.5	1730	2130	2430	2750
Airport Sump	0.4	160	170	190	200
Airport Ditch	1.4	740	870	940	1030
Rancho Santa Cruz Ditch	1.5	460	610	730	870

Note: Baseline condition peak discharges are based on fully urbanized watershed with existing (1995) topography.

Table 4
Summary of Computed 100-Year Flood Elevations
Mission Inlet Floodway Baseline Conditions

Location	100-Year Flood Elevation
Cell 12 (Mission Pump to San Juan Canal)	103.9
Cell 13 (San Juan Canal to 23rd St)	104.7
Cell 14 (23rd St to Shary Rd)	105.1
Cell 15 (Shary Rd to Rio Grande Rd)	105.7
Cell 16 (Rio Grande Rd to FM 1016)	106.2
Cell 17 (FM 1016 to Mission Inlet)	111.5

Note: Baseline condition flood elevations are based on fully urbanized watershed with existing (1995) topography.



GENERAL NOTES:

1. TOPOGRAPHY FLOWN MARCH 1995 BY WILLIAM STACKHOUSE, SAN ANTONIO, TX.
2. 100 YEAR PONDING ELEVATIONS BASED ON EXISTING (1995) PLANIMETRICS WITH FUTURE FULLY URBANIZED WATERSHED.
3. BASE FLOOD ELEVATIONS FOR BANKER FLOODWAY ARE BASED ON THE MAXIMUM ALLOWABLE DIVERSION FLOW (Q=106,500 CFS).

LEGEND

BASE FLOOD ELEVATION

100 YEAR FLOOD ELEVATION

★ LEVEE OVERTOPPED BY 100 YEAR FLOOD

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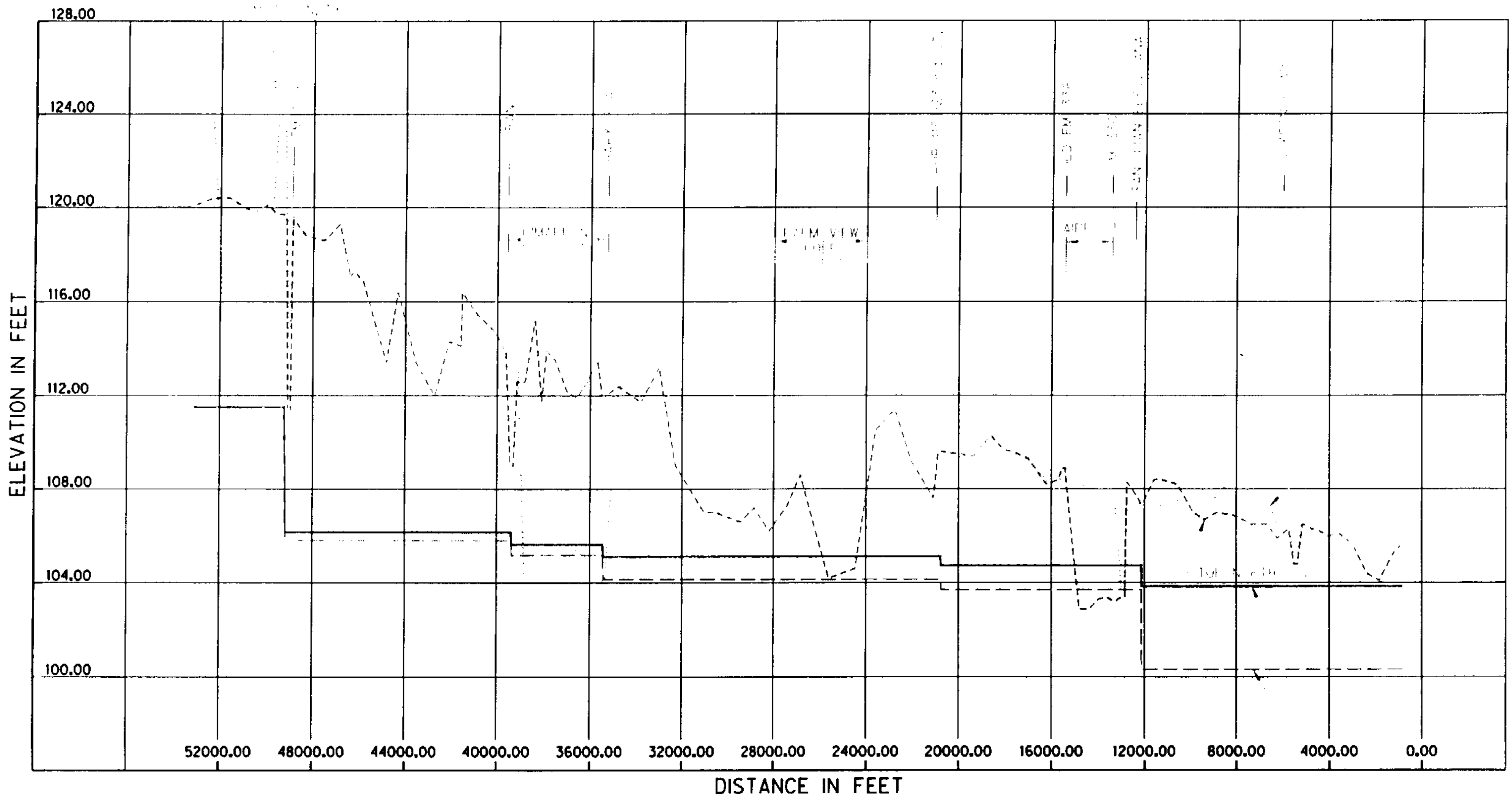
OVERALL FLOODPLAIN MAP

FLOOD PROTECTION PLANNING STUDY FOR SOUTHERN McALLEN AND MISSION, TEXAS

FIGURE 6

CITY OF McALLEN



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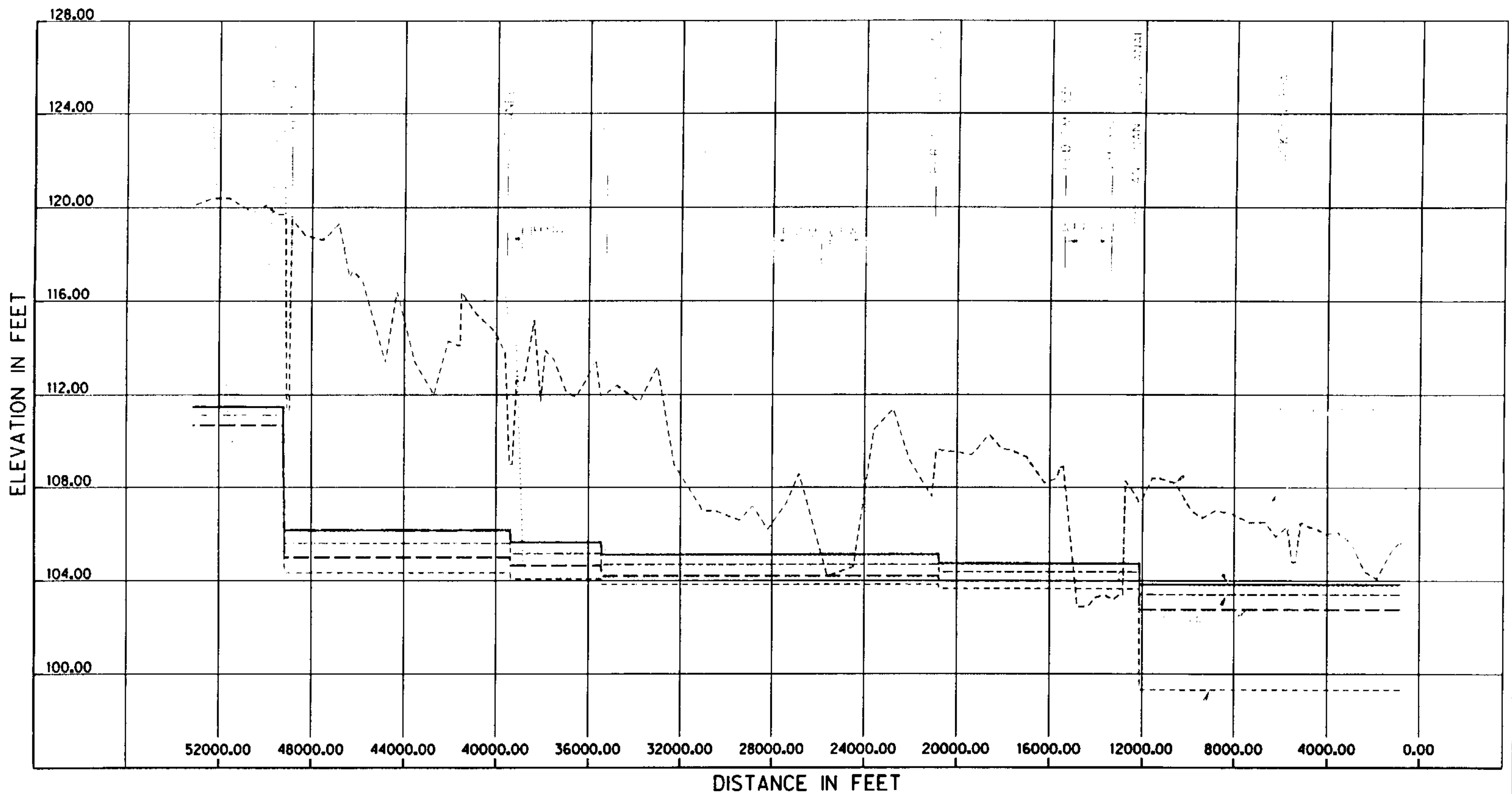
MISSION INLET FLOOD PROFILE
100 YEAR EVENT
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

FIGURE 7

CITY OF McALLEN



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MISSION INLET FLOOD PROFILE
10, 25, 50 AND 100 YEAR EVENTS
FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN McALLEN AND MISSION, TEXAS

FIGURE 8

CITY OF McALLEN

Table 5
Summary of Computed 100-Year Flood Elevations
Sharyland/Trade Zone Baseline Conditions

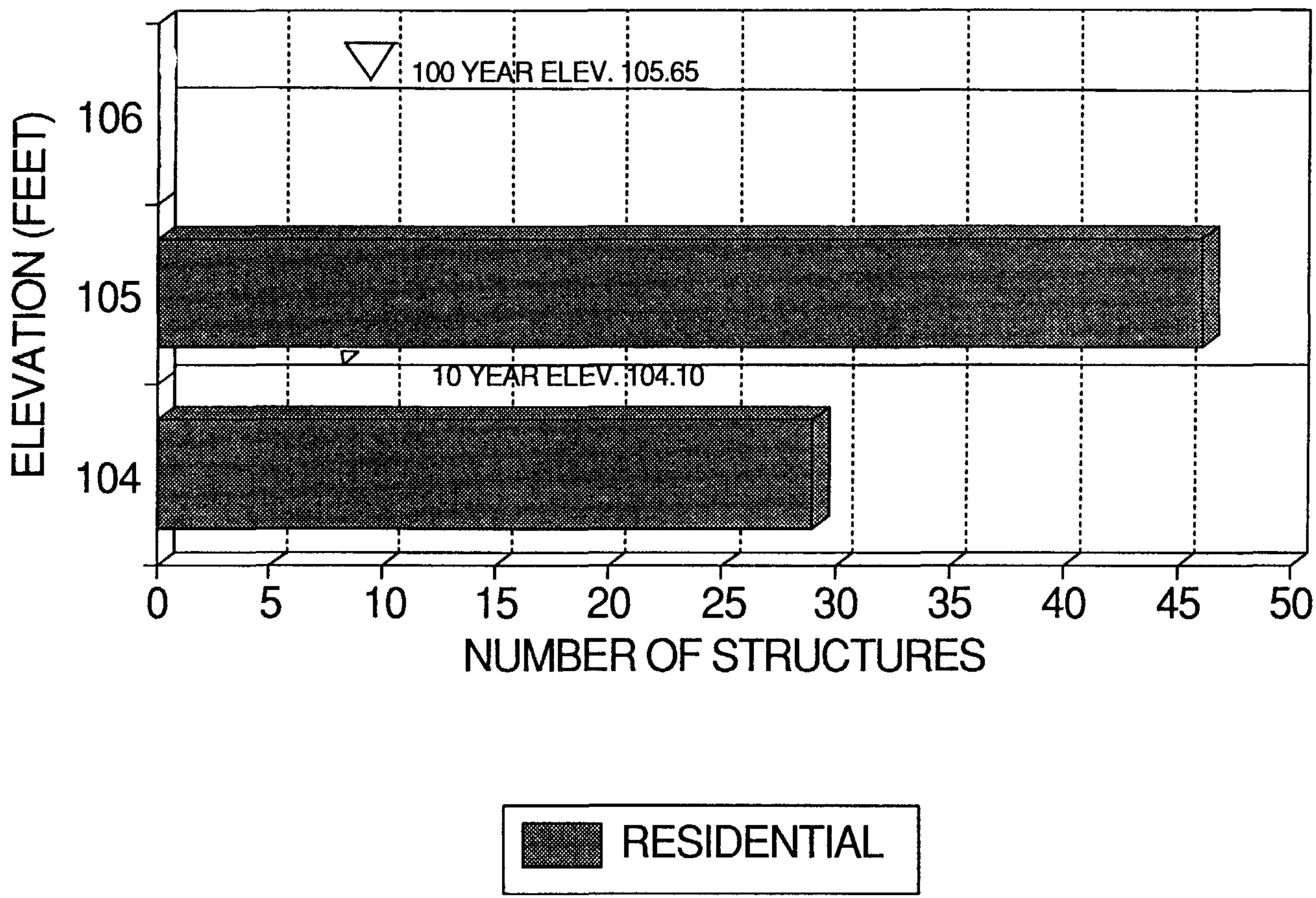
Location	100-Year Peak Flood Elevation
Cell 1	112.1
Cell 2	105.6
Cell 3	106.6
Cell 4	104.6
Cell 5	105.7
Cell 6	102.7
Cell 7	105.4
Cell 8	103.3
Cell 9	102.3
Cell 10	96.7
Cell 11	93.5

Note: Baseline condition flood elevations are based on fully urbanized watershed with existing (1995) topography.

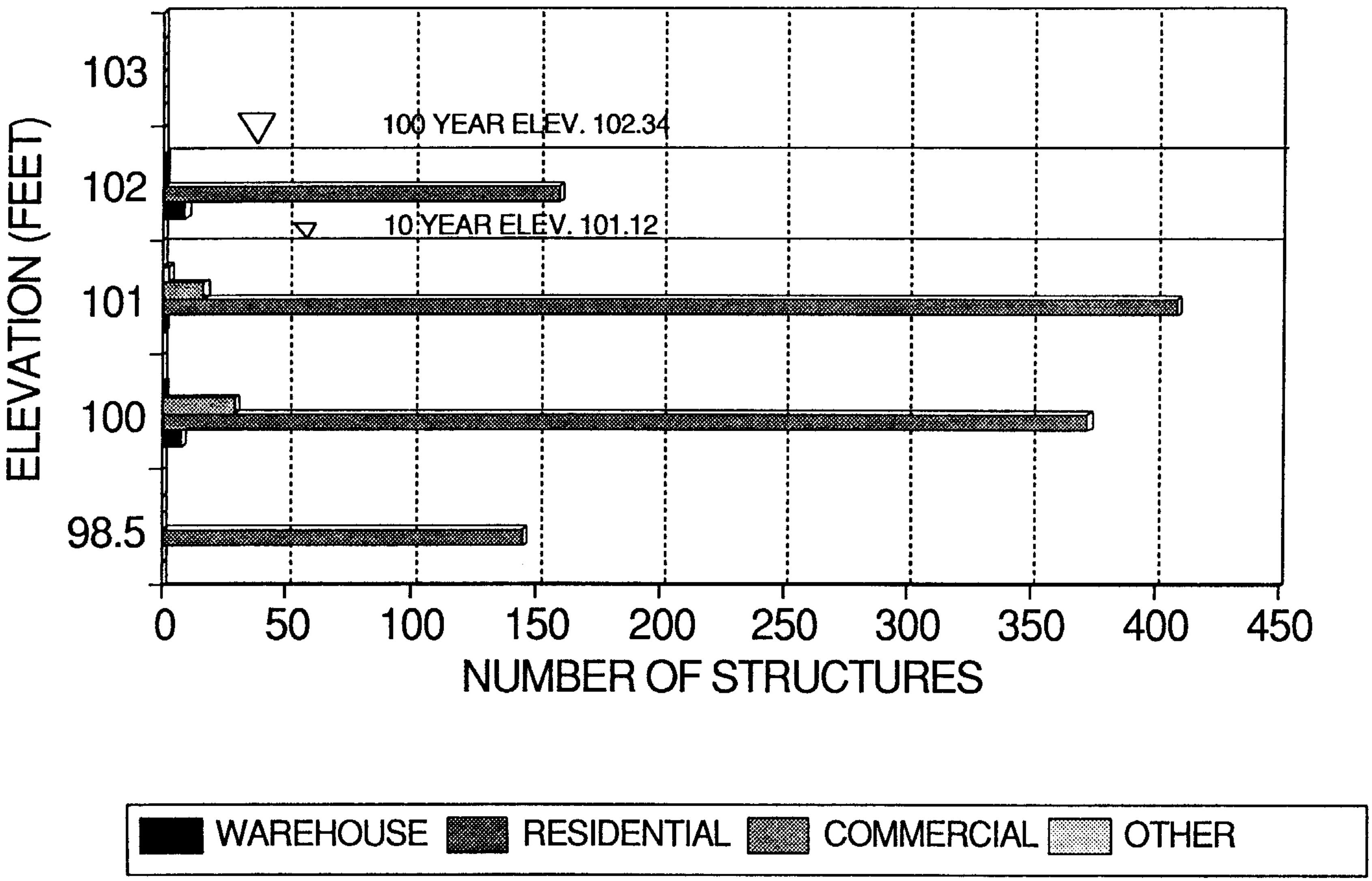
Table 6 - Summary of Baseline Condition 100 Year Single Occurrence Flood Losses

Location	Total Flood Plain Acres	Cropland Flood Plain Acres	Number of Structures in Flood Zone			
			Residential	Warehouse	Commercial	Other
Mission Inlet	2590	N/A	75	0	0	0
Cell 1	118	118	0	0	0	0
Cell 2	110	110	0	0	0	0
Cell 3	298	298	0	0	0	0
Cell 4	158	150	0	0	0	0
Cell 5	67	67	0	0	0	0
Cell 6	181	181	0	0	0	0
Cell 7	195	195	0	0	0	0
Cell 8	152	115	0	0	0	0
Cell 9	2715	1079	1085	18	47	5
Cell 10	540	365	0	0	0	0
Cell 11	238	120	6	0	0	0
Total	**7362**	**2798**	**1166**	**18**	**47**	**5**

SINGLE OCCURRENCE FLOOD LOSSES
MISSION INLET (CIMARRON)



SINGLE OCCURRENCE FLOOD LOSSES
CELL 9



SINGLE OCCURRENCE FLOOD LOSSES

CELL 11

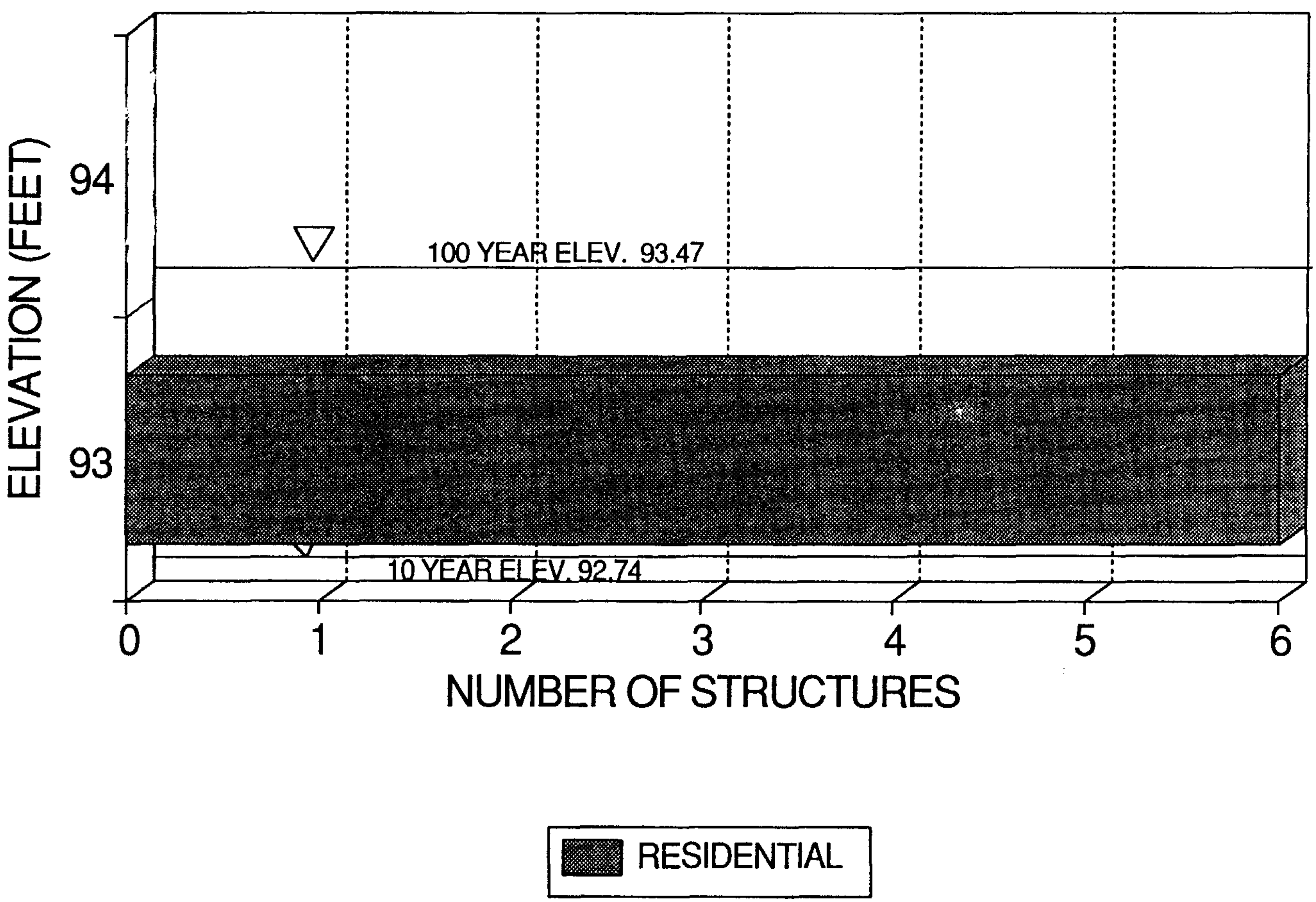


Table 7
Summary of 100-Year Peak Storage Requirement
For Sharyland/Trade Zone Baseline Conditions

100-YEAR PEAK STORAGE REQUIREMENT				
DRAINAGE AREA	AREA (sm)	AREA (ac)	PEAK STORAGE (ac-ft)	STORAGE/ACRE (ac-ft/ac)
Cell 1	0.67	429	317	0.74
Cell 2	1.26	806	589	0.73
Cell 3	2.36	1510	1249	0.83
Cell 4	0.69	442	364	0.82
Cell 5	1.06	678	555	0.82
Cell 6	0.58	371	311	0.83
Cell 7	1.83	1172	916	0.78
Cell 8	0.59	378	293	0.78
Cell 9	4.80	3072	2491	0.81
Cell 10	1.59	1018	835	0.82
Cell 11	0.75	480	383	0.80

Note: Baseline condition flood elevations are based on fully urbanized watershed with existing (1995) topography.

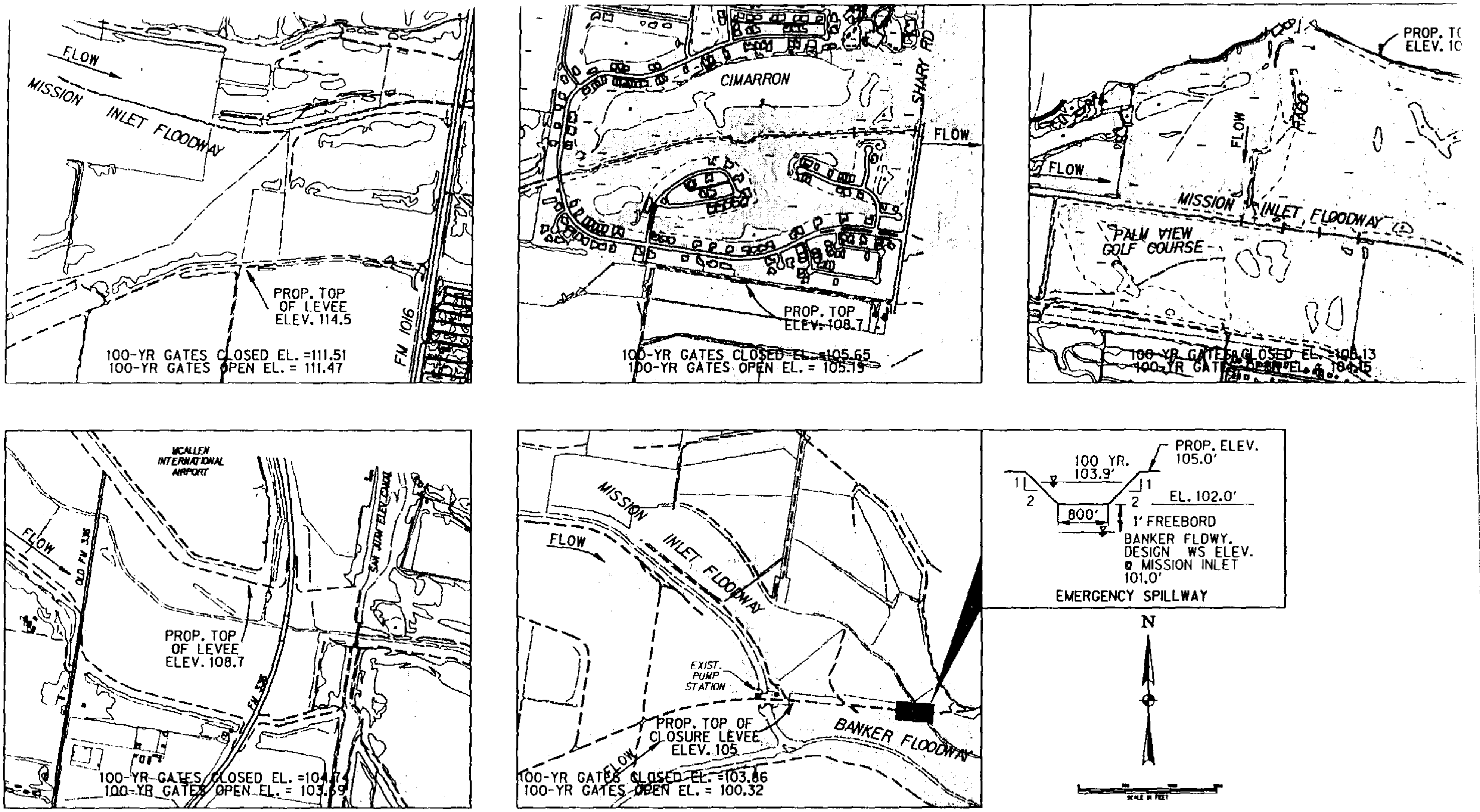
Table 8 - Sensitivity Analysis Summary

Scenario Tested	Results
Gates Open at Mission Inlet Pump Station	• 100-yr elevation at Pump Station decreased from 103.8' to 100.3' • 100-yr elevation at Shary Rd decreased from 105.7' to 105.2'
Mission Inlet Pumps in Operation	• No significant differences from baseline conditions.
Adjust Loss Rates to 1" for Agricultural Areas and 0" for Urban Areas	• 100-yr elevation at Pump Station decreased from 103.8' to 103.7' • 100-yr peak discharge decreases 6-14% throughout floodway.
Drainage from Edinburg-Mission Lateral System Excluded	• 100-yr elevation at Pump Station decreased from 103.8' to 102.8' • 100-yr peak discharge at confluence node decreased from 15,760 cfs to 9,520 cfs (40%).
Note: All scenarios compared to Baseline Conditions, fully urbanized watershed with existing (1995) topography.	

Flood Protection Planning Study for Southern McAllen and Mission, Texas

CONCEPTUAL DESIGN SOLUTIONS

- Mission Inlet Levee Modifications
- Mission Inlet Relief Spillway
- Proposed Flood Storage Sump Area Locations



PROPOSED LEVEE MODIFICATIONS
MISSION INLET FLOODWAY

FLOOD PROTECTION PLANNING STUDY
FOR SOUTHERN MCALLEN AND MISSION, TEXAS

FIGURE 9

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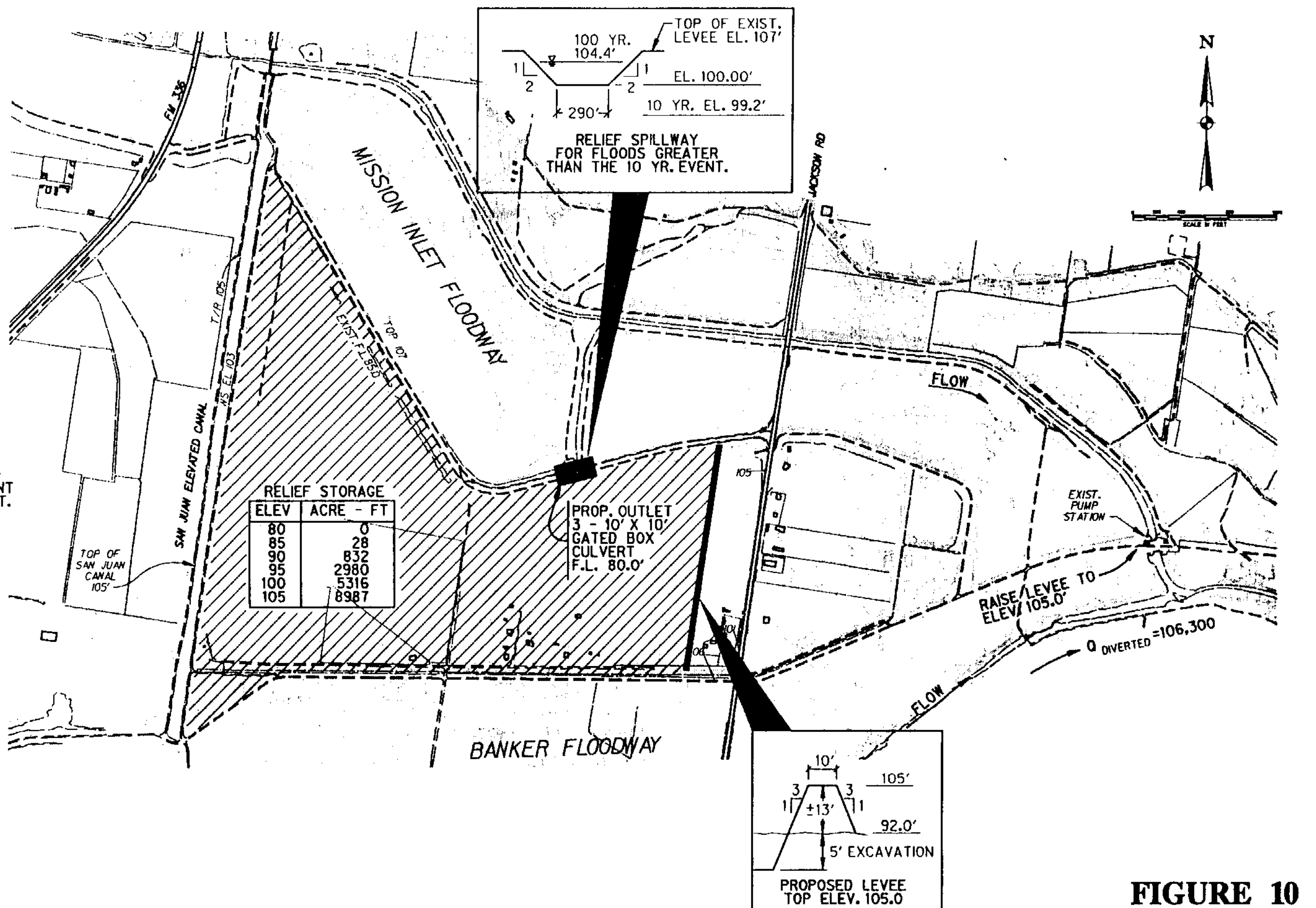
CITY OF McALLEN

NOTE:

FOR 'GATE CLOSED' SCENARIO
ADDITIONAL STORAGE REQUIRED:
7050 ac. ft. FOR 100 YR. EVENT
3830 ac. ft. FOR 50 YR. EVENT.



RELIEF STORAGE

ELEV	ACRE - FT
80	0
85	28
90	832
95	2980
100	5316
105	8987

FIGURE 10

STORAGE REQUIREMENT FOR 100 YR GATES CLOSED SCENARIO

FLOOD PROTECTION PLANNING STUDY FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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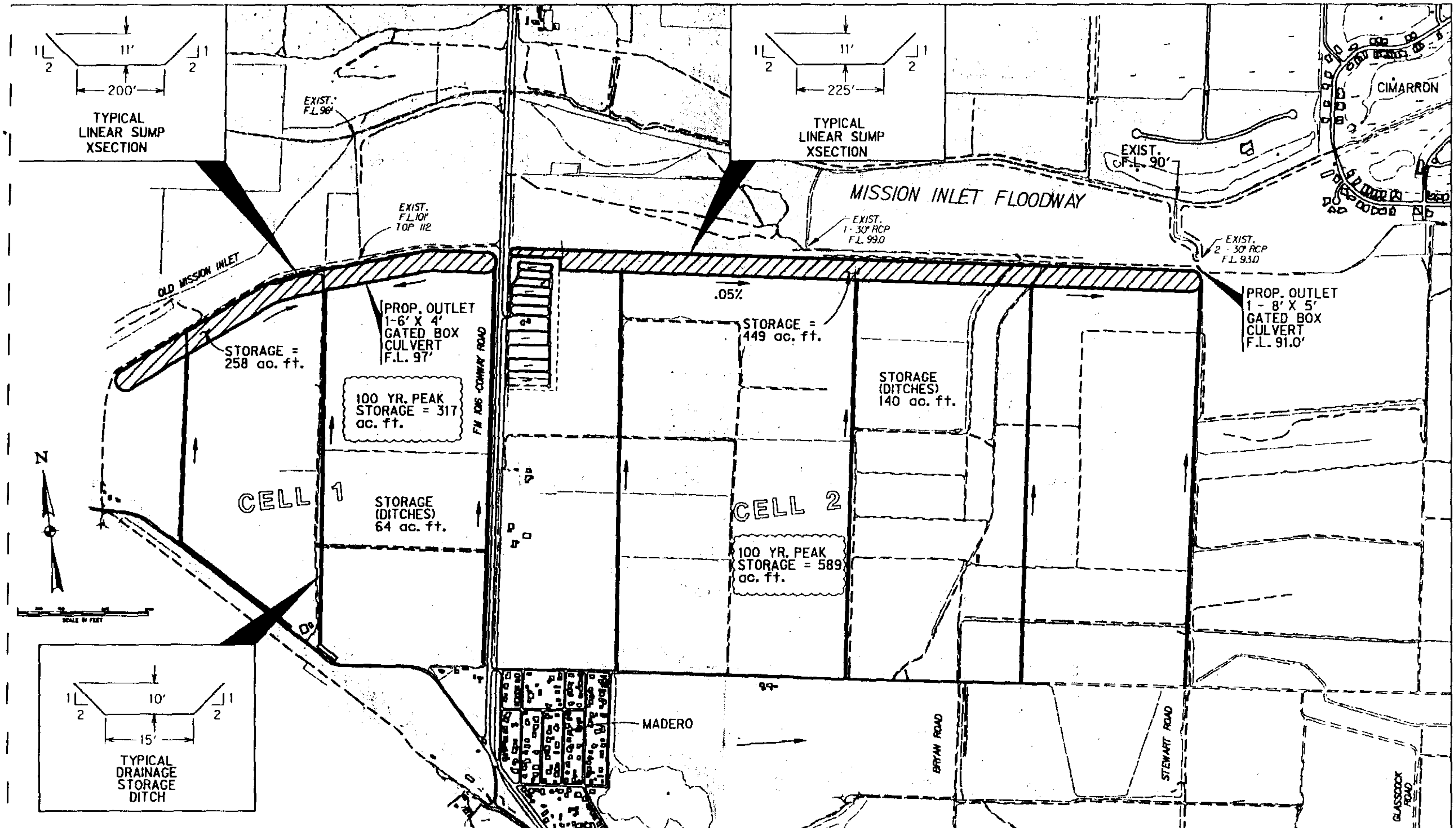
CELIIN2.DGN



PROPOSED DRAINAGE IMPROVEMENT FOR CELLS 1 & 2

FLOOD PROTECTION PLANNING STUDY
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FIGURE 11

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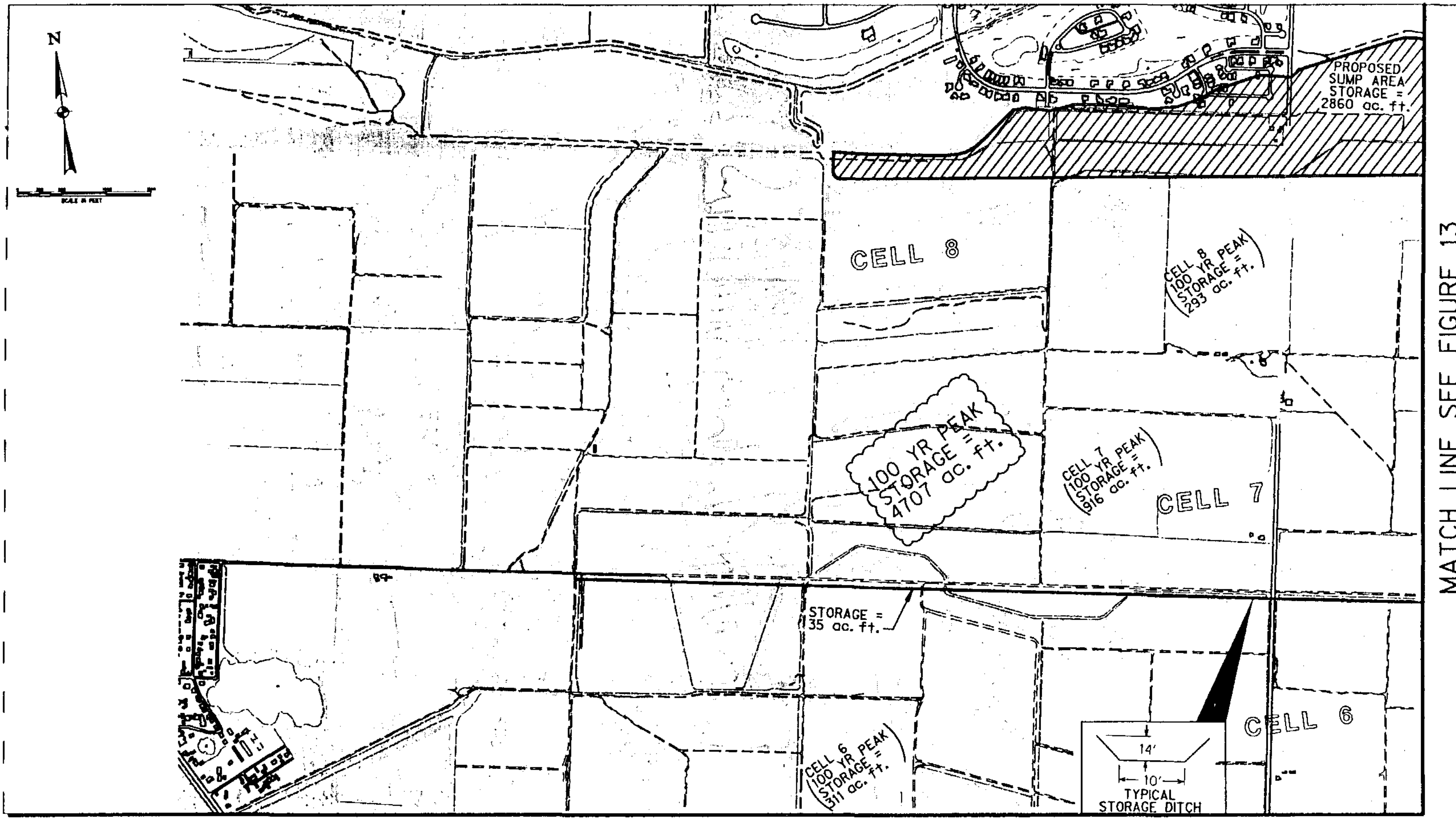

MATCH LINE SEE FIGURE 14

FIGURE 12

PROPOSED DRAINAGE IMPROVEMENT FOR CELLS 3 – 9
SHEET 1 OF 4

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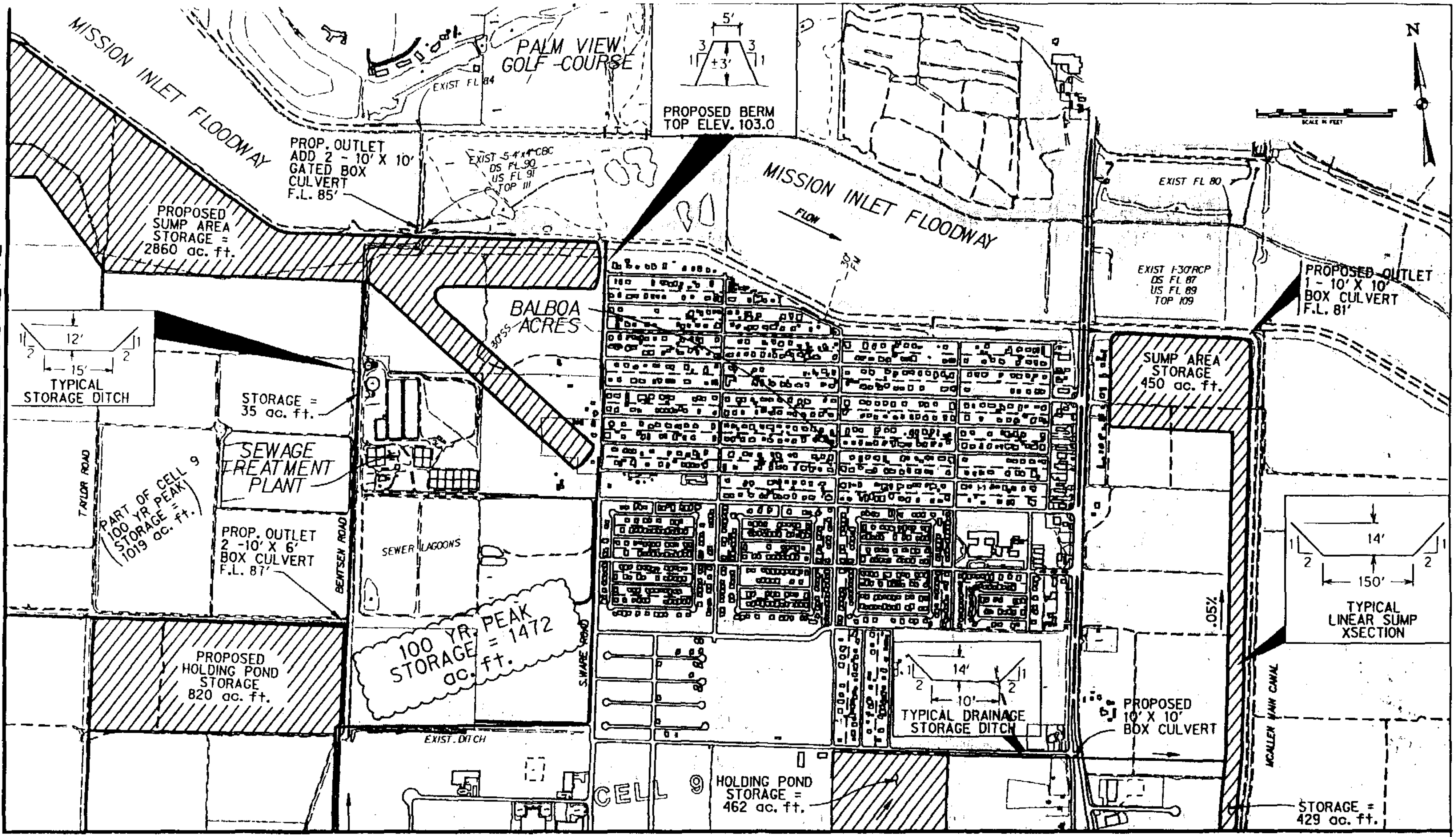

MATCH LINE SEE FIGURE 15

FIGURE 13

PROPOSED DRAINAGE IMPROVEMENT FOR CELLS 3 – 9
SHEET 2 OF 4
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FOR SOUTHERN MCALLEN AND MISSION, TEXAS

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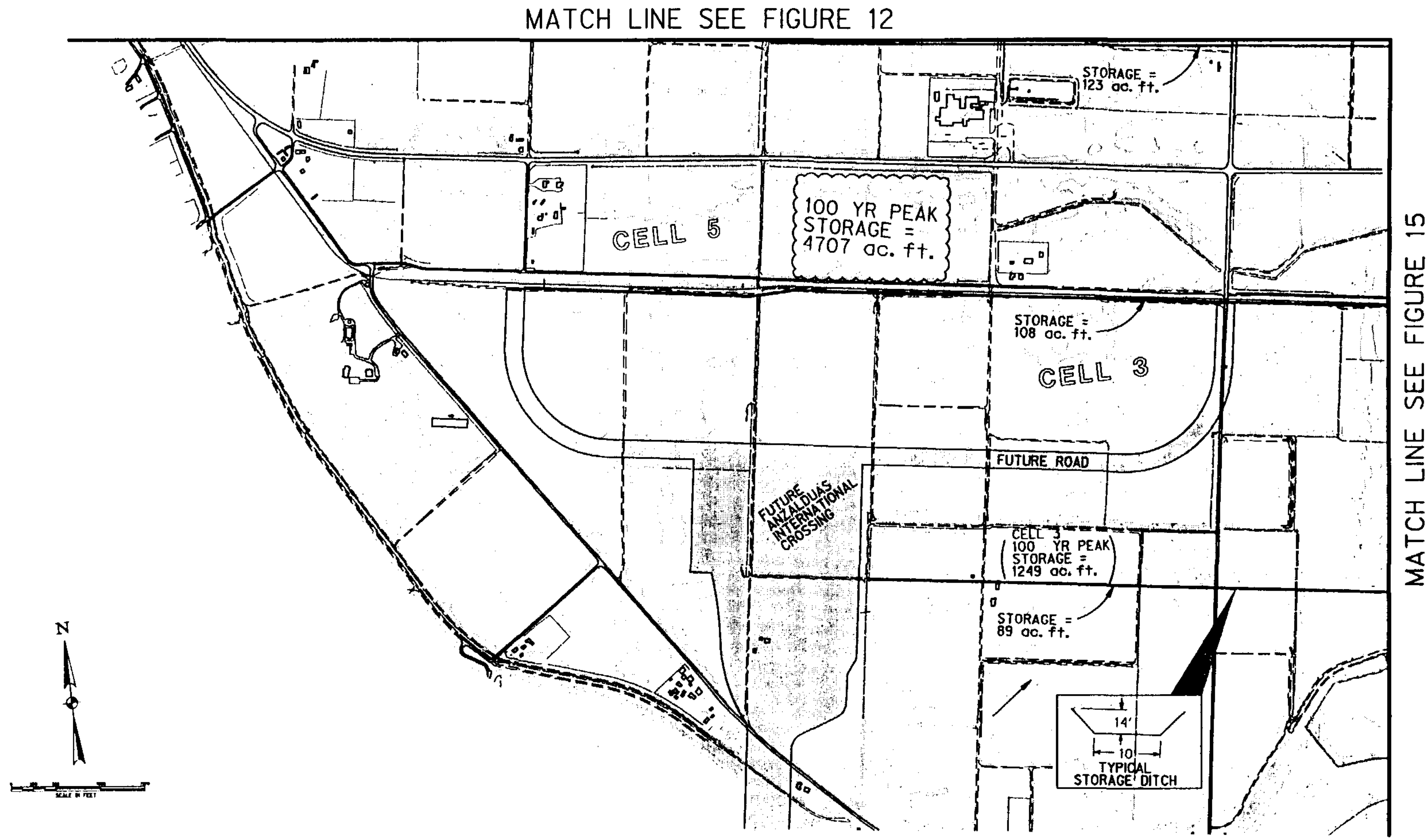

PROPOSED DRAINAGE IMPROVEMENT FOR CELLS 3-9
SHEET 3 OF 4

FLOOD PROTECTION PLANNING STUDY
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FIGURE 14

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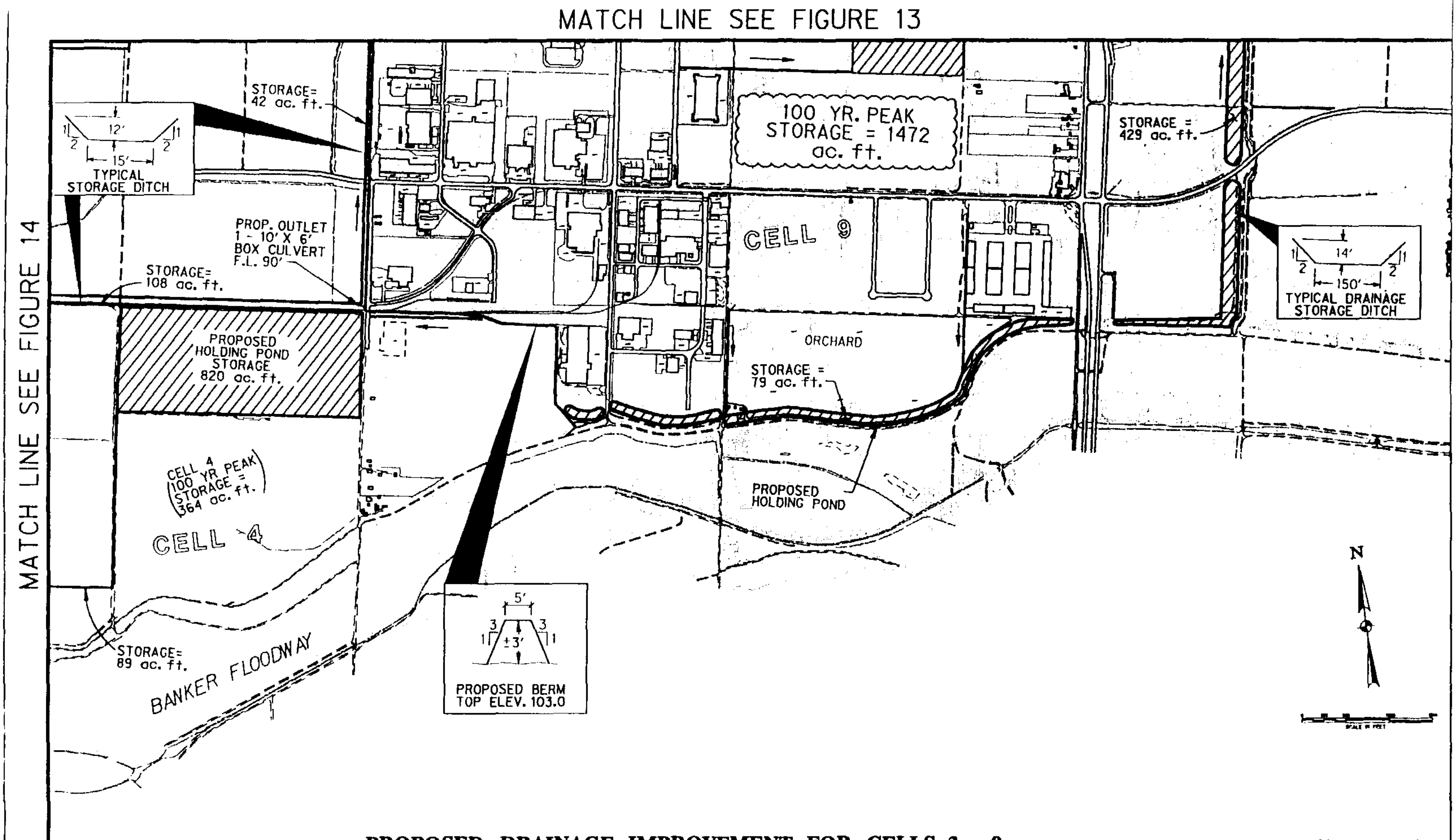

PROPOSED DRAINAGE IMPROVEMENT FOR CELLS 3 - 9
SHEET 4 OF 4

FLOOD PROTECTION PLANNING STUDY
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FIGURE 15

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Flood Protection Planning Study for Southern McAllen and Mission, Texas

SUMMARY OF FINDINGS

- The computed 100-year flood (with gates closed) will overtop Mission Inlet levee at five locations.
- The computed 100-year flood (with gates open) will overtop Mission Inlet levee at three locations.
- The estimated average freeboard at the Banker Floodway (for 106,300 cfs) is about 2 feet.
- Appproximately 1236 structures are inundated by the computed 100-year flood.
- The required flood storage required to provide flood relief for structures located in Balboa Acres and the Trade Zone is about 1470 acre-feet.