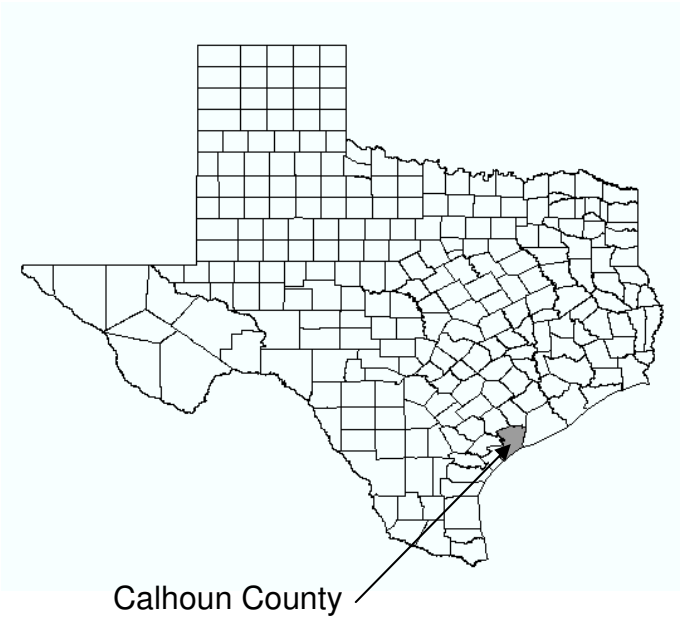
FLOOD INSURANCE STUDY

CALHOUN COUNTY, TEXAS

AND INCORPORATED AREAS

VOLUME 1 of 3

Community Name	Community Number
CALHOUN COUNTY (UNINCORPORATED AREAS)	480097
POINT COMFORT, CITY OF	480098
PORT LAVACA, CITY OF	480099
SEADRIFT, CITY OF	480100



PRELIMINARY
JUNE 17, 2016

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
48057CV001B

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

This preliminary revised Flood Insurance Study contains profiles presented at a reduced scale to minimize reproduction costs. All profiles will be included and printed at full scale in the final published report.

Part or all of this Flood Insurance Study may be revised and republished at any time. In addition, part of this Flood Insurance Study may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the Flood Insurance Study. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current Flood Insurance Study components.

Initial Countywide FIS Effective Date: October 16, 2014
Revised Countywide FIS Dates:

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FLOOD INSURANCE STUDY
CALHOUN COUNTY, TEXAS AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Calhoun County, Texas; including the Cities of Point Comfort, Port Lavaca, and Seadrift; and the unincorporated areas of Calhoun County (referred to collectively herein as Calhoun County); and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence, and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this FIS report are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

Pre-countywide Studies

Calhoun County

The hydrologic and hydraulic analyses for the previous FIS were performed by Espey, Huston & Associates, Inc, for the Federal Emergency Management Agency (FEMA), under Contract No. 4786. That study was completed in March 1981 (Reference 1).

City of Point Comfort

The hydrologic and hydraulic analyses for the previous FIS were performed by Espey, Huston & Associates, Inc, for FEMA, under Contract No. 4786. That study was completed in March 1981 (Reference 2).

City of Port Lavaca

The hydrologic and hydraulic analyses for the previous FIS were performed by Espey, Huston & Associates, Inc, for FEMA, under Contract No. 4786. That study was completed in August 1983 (Reference 3).

City of Seadrift

The hydrologic and hydraulic analyses for the previous FIS were performed by Espey, Huston & Associates, Inc, for FEMA, under Contract No. 4786. That study was completed in August 1983 (Reference 4).

Countywide Study

For the October 16, 2014 initial countywide FIS, hydrologic analysis for the Guadalupe River was computed by the U.S. Geological Survey (USGS), Water Resources Division. That study was completed in October 2006. A new detailed hydraulic study of the Guadalupe River was prepared for FEMA by Halff Associates, Inc., under Contract No. EMT-2002-CO-0051. That study was completed in August 2008.

For this map revision, as part of the Levee Analysis and Mapping Procedure (LAMP) for the Victoria Barge Canal Levee and Guadalupe River was prepared for FEMA by RAMPP, under FEMA IDIQ Contract No. HSFEHQ-09-D-0369. The Victoria Barge Canal Levee study was completed on September 30, 2014.

Base map information shown on this FIRM was provided in a digital format by the Texas Natural Resources Information System (TNRIS). This information was photogrammetrically compiled at a scale of at least 1:24,000 from aerial photography dated 2004. The projection used in the preparation of this map is Texas State Plane South Central Zone (FIPS Zone 4204). The horizontal datum used is NAD 83. Differences in the datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent counties may result in slight positional differences in map features at the county boundaries. These differences do not affect the accuracy of information show on the FIRM.

1.3 Coordination

Consultation Coordination Officer's (CCO) meetings may be held for each jurisdiction in this countywide FIS. An initial CCO meeting is held typically with representatives of FEMA, the community, and the study contractor to explain the nature and purpose of a FIS, and to identify the streams to be studied by detailed methods. A final CCO meeting is held typically with representatives of FEMA, the community, and the study contractor to review the results of the study.

Pre-countywide Studies

The dates of the initial and final CCO meetings held for Calhoun County and the incorporated communities within its boundaries are shown in Table 1, "Initial and Final CCO Meetings." The information in Table 1 only provides information for CCO meetings held prior to the October 16, 2014 countywide study.

Table 1 – INITIAL AND FINAL CCO MEETINGS

Community	Initial CCO Date	Final CCO Date
Calhoun County (Unincorporated Areas)	*	*
Point Comfort, City of	May 15, 1978	December 4, 1981
Port Lavaca, City of	May 2, 1978	March 15, 1984
Seadrift, City of	May 2, 1978	March 14, 1984

*Data not available

The initial CCO meetings were held with representatives from FEMA, the communities, and the study contractors to explain the nature and purpose of FIS reports, and to identify the streams to be studied by detailed methods. The final CCO meetings were held with representatives from FEMA, the communities and the study contractors to review the results of the studies.

Countywide Study

The initial Consultation Coordination Officer (CCO) meeting for the October 16, 2014 initial countywide FIS was held on April 11, 2006, and attended by representatives of FEMA, Calhoun County, the City of Port Lavaca, Guadalupe-Blanco River Authority (GBRA), Texas Department of Transportation (TxDOT), and Halff Associates, Inc.

The results of the October 16, 2014 study were reviewed at the final CCO meeting held on February 12, 2013, and attended by representatives of FEMA, RAMPP, Calhoun County, the Texas Water Development Board, and the Cities of Port Lavaca, Seadrift, and Point Comfort. All problems raised at that meeting have been addressed in this study.

This revisions initial Consultation Coordination Officer (CCO) meeting was held on November 4, 2014, and attended by representatives of FEMA, RAMPP, and Calhoun County.

The results of this revisions study were reviewed at the final CCO meeting held on _____ and attended by_____.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS report covers the geographic area of Calhoun County, Texas, including the incorporated communities listed in Section 1.1.

Pre-countywide Studies

For the original City of Port Lavaca and City of Seadrift studies, analyses included coastline flooding due to hurricane-induced storm surge. Both the open coast and its inland propagation were studied; in addition, the effects of wave heights were also considered. Areas studied by detailed methods were selected with priority given to all

known flood hazard areas, and areas of projected development or proposed construction through August 1988.

For the City of Point Comfort FIS dated April 15, 1982, areas studied by detailed methods were selected with priority given to all known flood hazard area, and areas of projected development or proposed construction through December 1983.

Countywide Study

The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development or proposed construction through December 2011.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon, by FEMA and community officials.

The flooding sources studied by detailed methods along with the limits of study are shown in Table 2, "Scope of Study."

Table 2 – Scope of Study
Stream Reaches Studied by Detailed Methods

Stream Name	Downstream Limit	Upstream Limit	Length (mi)
New Detailed Study Streams			
Guadalupe River	Approximately 770 feet downstream of State Highway 35	Calhoun County/ Victoria County boundary	12.23
Guadalupe River	Approximately 2.28 miles downstream of State Highway 35	Approximately 770 feet downstream of State Highway 35	2.13
Redelineated Detailed Study Streams			
Little Chocolate Bayou	Approximately 50 feet downstream of State Highway 238	Approximately 160 feet upstream of Southern Pacific Railroad	2.12
Lynn Bayou	Approximately 1,200 feet downstream of State Highway 35	Approximately 1,100 feet upstream of Oakglen Drive	1.10
Seadrift Stream B	Approximately 115 feet downstream of Baltimore Avenue	Approximately 1.24 miles upstream of State Highway 185	1.68

2.2 Community Description

Calhoun County is located along the Texas Gulf Coast extending from the western tip of Matagorda Peninsula to the western shore of San Antonio Bay. The north central portion of the county, near the county seat of Port Lavaca, is approximately 26 miles southeast of the City of Victoria and 82 miles northeast of the City of Corpus Christi. The county is surrounded by Matagorda County to the east, Jackson County to the north, Victoria County to the northwest, Refugio County to the west, and Aransas County to the southwest (Reference 1).

The topography of Calhoun County is generally flat with elevation ranging from mean sea level to approximately 55 feet above North American Vertical Datum of 1988 (NAVD). Ninety percent of Calhoun County lies below 30 feet above mean sea level. (References 1 and 5). The county lies within the Gulf Coast Prairies vegetation area where the predominant vegetation is prairie grasses, tidal grasses, and scattered stands of mesquite and live oak (References 1 and 5).

According to U.S. Census 2010 figures, the population of Calhoun County was 21,381. This represents an increase in population of 3.1 percent since the 2000 census (Reference 6). The U.S. Census 2010 population for the three incorporated communities in the county are as follows: City of Point Comfort (737), City of Port Lavaca (12,248), and City of Seadrift (1,454) (Reference 7).

The chief enterprises in the county are farming and industry. Main crops include cotton, grain sorghum, and corn. Several large ranches raise beef cattle. The majority of the economy is based on aluminum manufacturing, plastics plants, marine construction, agribusinesses, petroleum, tourism, and fish processing. The Intracoastal Waterway, the Victoria Barge Canal, and the deep water channel to the City of Point Comfort provide water transportation within the county (References 5 and 8).

Calhoun County experiences a humid subtropical climate with warm summers. The annual average rainfall for Calhoun County is 34.78 inches although yearly totals may vary widely due to the passage of intermittent tropical storms. The wettest month is September with 4.97 inches. The driest month is April having an average rainfall of 1.55 inches. The hottest month of the year is July having an average temperature of 88 degrees Fahrenheit (^{o}F). The coldest month of the year is in January having an average temperature of 48°F (References 5 and 8).

2.3 Principal Flood Problems

Calhoun County has sustained moderate to heavy flooding from several hurricanes striking the Texas Gulf Coast. The amount of tidal surge generated for any given storm or hurricane is dependent on the storm's characteristics and location (References 1 and 2).

The mouth of the Lavaca River, which forms the headwaters of the Navidad River system, is approximately 3 miles northwest of the City of Point Comfort. The Lavaca River has its outfall directly into Lavaca Bay, which opens in turn into Matagorda Bay. Local residents report that prior to 1980 there had never been any flooding problems associated with the City of Point Comfort's proximity to the Lavaca River (Reference 2).

In the City of Point Comfort, there are no large natural streams or swales. Natural drainage flows from east to west and enters the bay at the edge of the coastal cliffs. Although the city is located on the edge of a bay with outfall into the Gulf of Mexico, coastal flooding from storm induced tidal surge has not been a major problem in the past. (Reference 2).

High tidal surges that accompany tropical storms common to the Gulf of Mexico can cause backwater flooding problems within the City of Port Lavaca along Lynn Bayou and Little Chocolate Bayou when streamflow is high. Vegetation within the downstream portions of Lynn Bayou, near the wastewater treatment plant, has also caused flooding problems in the past. Subsequent stream overbank and street flooding has occurred along Holiday Lane and Brookhollow Drive in the Brookhollow subdivision located north of State Highway 35 (Reference 3).

In the City of Port Lavaca, the Bonorden residential addition, which is located northeast of and adjacent to the intersection of U.S. Highway 87 and the Southern Pacific Railroad, and those neighborhoods south of the railroad tracks and east of Alcoa Drive have experienced street and yard flooding during intense rainfall events (Reference 3).

In the City of Port Lavaca, Corporation Ditch, beginning near Tilley Street and following Half League Road and the railroad tracks to an outfall on Lavaca Bay, was lined with concrete in the late 1960's to provide more efficient drainage. However, ponding and street flooding persisted in these south central neighborhoods until additional storm sewer pipes were installed in 1972 and 1973 to convey the surface runoff to Corporation Ditch more effectively. Street flooding was also a major problem near the intersection of Fifth and Jackson Streets in the south of the City of Port Lavaca until drainage conduits were installed in the 1980's and the Shofner drainage conduit capacity was expanded (Reference 3).

Even though the City of Seadrift is located on the edge of a large bay with outfall to the Gulf of Mexico, coastal flooding from storm induced tidal surge has not been a major problem in the past. The mouth of the Guadalupe River with outfall into Guadalupe Bay and then into San Antonio Bay is approximately 5 miles northwest of the City of Seadrift. Local residents report that prior to the early 1980's there had never been any flooding problems associated with this river. An unnamed stream enters the northeastern section of the city near Powers Street and empties into San Antonio Bay at the foot of Main and Pine Streets. Local residents report that no riverine flooding had occurred in the City of Seadrift in connection with this watercourse prior to the early 1980's. No additional reporting by local residents regarding flooding in the City of Seadrift was found (Reference 4).

Brief descriptions of several significant storms provide historic information to which coastal flood hazards and the projected flood depths can be compared (Reference 1).

<u>1919 Storm (September 2 - 15, 1919).</u> This storm was first noticed in the tropical storm stage in the extreme eastern portion of the Caribbean Sea. It was moving in a generally northwesterly direction toward the eastern portion of the Dominican Republic. From there it moved into the Atlantic Ocean before turning to a more westerly course, passed between the tip of Florida and Cuba, and entered the Gulf on a generally westerly course before striking the Texas Coast in the vicinity of

Baffin Bay. The eye of the storm moved inland over the City of Kingsville and then turned west-northwestward towards the City of Laredo.

Prior to Hurricane Carla (1961), the 1919 Storm was considered the largest known hurricane to strike the Texas Coast. Based on observations from various locations along the coast, the 1919 Storm mass had an unusually large diameter as did Carla. Inadequate data for the 1919 Storm prevents conclusive comparisons between the big storms.

Maximum sustained wind velocity recorded at the City of Corpus Christi was 80 miles per hour. Surge elevations of up to 16 feet were recorded as the storm surge swept across the barrier islands and through the passes, piling water upon the landward shores of Corpus Christi and Nueces Bays. Highest recorded surge elevations along the coast were approximately 11.1 feet. Surges of 6.6 feet or greater were experienced along almost the entire Texas Coast. The storm left 350 people dead and the damages exceeded $20 million (References 1 and 9).

1942 Storm (August 21-31, 1942). This was the second storm in two weeks to hit the Texas Coast. The first, a much smaller storm, crossed the coastline on Bolivar Peninsula just east of Galveston Island. However, the second storm was much more severe and larger in area. This storm was first discovered in the extreme western portion of the Atlantic near the Windward Islands on August 21. It gained strength as it proceeded across the Caribbean Sea on a west-northwesterly course and was classified as a hurricane on August 24. It continued along the same course, striking the Yucatan Peninsula on August 27, and moved into the Gulf of Mexico. The storm continued on a direct course toward the mid-Texas Coast and San Antonio Bay. The eye of the storm moved across Matagorda Island on August 30 and passed over the City of Seadrift as it moved inland. The peak hurricane surges recorded on the open coast were 11.8 feet at the City of Freeport, 6.2 feet at the City of Galveston, 5.0 feet at the Town of High Island, 3.4 feet at the City of Port Aransas, and 5.5 feet at the Town of Sabine. Corpus Christi Bay had maximum tides of about 2 feet and a depressed tide of -1.4 feet as the winds shifted and blew gulfward across the bay. This big storm killed eight people, resulted in approximately $11.5 million in property damages, and caused an additional $15 million in crop damage (Reference 4).

1945 Storm (August 24 - 29, 1945). This tropical cyclone was first reported in the southwestern part of the Gulf of Mexico on August 24, moving steadily northward. The storm moved in a northerly direction to within about 40 miles of City of Port Isabel by August 25 and continued northward, skirting the Texas Coast before moving inland in the vicinity of San Jose Island on the morning of August 26. The storm continued in a northeasterly direction with the eye passing just north of the Village of Port O'Connor, across Matagorda Bay, and struck the City of Palacios on the morning of August 27 as it moved inland towards the City of Bay City.

The storm was unusual in the coastal path it maintained, thereby raking essentially the entire Texas Coast, and also because of its slow forward movement, traveling at less than 5 miles per hour. The area between the City of Port Aransas and the mouth of the Colorado River received the maximum force of the hurricane.

The maximum storm surge varied considerably along the coast with about 3.2 feet at the City of Corpus Christi, 6.6 feet at the Town of Olivia, 7 feet at the City of Palacios, 3.7 feet at the City of Port Aransas, 3 feet recorded at the City of Port Isabel, 14.5 feet at the City of Port Lavaca, and 8 feet at the Village of Port O'Connor. Maximum wind velocities were estimated at 85 miles per hour at the City of Palacios, 100 to 125 miles per hour at the City of Port Aransas, 76 miles per hour at the City of Port Isabel, and 135 miles per hour at the Town of Olivia, the City of Port Lavaca, the Village of Port O'Connor, and the City of Seadrift.

The storm caused extensive beach erosion throughout the affected area and severely eroded the western Matagorda Bay shores. Several miles of the shore receded 50 feet as a result of the storm. The storm killed three people, injured 25, and caused damages exceeding $20 million (References 3 and 4).

Hurricane Carla (September 11, 1961). Hurricane Carla originated in the Caribbean Sea, and when it passed through the Yucatan Peninsula, the storm was packing winds of 110 miles per hour. The large, unusually slow-moving hurricane strengthened with its cyclonic winds covering the entire Gulf of Mexico. Carla moved inland over the Village of Port O'Connor northward through the Cities of Port Lavaca and Point Comfort. Maximum sustained wind velocities at the City of Port Lavaca were estimated at 115 miles per hour with gusts estimated at more than 170 miles per hour. High-water marks indicate surge heights reached elevations of up to 22 feet at the City of Port Lavaca, 7.5 feet at the City of Rockport, and 10.3 feet along the eastern Aransas County line near the Aransas National Wildlife Refuge, as the storm swept across the barrier islands and piled water upon the landward shores of Matagorda Bay. Highest recorded surge elevations along the open coast were approximately 12.3 feet.

This hurricane also spawned a rash of 26 tornadoes which took several lives in Texas and caused extensive damage. Although rainfall accompanying the hurricane was heavy in several local areas, the total volume of precipitation was not unusually high. At the City of Freeport, the 4 day rainfall was about 10 inches. Carla is significant because of the large area that was affected and the length of time the abnormal water levels prevailed. The effects of the big storm were felt as far east as Louisiana. Approximately 1,700,000 acres of Texas coastal land, including entire communities, were inundated, 32 people were killed, and damage from wind and surge was estimated at $408 million. Normal activities were disrupted for several weeks. Damages from hurricane flooding were estimated to be $78.7 million, and total damages were $149.3 million for the five county Matagorda Bay study area (References 4, 10, and 11).

Hurricane Beulah (September 5 - 22, 1967). Beulah began innocently as a weak tropical depression east of the Windward Islands. Moving into warm Caribbean waters, the storm intensified to the category of a hurricane. Beulah was disrupted temporarily near Jamaica, and then regained intensity. Beulah moved inland just east of the City of Brownsville. Torrential rains fell on south Texas and northeastern Mexico. Storm rainfall amounts ranged from 10 to 20 inches over much of the area. The total rainfall exceeded 30 inches in some areas. The storm surge reached 20 feet along lower sections of Padre Island, 6.0 to 6.5 feet in the City of Rockport and the Town of Fulton. Thirty one cuts were made completely through the island. An amazing 115 tornadoes were spawned by the system, the most ever known to be generated by a

tropical system. Most of the tornadoes were confined to the entire coast of Texas. Although considerable damage resulted from strong wind and high tides, the majority of the destruction was due to torrential rains and resultant flooding. Some damage was also caused by hurricane connected tornadoes (References 10, 11, and 12).

Hurricane Celia (July 30 – August 5, 1970). Celia originated as a tropical depression in the northwestern Caribbean Sea on July 30. The depression developed into a hurricane on August 1 after entering the Gulf of Mexico. The relatively small storm mass moved moderately fast and erratically across the gulf toward the Texas Coast. Celia lost strength on the morning of August 3 as the storm rapidly increased in size, but as Celia neared the coast, the eye of the storm became smaller and more concentrated and the wind speeds increased. When Celia was located about 30 miles east-southeast of the City of Corpus Christi, the storm had regained strength with highest winds estimated at 115 miles per hour. The storm continued to intensify as it moved inland across Mustang Island and into Corpus Christi Bay at a forward speed of 17 miles per hour. The anemometer at the weather station in the City of Aransas Pass was blown away after measuring wind gusts of 150 miles per hour. Subsequent peak gusts were estimated to have reached 180 miles per hour. Maximum gusts of 160 miles per hour were recorded at the City of Corpus Christi National Weather Service Office.

The metropolitan area of the City of Corpus Christi; the Cities of Robstown, Port Aransas, and Aransas Pass; and the small towns along Corpus Christi Bay suffered the most damage. Although considerable damage resulted from storm surge, the majority of the destruction resulted from high winds. A surge of 9.2 feet was recorded on the Gulf Beach at the City of Port Aransas, and a surge of 11.4 feet was recorded on the south side of the City of Aransas Pass. At the City of Corpus Christi, the stillwater surge elevation ranged from 3.9 to 5.6 feet. Celia's flood waters rose to 4.3 feet at the Town of Lamar, 5.2 feet at the Town of Fulton, and 8.4 feet south of the City of Rockport. Hurricane surge waters eroded beaches and roads and stalled communications and utility systems over much of the coastal communities. In addition, most of San Jose Island was inundated during the storm with the exception of a high central ridge.

Celia was among the costliest storm in the state's history, having caused an estimated total damage of $470 million. Wind damage accounted for $440 million of this total. There were 13 people killed and over 450 injured. More than 9,000 homes were destroyed, while 14,000 other homes were damaged. In addition, 250 businesses and 300 farm buildings were damaged or destroyed (References 3 and 11).

Hurricane Allen (August 9 - 10, 1980). Hurricane Allen was one of the most intense hurricanes when it was over the open waters of the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. Allen reached category 5 status. Allen lost strength near the Yucatan Peninsula but regained it over the open waters of the Gulf of Mexico with a central pressure of 909 millibar (mb) (26.84 inches) on August 9.

On August 9, the eye of Hurricane Allen did not cross any land until it moved inland north of the City of Brownsville bringing highest tides and winds over the least populated section of the Texas Coast.

The strongest winds of 129 miles per hour were measured at the Village of Port Mansfield. Only two deaths were directly attributed to Hurricane Allen. A storm surge up to 12 feet along Padre Island caused numerous barrier island cuts and washouts (Reference 13).

Hurricane Bret (August 21 - 23, 1999). The hurricane developed off the coast of Nicaragua on August 16. Bret moved northwest, becoming a broad low pressure system over the Yucatan Peninsula on August 16 and 17. It formed into a tropical depression within the Bay of Campeche the morning of August 18. By noon, ship reports indicated it formed into a tropical storm. Bret remained nearly stationary through August 20, as upper level winds from an upper level low passing to the north countered the easterly winds at the surface.

As the upper low moved to the west, winds aloft became favorable for development and the system rapidly became a hurricane, moving northward. This motion continued until the night of August 21, when the upper low moved further to the west and southwest, steering Bret on a more westward track. Peaking in intensity as a category 4 hurricane as it made its turn toward Texas; the storm began encountering much cooler sea surface temperatures near the coast. Weakening quickly, Bret made landfall in the sparsely populated Kenedy County on the evening of August 22. The system became a tropical storm on the morning of August 23 and a tropical depression that evening as it crossed the Rio Grande near the City of Laredo, into Mexico. Highest sustained winds reached 73 miles per hour from the northwest before power failure at Rincon Del San Jose. The City of Falfurrias measured gusts to 98 miles per hour in the late evening of August 22 before power failure. Gale-force winds extended from the City of Corpus Christi to the City of Brownsville (Reference 12).

Hurricane Rita (September 22 - 26, 2005). Rita was an intense, destructive, and deadly hurricane that significantly impacted the Florida Keys and devastated extreme southeast Texas and southwest Louisiana. It formed off an old frontal zone, and developed into a tropical depression on September 17 just east of the Turks and Caicos Islands and moved westward, becoming a tropical storm on the afternoon of September 18 and a hurricane on September 20 as it moved through the Florida Straits. As it emerged into the Gulf of Mexico, Rita began to rapidly intensify.

Maximum sustained winds increased to 175 miles per hour on September 22 while moving through the central Gulf of Mexico. A significant shearline aloft lured Rita more northwesterly, and the tropical cyclone weakened as it moved away from the warm waters of the loop current. Landfall occurred between the Town of Sabine Pass and Johnsons Bayou, Louisiana as a category 3 hurricane. Rita slowly weakened as it accelerated inland and maintained at least tropical storm strength when it crossed back into northwest Louisiana. The cyclone moved northeast and merged with a frontal wave on September 26. A total of four direct and 55 indirect fatalities were associated with Hurricane Rita in Texas. Damages totaled $10 billion (Reference 12).

Hurricane Ike (September 12 - 15, 2008). A tropical wave left the coast of Africa on August 28. The system slowly evolved into a cyclone moving westward for much of its

lifetime. On September 7, Ike moved through the southeast Bahamas into eastern Cuba. The large system strengthened into a category 2 hurricane, which moved west-northwest through the Gulf of Mexico.

On August 12, Ike developed a banding-type eye, moved into the City of Galveston and weakened as it moved through eastern Texas and Arkansas. The system became an extratropical cyclone as it approached the Mid-Mississippi Valley and rapidly accelerated northeast through southeast Canada on August 14 and 15.

A large storm surge accompanied Hurricane Ike, particularly along the western Louisiana and the upper Texas coastlines. The worst damage was seen in Galveston and Chambers Counties. The Towns of Crystal Beach, Gilchrist, and High Island experienced near total destruction of property. The storm knocked out power to 2.6 million people across Texas and Louisiana. There were 20 direct and 64 indirect deaths associated with Hurricane Ike. Damages totaled $19.3 billion (Reference 12).

2.4 Flood Protection Measures

Existing hurricane flood protection within the study area is limited to a few locally constructed seawalls and flood gates in the more populated urban areas, as well as several earthen and concrete dikes constructed by private industries (Reference 1).

Apart from these publicly financed flood protection works, various private industries near the coast have constructed levees. Most industries along the waterfront operate under hurricane protection plans when the need arises for evacuation and securing the plant in the event of a hurricane (Reference 1).

Drainage in the City of Point Comfort occurs through the city streets and a system of roadside ditches which function adequately. A number of ditches with outfall into the bay were improved in 1978. A drainage ditch at the intersection of Austin and San Jacinto Streets was diverted into another ditch which runs northwest from San Jacinto Street into the bay to alleviate high water in the streets in the far northern section of the city along the waterfront. Minor street improvements have helped to remove water more quickly from the City of Point Comfort into the bay (Reference 2).

Improvements to the City of Port Lavaca drainage system during the 1980's measurably decreased the city's vulnerability to flooding. Most of the drainage system has a design capacity for controlling a 20-percent-annual-chance flood. The spillways and inlets were installed in 1972 along Lynn Bayou to control street flooding from Brookhollow Drive and Holiday Lane. The storm sewer pipe system of the Bonorden subdivision addition was updated in 1972 and 1973 and tied into Corporation Ditch. An underground storm sewer was installed (3-6x6 feet box culverts) underneath U.S. Highway 87 in 1970 to improve the streamflow of Blardone Ditch in the southwest of the City of Port Lavaca (Reference 3).

The Victoria Barge Canal is located along the east side of Guadalupe River. The Victoria Barge Canal Levee was built in the 1960s during the construction of the barge canal and protects the transportation canal from the Guadalupe River to the west. The Victoria Barge Canal is 35-miles long and connects the Turning Basin in Victoria County to the Gulf Intracoastal Waterway. This levee system primarily protects industrial and commercial property and structures associated with the oil and

gas industries who utilize the barge canal to move product from inland to the Gulf of Mexico.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that is expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent-annual-chance, respectively, of being equaled or exceeded during any year. 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 1 year are considered. For example, the risk of having a flood that equals or exceeds the 1-percent-annual-chance flood in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the county.

Pre-countywide Analyses

Hydrologic analyses were carried out to establish flood elevation-frequency relationships, for floods of the selected recurrence intervals for each flooding source studied in detail in the community.

The determination of coastal inundation caused by passage of a hurricane was approached by the Join Probability Method (Reference 14). The storm population was described by probability distributions of five parameters that influence surge heights. These five parameters were the central pressure depression (which measures the intensity of the storm), radius to maximum winds, forward speed of the storm, shoreline crossing point, and crossing angle. These parameters, or storm characteristics, were described statistically based on an analysis of observed storms.

By combination of all parameters each with its associated probability, a large number of simulated storms can be numerically modeled, each with its own unique probability.

The probability of each resulting storm surge is then combined with the storm recurrence rate (frequency at which storms strike the coast) and the corresponding frequency (events of this surge height per year) for each storm surge determined. This procedure permits the simulation of many years of record, from which reliable estimates of flood recurrence intervals can be made.

As a final step in the calculations, the astronomic tide of the study area was combined with the computed storm surge to yield recurrence intervals of total water level. For a given location, the two functions representing the exceedance curve for the surge heights and the probability density function for the astronomic tide were combined to obtain a new exceedance curve containing the possible combinations of phase of the peak surges with the astronomic tide amplitudes. The probability density function for the astronomic tide is calculated based on tidal amplitudes generated at regular intervals for a period of time with the use of predictive equations that contain the harmonic constants for all the harmonic components of the tide at a particular location.

Where the potential for generation of storm waves greater than one foot existed, an analysis of wave heights was also performed and the computed wave heights were combined with total water level to yield base flood elevations.

The determination of maximum wave crest elevations associated with the 10- and 100-year events was approached by the method recommended by the National Academy of Sciences. Further details are included in Section 3.3.2 of this study.

Countywide Analyses

3.1.1 New Detailed Study Streams

The USGS prepared a new hydrologic flood frequency analysis for the Guadalupe River to determine the 10-, 2-, 1-, and 0.2-percent-annual-chance flood frequency discharges (Reference 15). The flood frequency analysis was based on the stream gage located on the Guadalupe River at U.S. Business Highway 59 at the City of Victoria (No. 08176500). The USGS has maintained the gage at the City of Victoria since 1934. Canyon Lake Dam was constructed above New Braunfels in 1964. The drainage area above the dam is 1,432 sq. mi. (about 28 percent of the total drainage area at the City of Victoria). However, evaluation of the flood peaks for the periods 1935-1963 and 1964-2005 indicates no identifiable reduction in flood magnitude or frequency. Additionally, at the Guadalupe River above the Comal River at the City of New Braunfels, three of the five highest peaks for the period 1928-2005 have occurred since the construction of Canyon Lake Dam. Therefore, flood-peak discharges for the entire period of record (1935-2005) were used to compute station flood frequency. In addition, the 1936 flood was reported to be higher than any prior flood since 1833. Therefore, a historical record length of 173 years was used in the analyses. Station flood frequency was computed using methods presented in the "Guidelines for Determining Flood Flow Frequency," Bulletin 17B of the Interagency Advisory Committee on Water Data (Reference 16), as recommended in "Guidelines and Specifications for Flood Hazard Mapping Partners", prepared by FEMA (Reference 17). Regional flood frequency discharges were developed in 2005 as a function of mean annual precipitation, basin slope, and a power transformation of drainage area (Reference 18). The station flood frequency discharges compared well with the regional estimates. The discharges utilized for the study were derived by weighting the station and the regional estimates (Reference 15).

3.1.2 Redelineated Detailed Study Streams

The redelineated streams were initially studied by detailed methods. These flooding sources included all those listed in Table 2, "Scope of Study" under the "Redelineated Detailed Study Streams" heading. Distinctly different types of hydrologic analysis were performed for stream (rainfall-runoff) sources versus tidal surge related sources (Reference 1).

Flood discharges for Little Chocolate Bayou, Lynn Bayou, and Seadrift Stream B were based on the USGS Open-File Report 77-110 "Technique for Estimating the Magnitude and Frequency of Floods in Texas" (Reference 19). This technique was developed by the USGS through regression analyses of existing gaged streamflow records. These results were then further refined for six specific regions within the state. The area of concern for this study is located with Region I. Peak discharges for 10-, 2-, and 1-percent-annual-chance flood frequencies were estimated from these relationships using the drainage area and channel slope for the streams in question. Peak discharges for the 0.2-percent-annual-chance flood events were determined by a straight line extrapolation of the 10-, 2-, and 1-percent-annual-chance flood data on log-probability graph paper (References 1, 3, and 4).

Peak discharge-drainage area relationships for streams studied by detailed methods are shown in Table 3, "Summary of Discharges."

There was no new Hydrology calculated for this revision.

Table 3 – Summary of Discharges

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. mile)	PEAK DISCHARGES (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
GUADALUPE RIVER					
At U.S. Business Highway 59	5,200.00	65,700	145,000	192,000	347,000
LITTLE CHOCOLATE BAYOU					
At State Highway 238	8.51	1,090	1,750	2,030	2,850
At State Highway 35	6.74	920	1,470	1,690	2,350
At U.S. Highway 87	4.37	680	1,050	1,200	1,650
LYNN BAYOU					
At State Highway 35	4.23	750	1,220	1,410	1,970
At Oakglen Drive	1.33	330	500	560	760

Table 3 – Summary of Discharges

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. mile)	PEAK DISCHARGES (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
SEADRIFT STREAM B					
At Baltimore Avenue	5.01	560	800	880	1,130
At State Highway 185	3.85	440	620	680	860

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the Flood Insurance Rate Map (FIRM) represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

Pre-countywide Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in detail were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of the studied streams as well as lowland areas near the shoreline.

The channel roughness coefficients used in the hydraulic computations were chosen by engineering judgment and based on field inspection of each stream and its overbank area. A roughness coefficient of 0.045 was used for the main channel of streams, and a roughness coefficient of 0.060 was used for the overbanks.

Water-surface elevation of floods, due to the streamflow, of the selected recurrence intervals were computed using the U.S. Army Corps of Engineers HEC-2 backwater computer program (Reference 20). The starting water surface elevations for all streams studied were calculated using the slope-area method. Water surface profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals.

These hydraulic analyses for this study were based on unobstructed flow through the various structures that are located in the flowpath.

Because surge elevations of inland areas are often higher than those at the shoreline due to funneling and the movement of the surge onto higher ground, an overland propagation model (SURGEOD) was utilized to determine inland surge heights and flooding limits (Reference 21). SURGEOD is a one dimensional model with moveable boundary conditions which proceeds landward in its computations comparing the water-surface level at the landward limit with the ground level at the next landward elevation. When the water-surface is higher than the ground level, a “wall” boundary condition is

advanced one element landward until the surge level declines to zero. The propagation model is generated by an explicit finite difference solution to the hydrodynamic equation of long wave propagation. The momentum and continuity equations are utilized in non-linear transport form.

Input to the overland propagation model consists of surge levels (with the associated recurrence intervals derived from the storm surge model), Manning's friction coefficient, and ground elevations along the traverse. The principal output of the program includes flood levels for the 10-, 50-, 100-, and 500-year floods at each ground point on the traverse.

A grid consisting of 2.5 nautical miles per side was used throughout the study area. The grid extended from the Kleberg County/Kenedy County boundary to just north of East Matagorda Bay and offshore approximately 63 miles. The grid covered an area of approximately 10,350 square miles.

Countywide Analyses

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the FIRM.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

3.2.1 New Detailed Study Streams

For the October 16, 2014 initial countywide FIS a hydraulic model was prepared for the Guadalupe River to compute water surface elevations (WSELs) for the 10-, 2-, 1- and 0.2-percent-annual-chance flood events using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) River Analysis System (HEC-RAS) Version 4.0 (Reference 22). Cross sections were extracted from a terrain data set composed of the 2006 Texas Natural Resources Information System (TNRIS) Light Detection and Ranging (LiDAR) topography (Reference 23), supplemented with field surveys conducted during late 2006 and early 2007. Bridge data was obtained from field surveys and as-built plans. Starting water surface elevations were based on the slope/area method. Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and based on field observations and 2004 digital orthophotos (Reference 21) of the stream and the floodplain areas. The model was calibrated to historical storms from October 1998, July 2002, and November 2004. Additional high-water marks acquired from the GBRA were also incorporated into the calibration effort. Flood profiles were drawn showing computed water surface elevations for floods of the selected recurrence intervals.

For this revision, as part of the Levee Analysis and Mapping Procedure (LAMP) for the Victoria Barge Canal Levee, a two-dimensional HEC-RAS model (Reference 22) was used to map the natural valley on the landward side of the deaccredited levee.

3.2.2 Redelineated Detailed Study Streams

The analyses for the redelineated study streams were taken from the prior Flood Insurance Studies for Calhoun County. The Base (1-percent-annual-chance) Flood Elevations (BFEs) from the profiles were plotted on the same topographic data to better define the special flood hazard areas. The redelineated streams are identified in Section 2.1.

Cross sections for the backwater analyses of Little Chocolate Bayou, Lynn Bayou, and Seadrift Stream B were obtained by field surveying. Dimensions of all bridges and culverts were determined by field measurement or field checked to verify structural geometry from construction plans (References 1, 3, and 4).

Water surface elevations of floods of the selected recurrence intervals were computed using the USACE HEC-2 backwater computer program (Reference 24). The starting water surface elevations were calculated using the slope-area method (References 1, 3, and 4). The elevation for the entire reach of Seadrift Stream B is controlled by the tidal surge of San Antonio Bay.

Channel roughness coefficients used in the hydraulic computations were selected by engineering judgment and based on field observations of the streams and floodplain areas. Channel and overbank "n" values for the streams studied by detailed methods are shown in Table 4, "Summary of Roughness Coefficients."

Table 4 – Summary of Roughness Coefficients
Stream Reaches Studied by Detailed Methods

Stream Name	Channel "n" Value	Overbank "n" Value
Guadalupe River	0.065	0.050 - 0.150
Little Chocolate Bayou	0.045	0.060
Lynn Bayou	0.045	0.060
Seadrift Stream B	0.045	0.060

3.3 Coastal Analyses

The hydraulic characteristics of coastal flood sources were analyzed to provide estimates of flood elevations for selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown in the coastal data tables and flood profiles provided in the FIS report.

Pre-countywide Analyses

The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is described in the National Academy of Sciences report (Reference 25). This methodology is based on the following major concepts. First, depth-limited waves in shallow water reach a maximum breaking height that is

equal to 0.78 times the stillwater depth. The wave crest elevation is 70 percent of the total wave height plus the stillwater elevation. The second major concept is that wave height may be diminished due to the presence of obstructions such as sand dunes, dikes and physical characteristics of the obstruction and is determined by procedures prescribed in Reference 25. The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch length and depth.

Wave heights were computed along transects (cross section lines) that were located along the coastal areas, as illustrated in Figure 1, Transect Schematic in accordance with the User's Manual for Wave Height Analysis (Reference 26). The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced closely together in areas of complex topography and dense development. In areas having more uniform characteristics, they were spaced at larger intervals. It was also necessary to locate transects in areas were unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects.

The transects were continued inland until the wave was dissipated, or until flooding from another source with equal or greater elevation was reached. Along each transect wave heights and elevations were computed considering the combined effects of changes in ground elevations, vegetation and physical features. The Stillwater elevations for the 100-year flood were used as the starting elevations for these computations. Wave heights were calculated to the nearest 0.1 foot, and wave elevations were determined at whole-foot increments along the transects. Areas with a wave component 3-feet or greater were designated as velocity zones. Other areas subject to wave action were designated as A Zones with base flood elevations adjusted to include wave crest elevations.

Countywide Analyses

3.3.1 Storm Surge Analyses and Modeling

For areas subject to coastal flood effects, the 10-, 2-, 1-, and 0.2-percent-annual-chance stillwater elevations were taken directly from a detailed storm surge study documented in "Flood Insurance Study: Coastal Counties, Texas Intermediate Submission 2 – Scoping and Data Review" prepared by USACE (Reference 27). This storm surge study was completed in November 2011.

The Advanced Circulation (ADCIRC) model for coastal and ocean hydrodynamics was applied by USACE to calculate stillwater elevations for coastal Texas. The ADCIRC model uses an unstructured grid and is a finite element long wave model. It has the capability to simulate tidal circulation and storm surge propagation over large areas and is able to provide highly detailed resolution in areas of interest along shorelines, open coasts, and inland bays. It solves three dimensional equations of motion, including tidal potential, Coriolis, and non-linear terms of the governing equations. The model is formulated from the depth-averaged shallow water equations

for conservation of mass and momentum which result in the generalized wave continuity equation.

In performing the coastal analyses, nearshore waves were required as inputs to wave runup and overland wave propagation calculations, and wave momentum (radiation stress) was considered as contribution to elevated water levels (wave setup). The Steady State Spectral Wave (STWAVE) model was used to generate and transform waves to the shore for the Texas Joint Storm Surge (JSS) Study. STWAVE is a finite difference model that calculates wave spectra on a rectangular grid. The model outputs zero-moment wave height (Hs), peak wave period (Tp), and mean wave direction at all grid points and two-dimensional spectra at selected grid points. STWAVE includes an option to input spatially variable wind and storm surge field. Storm surge significantly alters wave transformation and generation for the hurricane simulations in shallow-flooded areas.

STWAVE was applied on five grids for the Texas JSS: NE, CE, SW, NEn, and CEn. Three large grids (NE, CE, SW) with offshore boundaries at depths near 100 feet encompassed the entire coast of Texas and applied the efficient half-plane version of STWAVE (which must approximately align with the shoreline). Two nested grids (NEn and CEn) covered Galveston Bay and Corpus Christi Bay and applied the full-plane version of STWAVE to allow generation of wind waves in all directions. Notably, memory requirements for the full-plane model precluded its use for the large grids with offshore boundaries. The input for each grid includes the bathymetry (interpolated from the ADCIRC domain), surge fields (interpolated from ADCIRC surge fields), and wind fields (interpolated from the ADCIRC wind fields, which apply land effects to the base wind fields). The wind and surge applied in STWAVE are spatially and temporally variable for all domains. STWAVE was run at 30-minute intervals for 93 quasi-time steps (46.5 hours).

The ADCIRC model computational domain and the geometric/topographic representation developed for the Joint Coastal Surge effort was designated as the TX2008 mesh. This provided a common domain and mesh from the Texas-Mexico border to western Louisiana, extends inland across the floodplains of Coastal Texas (to the 30- to 75-foot contour NAVD88), and extends over the entire Gulf of Mexico to the deep Atlantic Ocean. The TX2008 domain boundaries were selected to ensure the correct development, propagation, and attenuation of storm surge without necessitating nesting solutions or specifying ad hoc boundary conditions for tides or storm surge. The TX2008 computational mesh contains more than 2.8 million nodes and nodal spacing varies significantly throughout the mesh. Grid resolution varies from approximately 12 to 15 miles in the deep Atlantic Ocean to about 100 feet in Texas. Further details about the terrain data as well as the ADCIRC mesh creation and grid development process can be found in "Flood Insurance Study: Coastal Counties, Texas Intermediate Submission 2 – Scoping and Data Review" (Reference 27).

3.3.2 Statistical Analyses

The Joint Probability Method (JPM) is a simulation methodology that relies on the development of statistical distributions of key hurricane input variables such as central pressure, radius to maximum wind speed, maximum wind speed, translation speed, track heading, etc., and sampling from these distributions to develop model hurricanes. The resulting simulation results in a family of modeled storms that preserve the relationships between the various input model components, but provides a means to model the effects and probabilities of storms that historically have not occurred.

Due to the excessive number of simulations required for the traditional JPM method, the JPM-Optimum Sampling (JPM-OS) was utilized to determine the stillwater elevations associated with tropical events. JPM-OS is a modification of the JPM method and is intended to minimize the number of synthetic storms that are needed as input to the ADCIRC model. The methodology entails sampling from a distribution of model storm parameters (e.g., central pressure, radius to maximum wind speed, maximum wind speed, translation speed, and track heading) whose statistical properties are consistent with historical storms impacting the region, but whose detailed tracks differ. The methodology inherently assumes that the hurricane climatology over the past 60 to 65 years (back to 1940) is representative of the past and future hurricanes likely to occur along the Texas Coast.

A set of 446 storms (two sets of 152 low frequency storms plus two sets of 71 higher frequency storms) was developed by combining the “probable” combinations of central pressure, radius to maximum winds, forward speed, angle of track relative to coastline, and track. Tracks were defined by five primary tracks and four secondary tracks. Storm parameters for synthetic storms are provided in Table 11 of USACE "Flood Insurance Study: Coastal Counties, Texas Intermediate Submission 2 – Scoping and Data Review" (Reference 27). The estimated range of storm frequencies using the selected parameters was between the 10- and 0.2-percent-annual-chance storm events. The ADCIRC-STWAVE modeling system was validated using five historic storms: Hurricanes Carla (1961), Allen (1980), Bret (1999), Rita (2005), and Ike (2008).

3.3.3 Stillwater Elevations

The results of the ADCIRC model and JPM-OS provided 10-, 2-, 1-, and 0.2-percent-annual-chance stillwater elevations which include wave setup effects. Stillwater elevations are assigned at individual ADCIRC mesh nodes throughout the Texas Coast. Triangular Irregular Networks (TINs) and raster datasets were built from these nodes for use in wave analysis and floodplain mapping.

An Independent Technical Review (ITR) was performed on the overall storm surge study process. This review process was performed in accordance with USACE regulations. The ITR team was composed of

experts in the fields of coastal engineering and science, and was engaged throughout the study. Appendix K of "Flood Insurance Study: Coastal Counties, Texas Intermediate Submission 2 – Scoping and Data Review" includes all comments received from the ITR panel, as well as responses to those comments (Reference 27).

3.3.4 Wave Height Analyses

Using storm surge study results, wave height analysis was performed to identify areas of the coastline subject to overland wave propagation or wave runup hazards. Figure 1 shows a cross section for a typical coastal analysis transect, illustrating the effects of energy dissipation and regeneration of wave action over inland areas. This figure shows the wave crest elevations being decreased by obstructions; such as buildings, vegetation, and rising ground elevations; and being increased by open, unobstructed wind fetches. Figure 1 also illustrates the relationship between the local stillwater elevations, the ground profile, and the location of the Zone VE/AE boundary at the limit of 3 feet breaking waves. This inland limit of the coastal high hazard area is delineated to ensure that adequate insurance rates apply and appropriate construction standards are imposed, should local agencies permit building in this coastal high hazard area.

It has been shown in laboratory tests and observed in field investigations that wave heights as little as 1.5 feet can cause damage to and failure of typical Zone AE construction. Therefore, for advisory purposes only, a Limit of Moderate Wave Action (LiMWA) boundary has been added in coastal areas subject to wave action. The LiMWA represents the approximate landward limit of the 1.5-foot breaking wave.

The effects of wave hazards in the Zone AE between the Zone VE (or shoreline in areas where Zones VE are not identified) and the limit of the LiMWA boundary are similar to, but less severe than, those in Zone VE where 3-foot breaking waves are projected during a 1-percent-annual-chance flooding event.

In areas where wave runup elevations dominate over wave heights, such as areas with steeply sloped beaches, bluffs, and/or shore-parallel flood protection structures, there is no evidence to date of significant damage to residential structures by runup depths less than 3 feet. However, to simplify representation, the LiMWA was continued immediately landward of the VE/AE boundary in areas where wave runup elevations dominate. Similarly, in areas where the Zone VE designation is based on the presence of a primary frontal dune or wave overtopping, the LiMWA was also delineated immediately landward of the Zone VE/AE boundary.

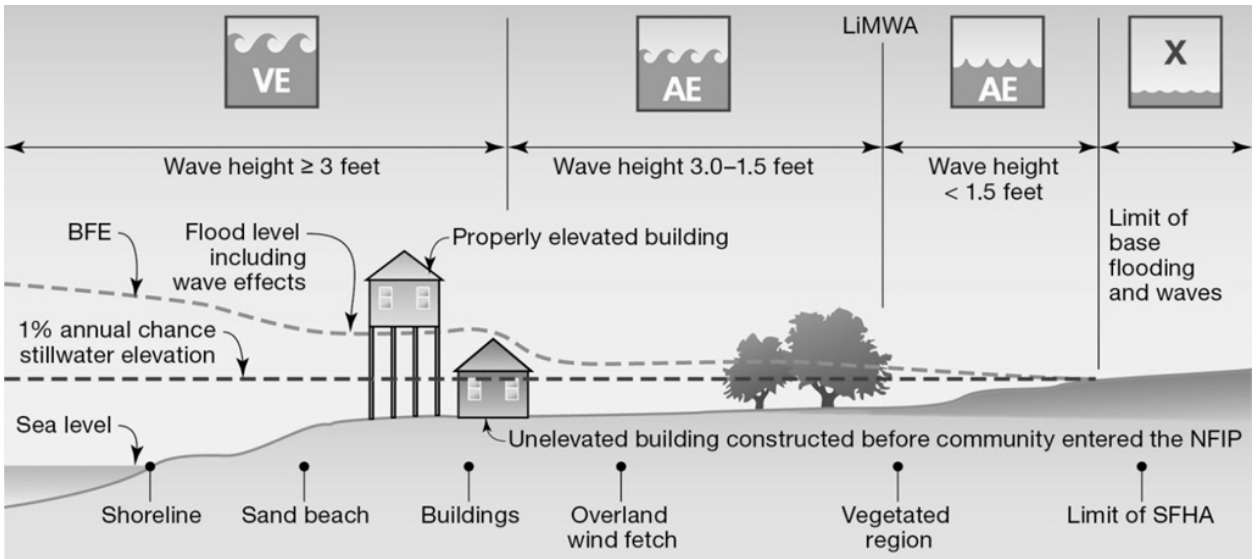

Figure 1: Transect Schematic

Transect locations and spacing is determined by considerations of physical and land use characteristics of the coast. The transects are located to adequately represent the dominant direction of overland wave propagation. The transects are closely spaced in areas of changing topography or land use and, conversely, spread further apart in areas of similar topography or land use. Transects are also located in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects. Where transects crossed, the largest wave height value was delineated on the FIRM panel. Transects are shown on the respective FIRM panels for the county.

This study applied topographic data from 2006 TNRIS LiDAR (Reference 23). In 2011 National Oceanographic and Atmospheric Administration (NOAA) modified and updated some areas of the data. The topographic data is referenced to NAVD88.

The combination of three land use data sources comprised the data used to identify areas of vegetative cover (forest, marsh grass, etc), buildings (density and spacing), and open water. The three sources are: aerial photos from the U.S. Department of Agriculture (Reference 28), U.S. Fish and Wildlife Service's National Wetlands Inventory maps (Reference 29), and NOAA's "Coastal Change Analysis Program" (C-CAP) data (Reference 30). Complete metadata for these data are found in the Technical Support Data Notebook (TSDN). In addition, Taylor Engineering collected detailed information about the features, such as building types, density, and vegetation types during a ground field reconnaissance.

Taylor Engineering performed storm-induced erosion analyses for this study. Erosion of the primary frontal dune was calculated along the county's shoreline with the Gulf of Mexico, using the 540 square feet method per FEMA's "Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update, 2007" (Reference 20).

Wave height calculation used in this study follows the methodology described in the "Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update, 2007" (Reference 20). Calculations of overland wave height propagation, using Wave Height Analysis for Flood Insurance Studies (WHAFIS), version 4.0, included both the 1- and 0.2-percent-annual-chance events (Reference 31). The 0.2-percent-annual-chance wave height results are not included on the FIRMs but are provided as wave-transect profiles in the TSDN.

Each transect calculates wave heights based on stillwater elevations (from the 1-percent- annual-chance surge modeling), ground elevations at each station along a transect, and land use properties. Wave setup was not calculated separately because wave setup was included in the base stillwater elevations from the storm surge analysis.

This study used default WHAFIS initial wave conditions based on fetch for each transect. Open water transects (primarily along the open gulf) used the maximum 24 miles of open fetch and interior transects used measured fetch lengths (Reference 31).

Figure 2, "Transect Location Map," shows the transect layout used for the overland wave analyses. Along each transect, wave envelopes were computed considering the combined effects of changes in ground elevation, stillwater surface elevation (including wave setup), vegetation, and physical features. Between transects, elevations were interpolated using LiDAR topographic data, land use and land cover data, and engineering judgment to determine the aerial extent of flooding (Reference 23). The transect data for each transect in the county, including the flood hazard zone, base flood elevations, transect location description, 10-, 2-, 1-, and 0.2-percent-annual-chance stillwater elevations at the start of the transect and the range found along the length of the transect is provided in the TSDN. Table 5, "Coastal Data," presents a summary of stillwater elevations along each transect.

The Technical Advisory Committee for Water Retaining Structures (TAW) method was used to calculate runup for transects 35 and 69. The 2-percent runup height from TAW was added to the stillwater elevation to compute a BFE. If the runup BFE exceeded the WHAFIS computed BFE, the map was adjusted to reflect the runup elevation (References 31 and 32).

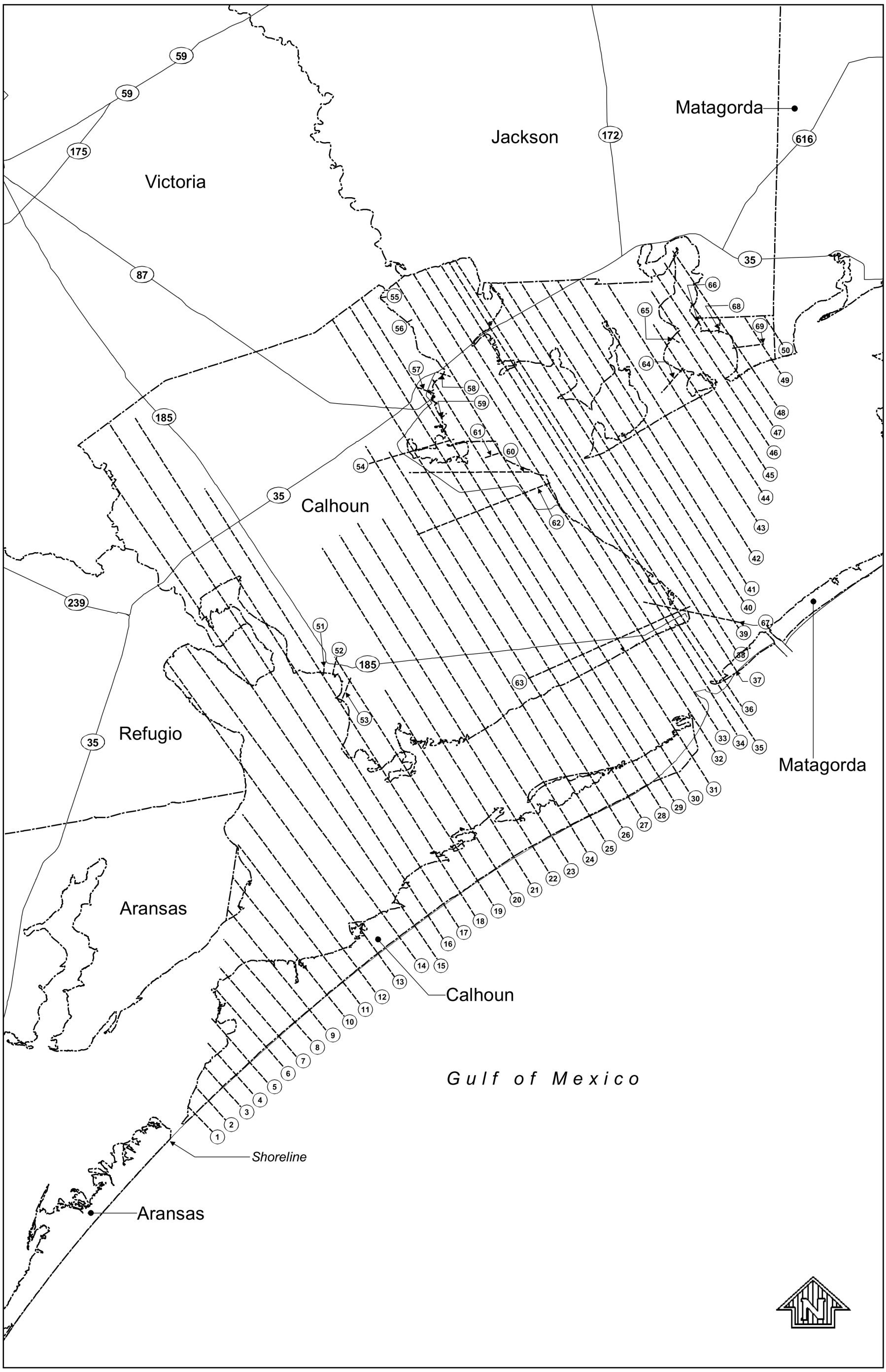

FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX
AND INCORPORATED AREAS

0 5 10 15 20 Miles

TRANSECT LOCATION MAP

Table 5 – Coastal Data

Transect No.	Description	Latitude & Longitude at Start of Transect	Starting Stillwater Elevations (feet) Range of Stillwater Elevations (feet)				Zone Designation and BFE (feet)
			10%-Annual-Chance NAVD	2%-Annual-Chance NAVD	1%-Annual-Chance NAVD	0.2%-Annual-Chance NAVD	NAVD
1	From the Gulf of Mexico extends inland to Calhoun County boundary	96°50'21.531"W 28°4'20.574"N	5.1 4.7 - 5.2	8.2 6.5 - 8.2	10.0 7.9 - 10.0	12.9 10.7 - 13.1	AE9-10 VE13,15
2	From the Gulf of Mexico extends inland to Calhoun County boundary	96°49'38.828"W 28°4'55.394"N	5.2 4.3 - 5.2	8.1 5.9 - 8.1	10.0 7.2 - 10.0	13.0 9.5 - 13.1	AE9-10 VE13,15
3	From the Gulf of Mexico extends inland to Calhoun county boundary	96°48'52.219"W 28°5'32.405"N	5.2 3.7 - 5.2	8.4 6.0 - 8.0	10.1 6.5 - 10.1	12.6 8.2 - 13.3	AE9-10 VE13,15
4	From the Gulf of Mexico extends inland to Calhoun County boundary	96°48'10.495"W 28°6'4.877"N	5.2 3.1 - 5.2	8.5 5.5 - 8.5	10.1 6.3 - 10.1	12.6 7.9 - 13.1	AE9,11 VE9-10,13
5	From the Gulf of Mexico extends inland to Calhoun County boundary	96°47'27.125"W 28°6'39.03"N	5.2 3.6 - 5.2	8.5 5.3 - 8.5	10.2 6.2 - 10.2	12.9 7.8 - 13.2	AE9-11 VE9-10,13,15
6	From the Gulf of Mexico extends inland to Calhoun County boundary	96°46'34.551"W 28°7'19.923"N	5.2 3.1 - 5.2	8.5 5.2 - 8.5	10.2 6.7 - 10.2	12.9 7.8 - 13.2	AE9-11 VE13,15
7	From the Gulf of Mexico extends inland across San Antonio Bay to Calhoun County boundary	96°45'55.03"W 28°7'49.422"N	5.2 3.4 - 5.2	8.5 5.5 - 8.5	10.2 6.7 - 10.2	12.7 8.4 - 13.0	AE9-11 VE9-10,13,15
8	From the Gulf of Mexico extends inland across San Antonio Bay to Calhoun County boundary	96°45'3.775"W 28°8'27.923"N	5.1 4.0 - 5.1	8.5 5.8 - 8.5	10.2 6.9 - 10.2	12.7 8.7 - 14.0	AE9-11 VE9-13,15
9	From the Gulf of Mexico extends inland across San Antonio Bay to Calhoun County boundary	96°44'18.699"W 28°9'1.354"N	5.2 3.5 - 5.2	8.5 5.5 - 8.5	10.3 6.8 - 10.5	12.9 8.5 - 13.1	AE8-11 VE9-13,15

Table 5 – Coastal Data (Continued)

Transect No.	Description	Latitude & Longitude at Start of Transect	Starting Stillwater Elevations (feet) Range of Stillwater Elevations (feet)				Zone Designation and BFE (feet)
			10%-Annual-Chance NAVD	2%-Annual-Chance NAVD	1%-Annual-Chance NAVD	0.2%-Annual-Chance NAVD	NAVD
10	From the Gulf of Mexico extends inland across San Antonio Bay to Calhoun County boundary	96°43'23.102"W 28°9'41.664"N	5.2 3.5 - 5.2	8.5 5.4 - 8.5	10.2 6.5 - 10.2	12.9 8.0 - 13.1	AE8-11 VE9-13,15
11	From the Gulf of Mexico extends inland across San Antonio Bay to Calhoun County boundary	96°42'32.696"W 28°10'16.595"N	5.2 3.6 - 5.2	8.5 5.1 - 8.5	10.4 6.1 - 10.4	13.2 7.7 - 13.5	AE9-10 VE9-11,13,15
12	From the Gulf of Mexico extends inland across San Antonio Bay to Calhoun County boundary	96°41'43.739"W 28°10'49.99"N	5.2 3.5 - 5.2	8.5 4.9 - 8.5	10.3 5.8 - 10.4	13.0 7.5 - 13.5	AE8-11 VE9-11,13,15
13	From the Gulf of Mexico extends inland across San Antonio Bay and Hynes Bay	96°40'42.313"W 28°11'31.342"N	5.2 3.4 - 5.2	8.4 4.7 - 8.4	10.2 5.6 - 10.8	12.8 7.4 - 13.7	AE8-12 VE9-13,15
14	From the Gulf of Mexico extends inland across San Antonio Bay and Hynes Bay	96°39'25.255"W 28°12'20.822"N	5.2 3.4 - 5.2	8.3 4.6 - 8.3	10.2 5.6 - 10.4	12.8 7.4 - 13.5	AE8-12 VE9-13,15
15	From the Gulf of Mexico extends inland across San Antonio Bay	96°38'50.206"W 28°12'43.533"N	5.2 3.1 - 5.2	8.3 3.9 - 8.3	10.2 5.6 - 10.3	12.9 7.5 - 13.4	AE8-14 VE9-11,13,15
16	From the Gulf of Mexico extends inland across San Antonio Bay	96°38'2.54"W 28°13'13.759"N	5.2 3.4 - 5.2	8.3 2.6 - 8.3	10.1 5.2 - 10.2	12.9 4.1 - 13.3	AE8-14 VE9-11,13,15
17	From the Gulf of Mexico extends inland across San Antonio Bay and Guadalupe Bay	96°37'12.409"W 28°13'44.065"N	5.2 2.9 - 5.2	8.3 2.6 - 8.3	10.2 5.6 - 10.2	13.2 7.5 - 13.5	AE7-14 VE9-11,13,15
18	From the Gulf of Mexico extends inland across San Antonio Bay	96°36'20.807"W 28°14'14.907"N	5.2 3.0 - 5.2	8.2 3.0 - 8.2	10.2 5.7 -10.2	13.2 5.1 - 13.4	AE7-10,13 VE8-11,13,15

Table 5 – Coastal Data (Continued)

Transect No.	Description	Latitude & Longitude at Start of Transect	Starting Stillwater Elevations (feet) Range of Stillwater Elevations (feet)				Zone Designation and BFE (feet)
			10%-Annual-Chance NAVD	2%-Annual-Chance NAVD	1%-Annual-Chance NAVD	0.2%-Annual-Chance NAVD	NAVD
19	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°35'25.803"W 28°14'47.232"N	5.2 3.1 - 5.2	8.1 4.4 - 8.2	10.0 5.1 - 10.0	13.0 7.6 - 13.3	AE7-10 VE8-10,13,15
20	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°34'27.943"W 28°15'19.527"N	5.2 3.3 - 5.2	8.1 4.2 - 8.2	10.1 5.8 - 10.1	13.2 7.7 - 13.5	AE7-10 VE8-10,13,15
21	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°33'30.61"W 28°15'50.388"N	5.3 3.1 - 5.3	8.1 4.5 - 8.2	10.0 5.6 - 10.0	13.1 7.7 - 13.3	AE6-10 VE8-11,13,15
22	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°32'32.08"W 28°16'19.467"N	5.3 3.2 - 5.3	8.1 4.6 - 8.1	10.0 5.7 - 10.0	13.1 7.8 - 13.4	AE6-11 VE8-11,13,15
23	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°31'32.618"W 28°16'47.158"N	5.2 3.2 - 5.2	8.0 4.4 - 8.1	10.0 5.9 - 10.0	13.2 7.8 - 16.7	AE7-11 VE8-11,13,15
24	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°30'33.29"W 28°17'15.233"N	5.3 3.3 - 5.3	8.1 4.5 - 8.5	9.9 5.9 - 11.9	13.0 7.9 - 16.0	AE7-11 VE8-11,13,15
25	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°29'32.392"W 28°17'40.916"N	5.3 3.0 - 5.3	8.1 4.6 - 9.5	9.8 6.0 - 13.1	12.9 7.9 - 18.0	AE7-13 VE8-11,13,15
26	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°28'31.208"W 28°18'5.742"N	5.3 3.0 - 6.7	8.0 4.9 - 9.8	9.8 6.1 - 12.3	12.9 8.0 - 17.0	AE7-13 VE8-11,13,15
27	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°27'30.288"W 28°18'31.274"N	5.3 2.8 - 6.5	8.0 4.7 - 9.2	9.8 5.9 - 12.7	13.0 7.6 - 16.8	AE7-14 VE8-11,13-15

Table 5 – Coastal Data (Continued)

Transect No.	Description	Latitude & Longitude at Start of Transect	Starting Stillwater Elevations (feet) / Range of Stillwater Elevations (feet)				Zone Designation and BFE (feet)
			10%-Annual-Chance NAVD	2%-Annual-Chance NAVD	1%-Annual-Chance NAVD	0.2%-Annual-Chance NAVD	NAVD
28	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°26'32.402"W 28°19'1.353"N	5.3 3.4 - 6.4	8.1 5.1 - 9.1	9.8 6.2 - 11.8	12.7 8.4 - 17.0	AE7-14 VE9-15
29	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°25'55.09"W 28°19'26.394"N	5.3 3.5 - 6.1	8.1 5.1 - 8.7	9.8 6.4 - 11.8	12.7 8.5 - 17.3	AE11-13 VE9-15
30	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°25'14.102"W 28°19'59.258"N	5.3 3.5 - 6.2	8.2 5.0 - 8.8	9.9 6.5 - 11.6	12.8 8.7 - 15.5	AE10-13 VE9-17
31	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°24'37.421"W 28°20'33.06"N	5.4 5.4 - 6.6	8.3 5.4 - 9.6	9.8 6.5 - 12.1	13.0 8.8 - 16.6	AE10-12 VE9-19
32	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°23'43.613"W 28°21'37.187"N	5.5 3.9 - 6.5	8.3 5.6 - 9.5	10.0 6.7 - 12.0	12.9 9.2 - 16.5	AE11-2,14 VE9-19
33	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°23'19.581"W 28°22'18.864"N	5.5 4.0 - 6.5	8.3 5.5 - 9.5	10.0 6.3 - 11.9	12.9 9.4 - 16.5	AE11-12 VE10-18
34	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°23'2.522"W 28°23'13.491"N	5.5 3.6 - 6.4	7.9 5.4 - 9.3	9.4 6.6 - 11.8	11.9 9.8 - 16.3	AE12-13 VE10-18
35	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°22'36.848"W 28°23'17.18"N	5.6 4.6 - 6.4	8.1 5.7 - 9.3	9.6 6.9 - 11.7	12.3 9.8 - 16.2	AE10-13 VE10-18
36	From the Gulf of Mexico extends inland across Espiritu Santo Bay	96°22'19.036"W 28°23'29.465"N	5.6 4.6 - 6.4	8.3 5.5 -9.2	9.8 7.1 - 11.7	12.5 9.8 - 16.1	AE10-13 VE10-17

Table 5 – Coastal Data (Continued)

Transect No.	Description	Latitude & Longitude at Start of Transect	Starting Stillwater Elevations (feet) / Range of Stillwater Elevations (feet)				Zone Designation and BFE (feet)
			10%-Annual-Chance NAVD	2%-Annual-Chance NAVD	1%-Annual-Chance NAVD	0.2%-Annual-Chance NAVD	NAVD
37	From Calhoun County boundary crosses Matagorda Bay and Lavaca Bay, and extends inland	96°21'43.968"W 28°24'10.851"N	5.7 [1] 4.7 - 6.2	8.5 [1] 6.2 - 9.1	10.1 [1] 7.9 - 11.5	12.8 [1] 9.9 - 16.2	AE10-13 VE12-17
38	From Calhoun County boundary crosses Matagorda Bay and Lavaca Bay, and extends inland	96°21'18.75"W 28°24'31.393"N	5.6 [1] 4.6 - 5.9	8.5 [1] 6.3 - 8.8	10.1 [1] 7.7 - 10.7	13.1 [1] 8.5 - 14.4	AE9-11,14 VE12-17
39	From Calhoun County boundary crosses Matagorda Bay and Keller Bay, and extends inland	96°20'44.92"W 28°24'56.133"N	5.6 [1] 4.5 - 5.8	8.5 [1] 6.4 - 8.6	10.3 [1] 7.7 - 10.7	13.6 [1] 6.6 - 14.8	AE9-11,16 VE11-18
40	From Calhoun County boundary crosses Matagorda Bay and Keller Bay, and extends inland	96°19'56.386"W 28°25'23.289"N	5.5 [1] 4.4 - 5.3	8.3 [1] 6.1 - 7.7	9.9 [1] 7.5 - 9.8	12.7 [1] 9.6 - 15	AE8-11 VE11-18
41	From Calhoun County boundary crosses Matagorda Bay and Keller Bay, and extends inland	96°19'20.112"W 28°25'31.442"N	5.4 [1] 4.4 - 5.4	8.0 [1] 6.2 - 7.9	9.4 [1] 7.5 - 10.1	11.9 [1] 9.6 - 14.9	AE9-12 VE11-18
42	From Calhoun County boundary crosses Matagorda Bay and extends inland	96°18'26.77"W 28°26'7.994"N	5.7 [1] 4.4 - 5.8	8.7 [1] 6.1 - 8.8	10.1 [1] 7.5 - 11.4	12.9 [1] 9.9 - 15.3	AE9-10 VE12-18
43	From Calhoun County boundary crosses Matagorda Bay and extends inland	96°17'34.688"W 28°26'46.751"N	5.7 [1] 4.5 - 5.5	8.7 [1] 6.2 - 8.0	10.3 [1] 7.7 - 10.2	12.9 [1] 10.2 - 13.7	AE8-9,11,13 VE12-18
44	From Calhoun County boundary crosses Matagorda Bay and Caranchua Bay, and extends inland	96°16'40.671"W 28°27'21.986"N	5.8 [1] 4.5 - 5.4	8.8 [1] 6.2 - 7.9	10.4 [1] 7.9 - 10.1	13.0 [1] 10.5 - 13.3	AE11,13 VE12-18

[1]Starting stillwater elevation for transect does not lie within this county

Table 5 – Coastal Data (Continued)

Transect No.	Description	Latitude & Longitude at Start of Transect	Starting Stillwater Elevations (feet) / Range of Stillwater Elevations (feet)				Zone Designation and BFE (feet)
			10%-Annual-Chance NAVD	2%-Annual-Chance NAVD	1%-Annual-Chance NAVD	0.2%-Annual-Chance NAVD	NAVD
45	From Calhoun County boundary crosses Matagorda Bay and Caranchua Bay, and extends inland	96°16'2.979"W 28°27'45.217"N	5.8 [1] 4.5 - 5.6	8.8 [1] 6.3 - 8.4	10.5 [1] 8.0 - 10.8	13.0 [1] 10.7 - 14.4	AE11,13 VE12-18
46	From Calhoun County boundary crosses Matagorda Bay and Caranchua Bay, and extends inland	96°15'17.494"W 28°28'12.512"N	5.8 [1] 4.6 - 5.8	8.9 [1] 6.4 - 8.7	10.4 [1] 8.3 - 11.3	13.1 [1] 11.1 - 14.7	AE11-13 VE13-18
47	From Calhoun County boundary crosses Matagorda Bay and Caranchua Bay, and extends inland	96°14'38.434"W 28°28'35.124"N	5.8 [1] 4.2 - 5.7	8.9 [1] 6.6 - 8.7	10.7 [1] 8.0 - 11.2	13.8 [1] 11.3 - 14.7	AE10-13 VE12-18
48	From Calhoun County boundary crosses Matagorda Bay and Caranchua Bay, and extends inland	96°13'57.705"W 28°28'58.325"N	5.8 [1] 3.2 - 5.8	8.9 [1] 6.1 - 8.8	10.6 [1] 7.9 - 11.4	13.1 [1] 11.7 - 15.0	AE9-13 VE12-18
49	From Calhoun County boundary near Matagorda Bay and extends inland	96°13'12.522"W 28°29'22.726"N	5.9 [1] 4.9 - 4.9	9.0 [1] 6.1 - 7.5	10.7 [1] 8.2 - 10.0	13.2 [1] 12.2 - 13.4	AE9-11 VE12-17
50	From Calhoun County boundary near Matagorda Bay and extends inland	96°12'26.122"W 28°29'46.965"N	5.9 [1] -- [2]	8.9 [1] -- [2]	10.7 [1] 8.4 - 8.5	13.3 [1] 11.5 - 12.7	AE9
51	From San Antonio Bay and extends inland	96°43'14.463"W 28°24'31.283"N	3.8 3.8 - 3.8	5.1 5.0 - 5.1	10.7 8.9 - 10.8	9.8 4.1 - 16.7	AE7 VE9-10
52	From San Antonio Bay and extends inland	96°42'45.819"W 28°24'29.451"N	3.8 3.8 - 3.8	5.1 4.9 - 5.1	6.7 6.6 - 6.7	10.1 10.1 - 10.3	AE7 VE9

[1]Starting stillwater elevation for transect does not lie within this county
[2]Length of transect within county is above stillwater elevations

Table 5 – Coastal Data (Continued)

Transect No.	Description	Latitude & Longitude at Start of Transect	Starting Stillwater Elevations (feet) / Range of Stillwater Elevations (feet)				Zone Designation and BFE (feet)
			10%-Annual-Chance NAVD	2%-Annual-Chance NAVD	1%-Annual-Chance NAVD	0.2%-Annual-Chance NAVD	NAVD
53	From San Antonio Bay and extends inland	96°42'19.645"W 28°23'15.694"N	3.7 3.7 - 3.7	4.9 4.3 - 5.0	6.1 5.7 - 6.1	9.4 9.4 - 9.7	AE7 VE9
54	From Lavaca Bay across Chocolate Bay and extends inland	96°36'21.404"W 28°35'7.465"N	6.1 4.2 - 6.8	8.6 8.3 - 9.9	10.5 9.6 - 12.8	14.4 14.5 - 17.4	AE12-13 VE13-15
55	From Lavaca Bay and extends inland	96°39'53.845"W 28°41'44.173"N	6.7 6.6 - 6.7	9.7 9.5 - 9.7	12.3 12.3 - 12.4	17.0 17 - 17.5	VE16-17
56	From Lavaca Bay and extends inland	96°38'31.963"W 28°40'34.731"N	6.4 6.4 - 6.4	9.2 9.2 - 9.3	11.7 11.7 - 11.7	16.2 16.2 - 16.2	VE16-18
57	From Lavaca Bay and extends inland	96°37'23.981"W 28°37'21.115"N	6.2 6.2 - 6.2	8.8 8.6 - 8.8	11.0 10.8 - 11.0	15.2 15.2 - 15.6	AE11,13 VE14,16
58	From Lavaca Bay and extends inland	96°36'43.457"W 28°38'10.339"N	6.1 6.1 - 6.2	8.7 7.8 - 8.8	11.0 11.0 - 11.3	15.1 15.1 - 15.7	AE13 VE14,16-17
59	From Lavaca Bay and extends inland	96°36'39.11"W 28°36'1.26"N	6.1 6.0 - 6.1	8.6 8.5 - 8.6	12.5 12.5 - 12.6	14.9 14.9 - 14.9	VE14-15
60	From Lavaca Bay and extends inland	96°32'11.64"W 28°33'35.048"N	5.4 5.4 - 6.1	7.7 7.5 - 8.6	9.4 8.5 - 10.5	12.8 12.1 - 15	AE9-12 VE12
61	From Lavaca Bay and extends inland	96°33'48.303"W 28°34'29.959"N	5.6 5.6 - 5.6	7.9 7.9 - 7.9	9.8 9.8 - 9.8	13.5 13 - 13.5	VE12
62	From Matagorda Bay and extends inland	96°31'18.821"W 28°33'2.172"N	5.4 5.0 - 5.6	7.5 7.0 - 7.8	9.2 8.3 - 13.0	12.5 12.2 - 16.5	AE10-14 VE13

Table 5 – Coastal Data (Continued)

Transect No.	Description	Latitude & Longitude at Start of Transect	Starting Stillwater Elevations (feet) / Range of Stillwater Elevations (feet)				Zone Designation and BFE (feet)
			10%-Annual-Chance NAVD	2%-Annual-Chance NAVD	1%-Annual-Chance NAVD	0.2%-Annual-Chance NAVD	NAVD
63	From Matagorda Bay and extends inland	96°24'15.26"W 28°27'10.136"N	4.9 4.8 - 4.9	6.8 5.8 - 8.2	8.1 7.1 - 10.2	10.1 9.9 - 12.9	AE7-11 VE11-13
64	From Carancahua Bay and extends inland	96°24'13.346"W 28°38'9.793"N	5.2 5.2 - 5.2	7.7 7.5 - 7.7	9.7 8.2 - 9.8	12.7 7.2 - 13.1	AE9,13 VE12,14
65	From Carancahua Bay and extends inland	96°24'44.377"W 28°39'36.82"N	5.3 5.3 - 5.4	7.9 7.8 - 7.9	10.2 10.2 - 10.2	13.5 13.4 - 13.5	AE13 VE14,15
66	From Carancahua Bay and extends inland	96°23'16.867"W 28°40'20.161"N	5.3 5.3 - 5.4	7.9 7.8 - 7.9	10.2 10.2 - 10.2	13.5 13.4 - 13.5	AE10 VE14-15
67	From Gulf of Mexico and across Matagorda Bay at the Village of Port O'Connor	96°18'44.844"W 28°25'52.864"N	5.7 [1] 4.6 - 5.3	8.7 [1] 6.4 - 7.6	10.1 [1] 7.2 - 9.0	12.8 [1] 8.5 - 11.6	AE7-11 VE11-15
68	From Carancahua Bay and extends inland	96°22'15.889"W 28°39'53.326"N	5.2 5.2 - 5.2	7.6 7.6 - 7.6	9.9 8.5 - 9.9	13.2 11.6 - 13.2	AE10-11 VE12-14
69	From Carancahua Bay and extends inland	96°21'26.41"W 28°39'5.237"N	5.1 5.1 - 5.1	7.3 6.3 - 7.5	9.6 8.2 - 9.9	12.7 12.5 - 13.3	AE9-11 VE12-14

[1]Starting stillwater elevation for transect does not lie within this county

3.4 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD). With the completion of the North American Vertical Datum of 1988, many FIS reports and FIRMs are now prepared using NAVD as the referenced vertical datum.

Flood elevations shown in this FIS report and on the FIRM are referenced to the NAVD. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. Some of the data used in this revision were taken from the prior effective FIS reports and FIRMs and adjusted to NAVD88. The datum conversion factor from NGVD29 to NAVD88 in Calhoun County is -0.38 feet.

For information regarding conversion between the NGVD and NAVD, visit the National Geodetic Survey (NGS) website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

NGS Information Services, NOAA, N/NGS12
National Geodetic Survey SSMC-3, #9202
Silver Spring Metro Center 3
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook associated with the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for benchmarks shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at www.ngs.noaa.gov.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages state and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS report provides 1-percent-annual-chance floodplain data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent-annual-chance flood elevations; delineations of the 1- and 0.2-percent-annual-chance floodplains; and a 1-percent-annual-chance floodway. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles, Floodway Data tables, and Summary of Stillwater Elevation tables. Users should reference the data presented in the FIS report as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed methods, the 1- and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic data from 2006 LiDAR based mass points suitable for a contour interval of 2 feet (Reference 23).

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM. On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, and VE), and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations, but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM.

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the base flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (see Table 6, “Floodway Data”). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)[2]	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (NAVD)	WITHOUT FLOODWAY (NAVD)	WITH FLOODWAY (NAVD)	INCREASE
Guadalupe River								
A	19,876	17,368	166,273	1.2	15.3	15.3	15.9	0.6
B	34,228	12,224	123,965	1.6	16.5	16.5	17.1	0.6
C	40,565	9,075	104,461	2.0	18.0	18.0	18.6	0.6
D	51,662	8,663	101,548	1.9	20.2	20.2	21.1	0.9
E	56,161	8,325	103,039	1.9	20.8	20.8	21.8	1.0
F	61,077	6,140	92,788	2.1	23.3	23.3	24.3	1.0

[1]Stream distance in feet above State Highway 35
[2]Total width of floodway in both Victoria & Calhoun counties

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY
CALHOUN COUNTY, TX
AND INCORPORATED AREAS

FLOODWAY DATA

GUADALUPE RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (NAVD)	WITHOUT FLOODWAY (NAVD)	WITH FLOODWAY (NAVD)	INCREASE
Little Chocolate Bayou								
A	0	238	907	2.2	12.3	5.1[2]	6.1	1.0
B	1,675	189	803	2.4	12.3	6.7[2]	7.6	0.9
C	2,575	137	624	2.9	12.3	7.9[2]	8.9	1.0
D	5,975	145	675	2.5	12.3	12.3	13.2	0.9
E	6,825	124	759	2.2	13.1	13.1	13.8	0.7
F	8,225	82	516	2.8	14.1	14.1	14.9	0.8
G	9,225	105	736	1.8	14.5	14.5	15.3	0.8
H	10,875	60	341	3.5	15.5	15.5	16.2	0.7
I	11,017	55	330	3.6	15.7	15.7	16.6	0.9

[1]Stream distance in feet above Limit of Detailed Study (Limit of Detailed Study is located approximately 50 feet downstream of State Highway 238)
[2]Elevation computed without consideration of storm surge from Lavaca Bay

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY
CALHOUN COUNTY, TX
AND INCORPORATED AREAS

FLOODWAY DATA

LITTLE CHOCOLATE BAYOU

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (NAVD)	WITHOUT FLOODWAY (NAVD)	WITH FLOODWAY (NAVD)	INCREASE
Lynn Bayou								
A	0	44	333	4.4	10.8	6.1[2]	7.1	1.0
B	700	37	276	5.2	10.8	7.5[2]	8.4	0.9
C	1,196	70	406	3.5	10.9	8.4[2]	9.4	1.0
D	2,861	50	283	4.8	11.1	11.1	11.5	0.4
E	4,736	64	192	2.9	14.9	14.9	15.5	0.6
F	5,786	30	152	3.2	16.2	16.2	17.1	0.9

[1]Stream distance in feet above Limit of Detailed Study (Limit of Detailed Study is located approximately 1,200 feet downstream of State Highway 35)
[2]Elevation computed without consideration of storm surge from Lavaca Bay

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY
CALHOUN COUNTY, TX
AND INCORPORATED AREAS

FLOODWAY DATA

LYNN BAYOU

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water surface elevation of the base flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 3, Floodway Schematic.

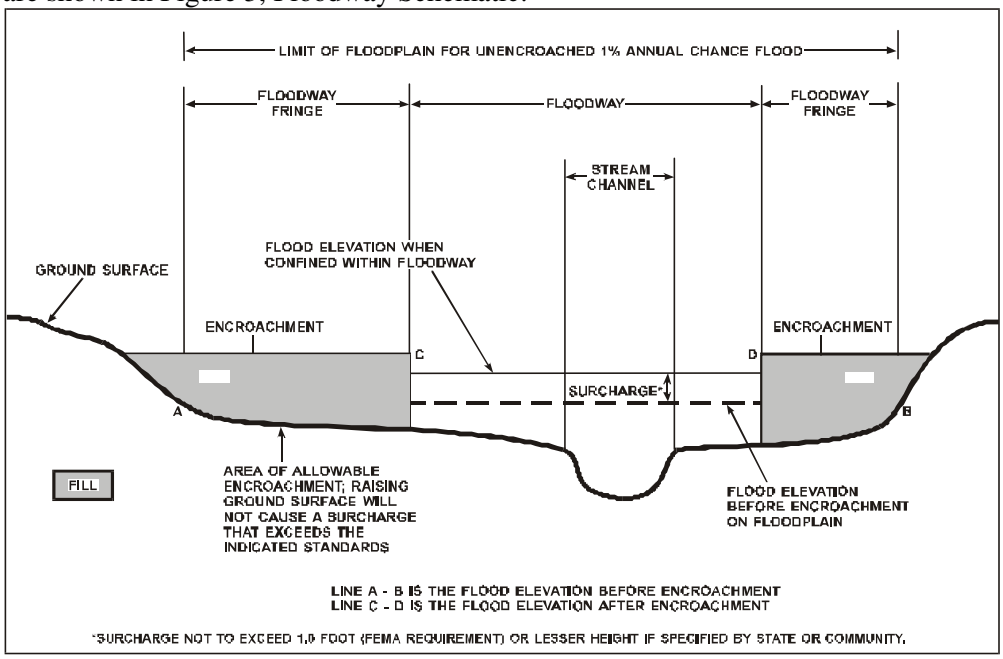

Figure 3: Floodway Schematic

For the October 16, 2014 initial countywide study, no floodway was computed for Seadrift Stream B.

In the case of redelineation, effort was made to maintain the prior effective regulatory floodway width and shape. However, due to updated topographic data, some modifications were made to contain the floodway within the limits of the 1-percent-annual-chance floodplain. Most modifications to the prior effective regulatory floodway boundaries are due to topographic changes that have occurred along the streams.

For this revision, the floodway portion of the Guadalupe River adjacent to the Victoria Barge Canal levee was calculated per Section 12.2 of FEMA's Operating Guidance 12-13 Non-Accredited Levee Analysis and Mapping Guidance (Reference 33).

Near the mouths of streams studied in detail, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, "Without Floodway" elevations presented in Table 6 for certain downstream cross sections of Guadalupe River, Little Chocolate Bayou, and Lynn Bayou are lower than the regulatory flood elevations in that area, which must take into account the 1-percent-annual-chance flooding due to backwater from other sources.

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS report by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS report by detailed methods. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the base flood by levees. No BFEs or depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

The countywide FIRM presents flooding information for the entire geographic area of Calhoun County. Previously, FIRMs were prepared for each incorporated community and the

unincorporated areas of the county identified as having SFHAs. This countywide FIRM also includes flood hazard information that was presented separately on Flood Boundary and Floodway Maps (FBFMs), where applicable. Historical data relating to the pre-countywide maps prepared for each community are presented in Table 7, "Community Map History."

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FLOOD INSURANCE RATE MAP EFFECTIVE DATE	FLOOD INSURANCE RATE MAP REVISIONS DATE
Calhoun County, Unincorporated Areas	June 16, 1970	None	March 19, 1971	July 1, 1974 December 2, 1977 October 1, 1983 January 3, 1985 April 2, 1992 June 30, 1999 November 7, 2001
Point Comfort, City of	May 24, 1974	April 9, 1976	April 15, 1982	April 3, 1985
Port Lavaca, City of	July 27, 1971	None	August 27, 1971	July 1, 1974 September 5, 1975 March 4, 1985
Seadrift, City of	December 4, 1970	None	December 4, 1970	July 1, 1974 May 2, 1975 March 18, 1985

TABLE 7

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

The preparation of updated FISs is on-going for several of the surround counties. The Calhoun County FIS is in agreement with these studies.

This FIS report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the NFIP.

This is a multi-volume FIS. Each volume may be revised separately, in which case it supersedes the previously printed volume. Users should refer to the Table of Contents in Volume 1 for the current effective date of each volume; volumes bearing these dates contain the most up-to-date flood hazard data.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting FEMA Region VI, Federal Insurance and Mitigation Division, 800 North Loop 288, Denton, Texas 76209.

9.0 BIBLIOGRAPHY AND REFERENCES

1. Federal Emergency Management Agency, Flood Insurance Study Calhoun County, Texas Unincorporated Areas Preliminary, January 6, 1984.

2. Federal Emergency Management Agency, Flood Insurance Study City of Point Comfort, Texas Calhoun County, April 15, 1982.

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32. Technical Advisory Committee for Water Retaining Structures (TAW), Technical Report – Wave Run-up and Overtopping at Dikes, Van der Meer, J.W., Delft, The Netherlands, May 2002.

33. Federal Emergency Management Agency, Operating Guidance 12-13: Non-Accredited Levee Analysis and Mapping Guidance, September 2013.

10. NOTES TO USERS AND MAP LEGEND FOR FIRM

NOTES TO USERS

For information and questions about this map, available products associated with this FIRM including historic versions of this FIRM, how to order products, or the National Flood Insurance Program in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Map Service Center website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website. Users may determine the current map date for each FIRM panel by visiting the FEMA Map Service Center website or by calling the FEMA Map Information eXchange.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Map Service Center at the number listed above.

For community and countywide map dates, refer to the Index Map.

To determine if flood insurance is available in the community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

PRELIMINARY FIS REPORT: FEMA maintains information about map features, such as street locations and names, in or near designated flood hazard areas. Requests to revise information in or near designated flood hazard areas may be provided to FEMA during the community review period, at the final Consultation Coordination Officer's meeting, or during the statutory 90-day appeal period. Approved requests for changes will be shown on the final printed FIRM.

The map is for use in administering the NFIP. It may not identify all areas subject to flooding, particularly from local drainage sources of small size. Consult the community map repository to find updated or additional flood hazard information.

BASE FLOOD ELEVATIONS: For more detailed information in areas where Base Flood Elevations (BFEs) and/or floodways have been determined, consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables within this FIS Report. Use the flood elevation data within the FIS Report in conjunction with the FIRM for construction and/or floodplain management.

Coastal Base Flood Elevations shown on the map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the FIS Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on the FIRM.

FLOODWAY INFORMATION: Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the FIS Report for this jurisdiction.

FLOOD CONTROL STRUCTURE INFORMATION: Certain areas not in Special Flood Hazard Areas may be protected by flood control structures. Refer to Section 4.3 "Non-Levee Flood Protection Measures" of this FIS Report for information on flood control structures for this jurisdiction

PROJECTION INFORMATION: The projection used in the preparation of the map was Texas State Plane South Central Zone (FIPS ZONE 4204). The horizontal datum was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

ELEVATION DATUM: Flood elevations on the FIRM are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

Local vertical monuments may have been used to create the map. To obtain current monument information, please contact the appropriate local community listed in Table 31 of this FIS Report.

BASE MAP INFORMATION: Base map information shown on the FIRM was provided in digital format by the Texas Natural Resources Information System (TNRIS). This information was photogrammetrically compiled at a scale of at least 1:24,000 from aerial photography dated 2004. For information about base maps, refer to Section 1.2 "Base Map" in this FIS Report.

Corporate limits shown on the map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after the map was published, map users should contact appropriate community officials to verify current corporate limit locations.

NOTES FOR FIRM INDEX

REVISIONS TO INDEX: As new studies are performed and FIRM panels are updated within Calhoun County, USA, corresponding revisions to the FIRM Index will be incorporated within the FIS Report to reflect the effective dates of those panels. Please refer to the Index Map to determine the most recent FIRM revision date for each community.

FLOOD RISK REPORT: A Flood Risk Report (FRR) may be available for many of the flooding sources and communities referenced in this FIS Report. The FRR is provided to increase public awareness of flood risk by helping communities identify the areas within their jurisdictions that have the greatest risks. Although non-regulatory, the information provided within the FRR can assist communities in assessing and evaluating mitigation opportunities to reduce these risks. It can also be used by communities developing or updating flood risk mitigation plans. These plans allow communities to identify and evaluate opportunities to

reduce potential loss of life and property. However, the FRR is not intended to be the final authoritative source of all flood risk data for a project area; rather, it should be used with other data sources to paint a comprehensive picture of flood risk.

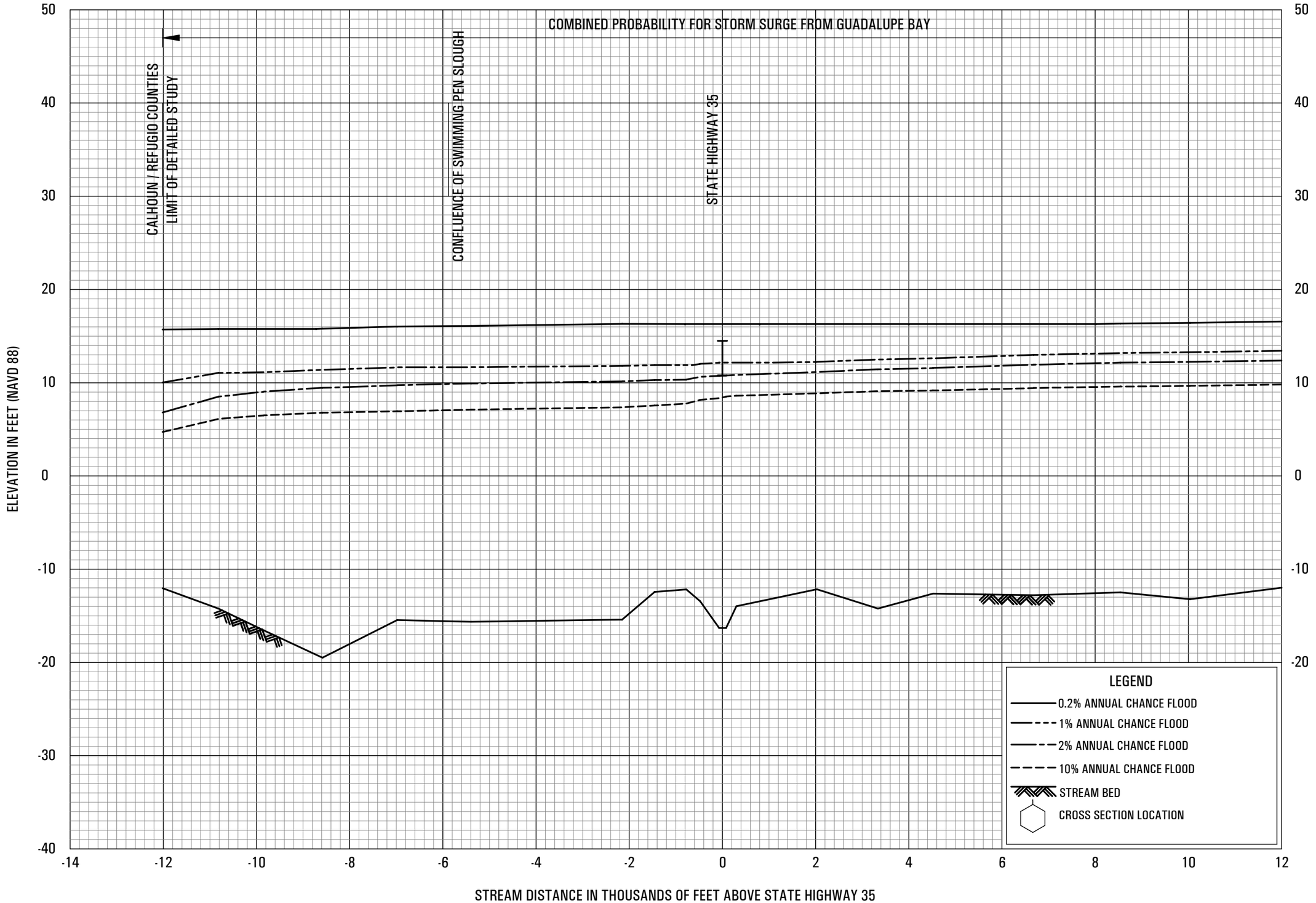
SPECIAL FLOOD HAZARD AREAS: *The 1% annual chance flood, also known as the base flood or 100-year flood, has a 1% chance of happening or being exceeded each year. Special Flood Hazard Areas are subject to flooding by the 1% annual chance flood. The Base Flood Elevation is the water surface elevation of the 1% annual chance flood. The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights. See note for specific types. If the floodway is too narrow to be shown, a note is shown.*

	Special Flood Hazard Areas subject to inundation by the 1% annual chance flood (Zones A, AE, AH, AO, AR, A99, V and VE)
Zone A	The flood insurance rate zone that corresponds to the 1% annual chance floodplains. No base (1% annual chance) flood elevations (BFEs) or depths are shown within this zone.
Zone AE	The flood insurance rate zone that corresponds to the 1% annual chance floodplains. Base flood elevations derived from the hydraulic analyses are shown within this zone, either at cross section locations or as static whole-foot elevations that apply throughout the zone.
Zone AH	The flood insurance rate zone that corresponds to the areas of 1% annual chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the hydraulic analyses are shown at selected intervals within this zone.
Zone AO	The flood insurance rate zone that corresponds to the areas of 1% annual chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the hydraulic analyses are shown within this zone.
Zone AR	The flood insurance rate zone that corresponds to areas that were formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
Zone A99	The flood insurance rate zone that corresponds to areas of the 1% annual chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or flood depths are shown within this zone.
Zone V	The flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations are not shown within this zone.
Zone VE	Zone VE is the flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations derived from the coastal analyses are shown within this zone as static whole-foot elevations that apply throughout the zone.

	Regulatory Floodway determined in Zone AE.
	Non-encroachment zone (see Section 2.4 of this FIS Report for more information)
FLOOD INSURANCE IS NOT AVAILABLE FOR STRUCTURES NEWLY BUILT OR SUBSTANTIALLY IMPROVED ON OR AFTER APRIL 8, 1987, IN THE DESIGNATED COLORADO RIVER FLOODWAY	The Colorado River Floodway was established by Congress in the Colorado River Floodway Protection Act of 1986, Public Law 99-450 (100 Statute 1129). The Act imposes certain restrictions within the Floodway.
OTHER AREAS OF FLOOD HAZARD	
	Shaded Zone X: Areas of 0.2% annual chance flood hazards and areas of 1% annual chance flood hazards with average depths of less than 1 foot or with drainage areas less than 1 square mile.
	Future Conditions 1% Annual Chance Flood Hazard – Zone X: The flood insurance rate zone that corresponds to the 1% annual chance floodplains that are determined based on future-conditions hydrology. No base flood elevations or flood depths are shown within this zone.
	Area with Reduced Flood Risk due to Levee: Areas where an accredited levee, dike, or other flood control structure has reduced the flood risk from the 1% annual chance flood. See Notes to Users for important information.
OTHER AREAS	
	Zone D (Areas of Undetermined Flood Hazard): The flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.
NO SCREEN	Unshaded Zone X: Areas of minimal flood hazard.
FLOOD HAZARD AND OTHER BOUNDARY LINES	
(ortho) **(vector)**	Flood Zone Boundary (white line on ortho-photography-based mapping; gray line on vector-based mapping)
	Limit of Study
	Jurisdiction Boundary
	Limit of Moderate Wave Action (LiMWA): Indicates the inland limit of the area affected by waves greater than 1.5 feet
	GENERAL STRUCTURES
Aqueduct *Channel* *Culvert* *Storm Sewer*	Channel, Culvert, Aqueduct, or Storm Sewer

Dam *Jetty* *Weir*	Dam, Jetty, Weir
	Levee, Dike, or Floodwall accredited or provisionally accredited to reduce the flood risk from the 1% annual chance flood.
	Levee, Dike or Floodwall not accredited to reduce the flood risk from the 1% annual chance flood.
Bridge	Bridge
COASTAL BARRIER RESOURCES SYSTEM (CBRS) AND OTHERWISE PROTECTED AREAS (OPA): *CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas. See Notes to Users for important information.*	
CBRS AREA **09/30/2009**	Coastal Barrier Resources System Area: Labels are shown to clarify where this area shares a boundary with an incorporated area or overlaps with the floodway.
OTHERWISE PROTECTED AREA **09/30/2009**	Otherwise Protected Area
REFERENCE MARKERS	
22.0	River mile Markers
CROSS SECTION & TRANSECT INFORMATION	
B 20.2	Lettered Cross Section with Regulatory Water Surface Elevation (BFE)
5280 21.1	Numbered Cross Section with Regulatory Water Surface Elevation (BFE)
17.5	Unlettered Cross Section with Regulatory Water Surface Elevation (BFE)
8	Coastal Transect
	Profile Baseline: Indicates the modeled flow path of a stream and is shown on FIRM panels for all valid studies with profiles or otherwise established base flood elevation.
	Coastal Transect Baseline: Used in the coastal flood hazard model to represent the 0.0-foot elevation contour and the starting point for the transect and the measuring point for the coastal mapping.
513	Base Flood Elevation Line (shown for flooding sources for which no cross sections or profile are available)

ZONE AE (EL 16)	Static Base Flood Elevation value (shown under zone label)
ZONE AO (DEPTH 2)	Zone designation with Depth
ZONE AO (DEPTH 2) (VEL 15 FPS)	Zone designation with Depth and Velocity
BASE MAP FEATURES	
Missouri Creek	River, Stream or Other Hydrographic Feature
234	Interstate Highway
234	U.S. Highway
234	State Highway
234	County Highway
MAPLE LANE	Street, Road, Avenue Name, or Private Drive if shown on Flood Profile
RAILROAD	Railroad
	Horizontal Reference Grid Line
—	Horizontal Reference Grid Ticks
+	Secondary Grid Crosshairs
Land Grant	Name of Land Grant
7	Section Number
R. 43 W. T. 22 N.	Range, Township Number
$^{42}76^{000m}$E	Horizontal Reference Grid Coordinates (UTM)
365000 FT	Horizontal Reference Grid Coordinates (State Plane)
80° 16’ 52.5”	Corner Coordinates (Latitude, Longitude)



FLOOD PROFILES

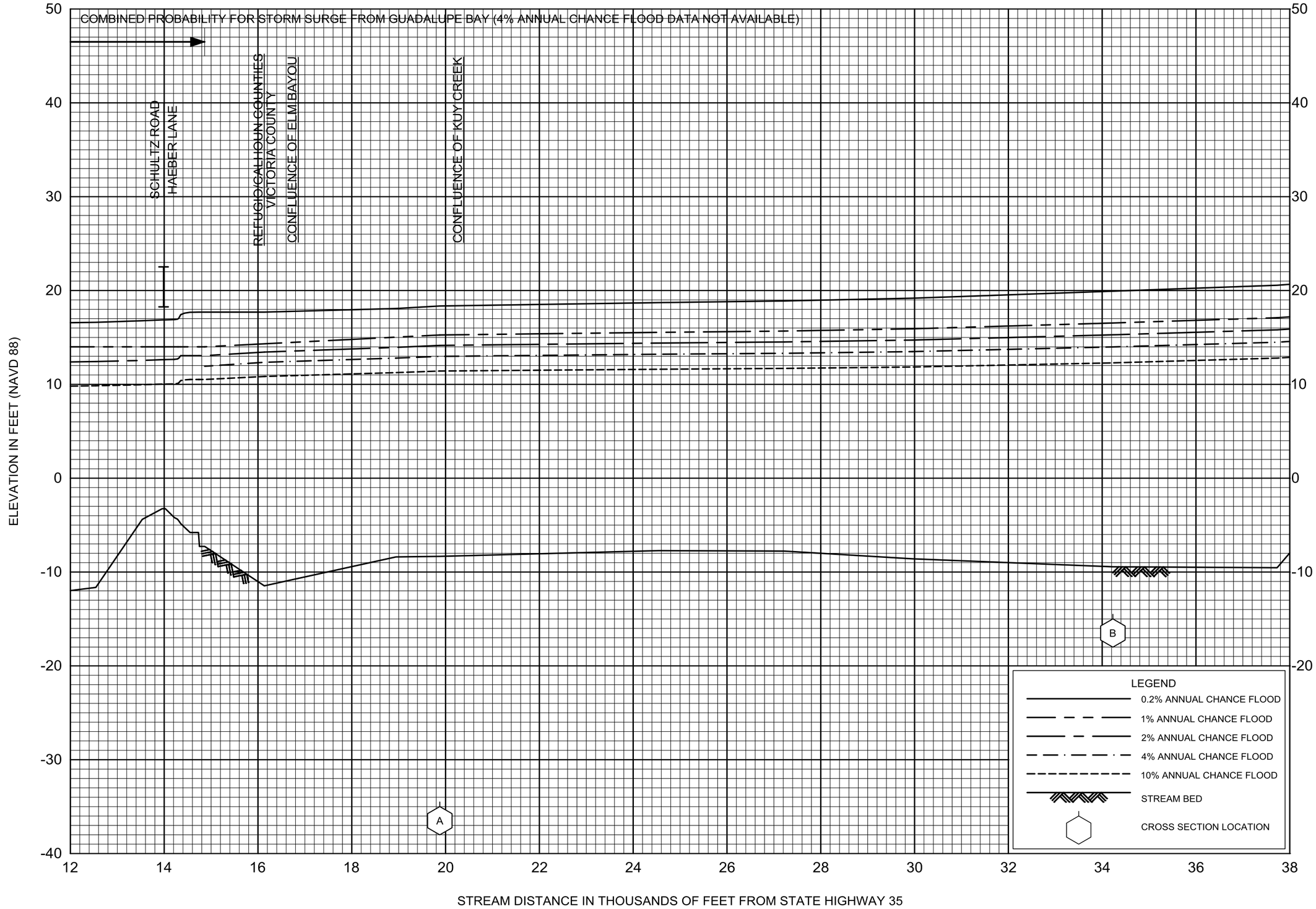
GUADALUPE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

01P



FLOOD PROFILES

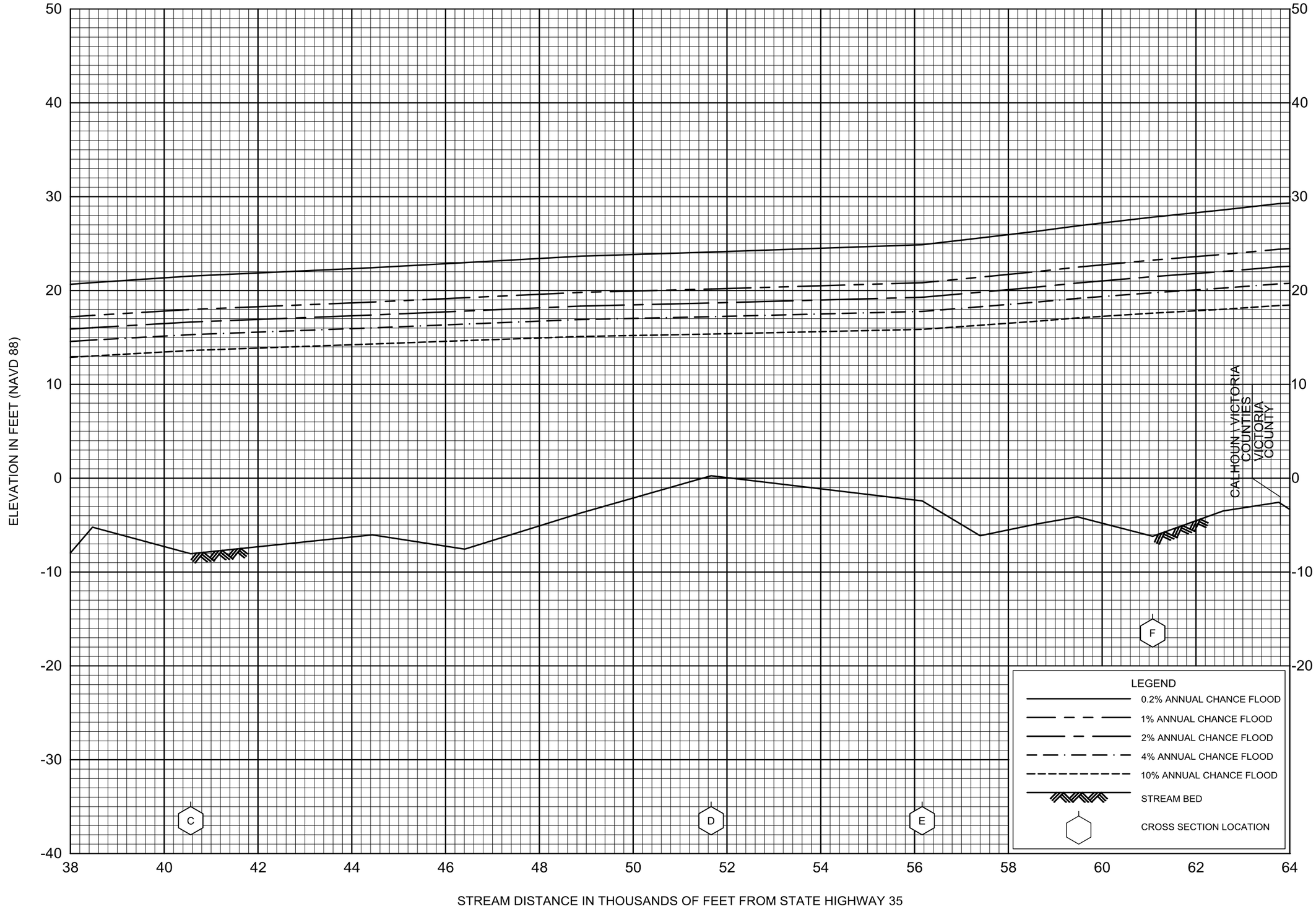
GUADALUPE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

02P



FLOOD PROFILES

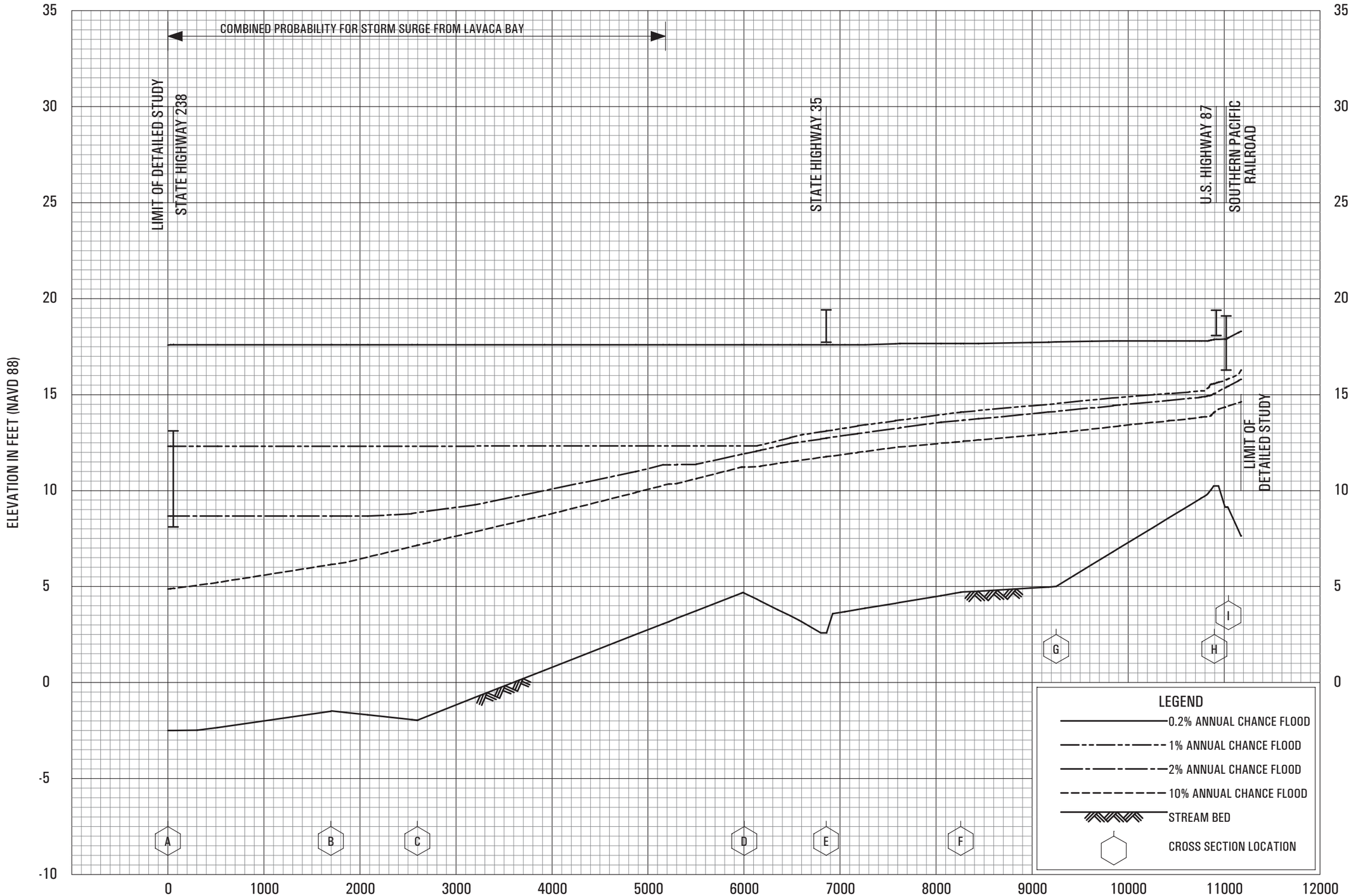
GUADALUPE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

03P



* DOWNSTREAM LIMIT OF DETAILED STUDY IS LOCATED APPROXIMATELY 50 FEET DOWNSTREAM OF STATE HIGHWAY 238

STREAM DISTANCE IN FEET ABOVE DOWNSTREAM LIMIT OF DETAILED STUDY

FLOOD PROFILES

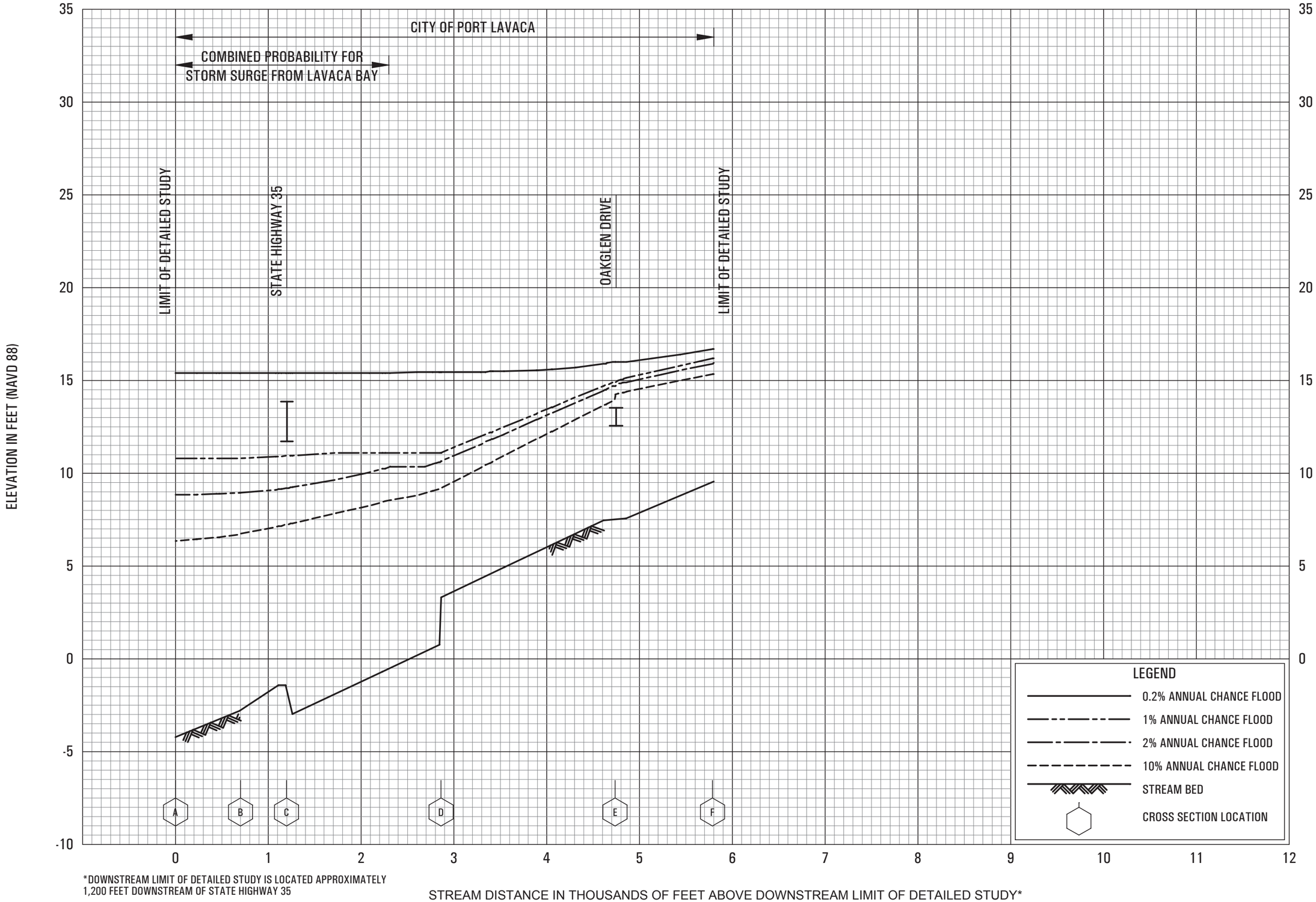
LITTLE CHOCOLATE BAYOU

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

04P



FLOOD PROFILES

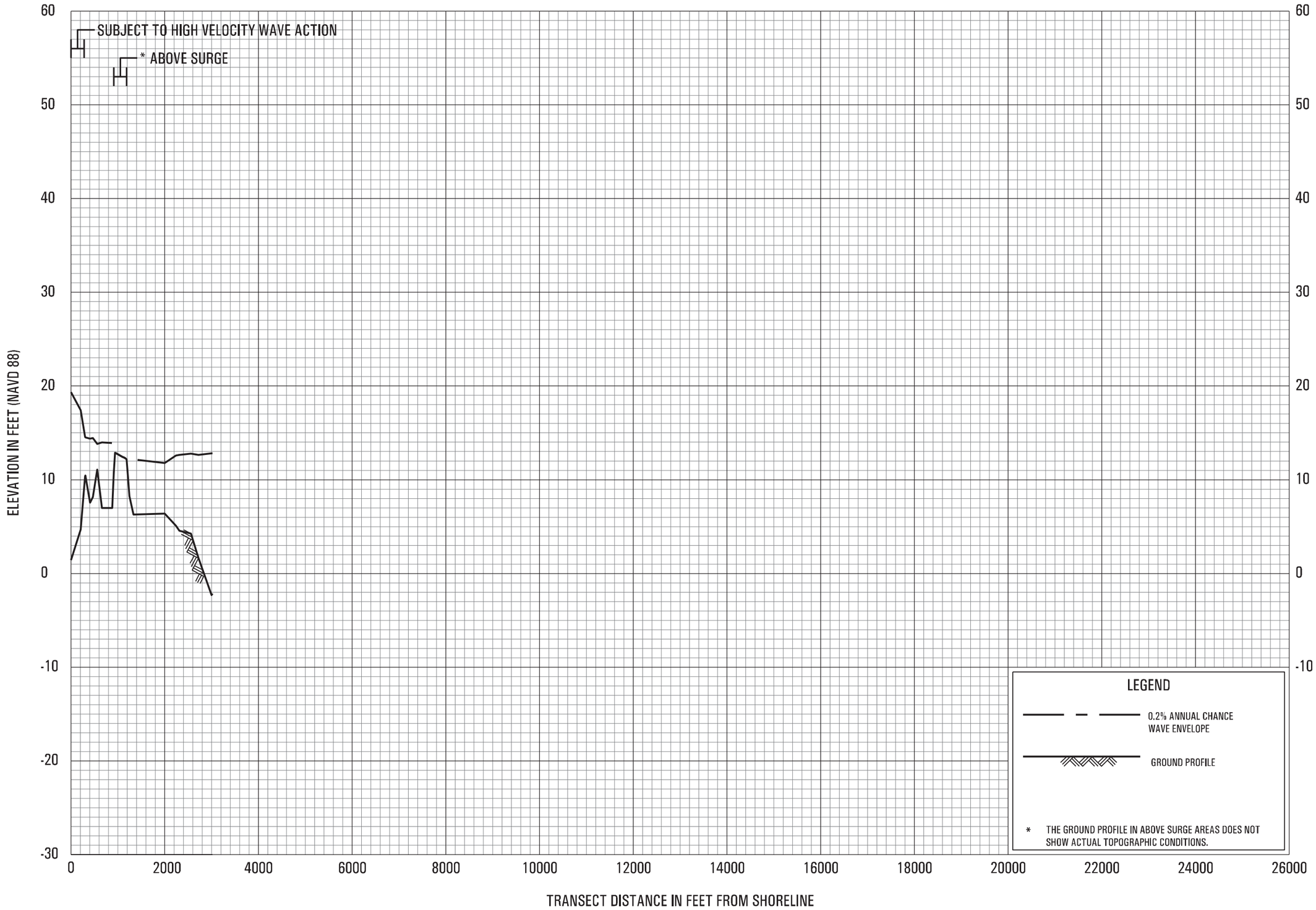
LYNN BAYOU

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

05P



0.2% ANNUAL CHANCE WAVE ENVELOPE

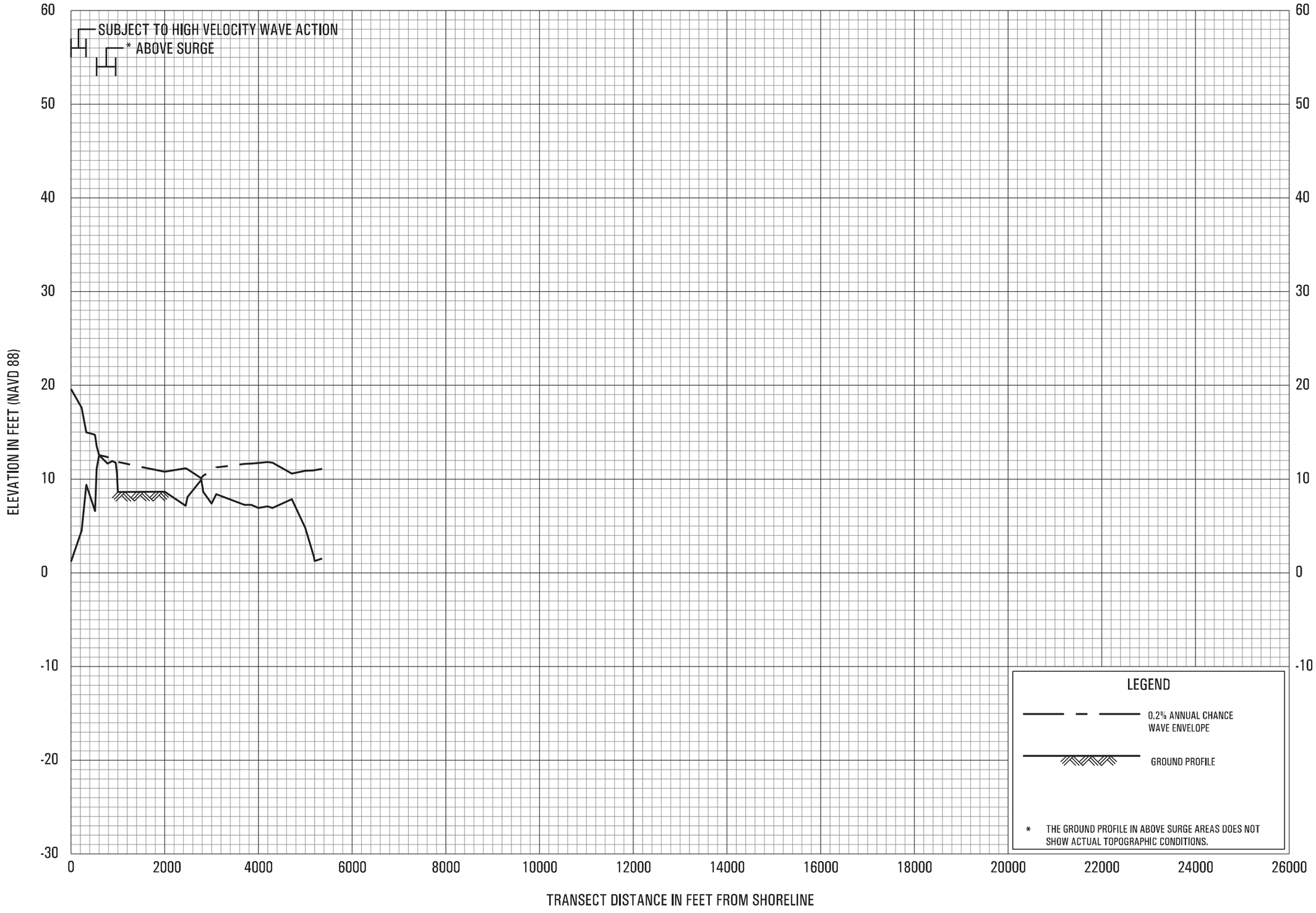
TRANSECT 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

01T



0.2% ANNUAL CHANCE WAVE ENVELOPE

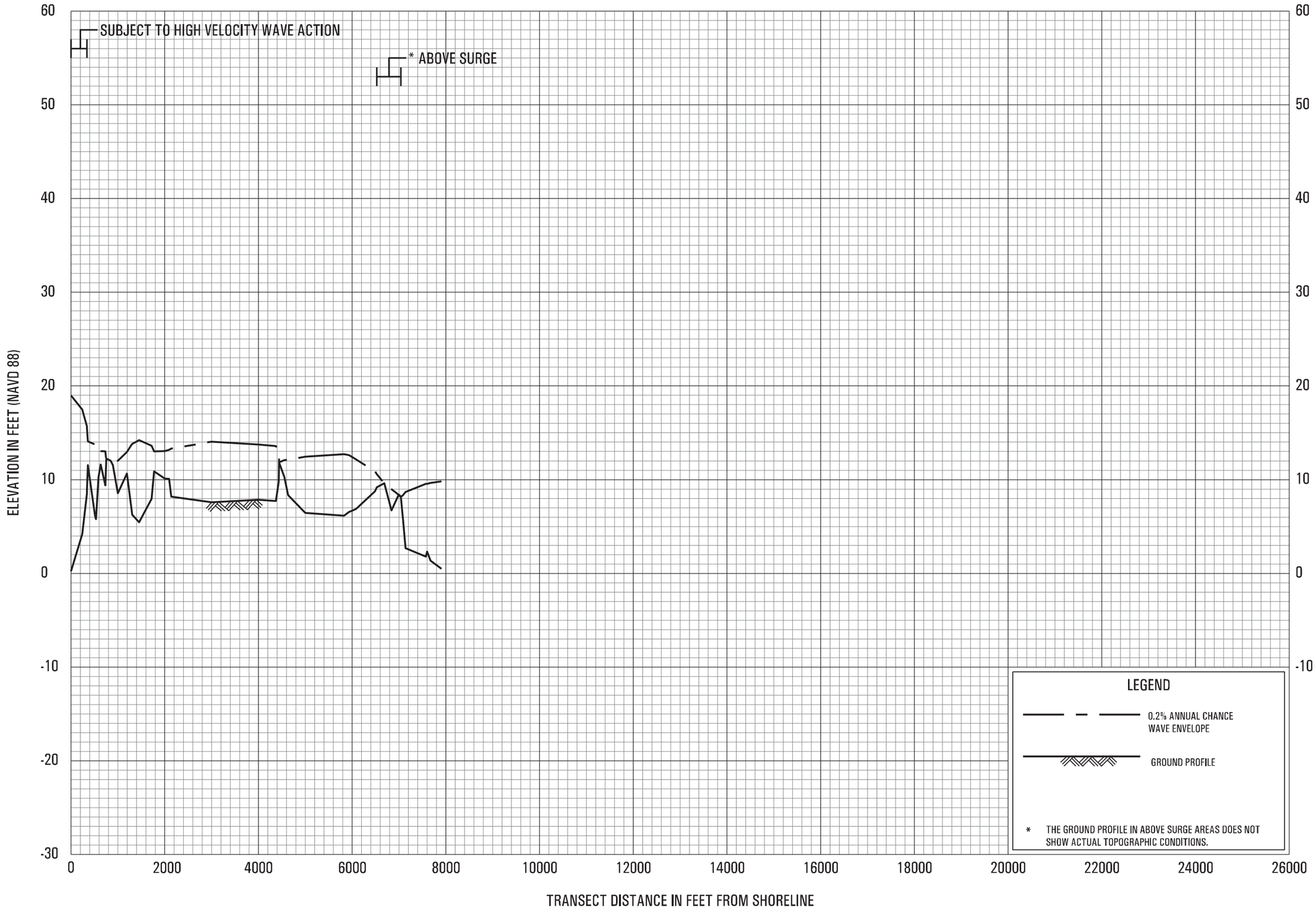
TRANSECT 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

02T



0.2% ANNUAL CHANCE WAVE ENVELOPE

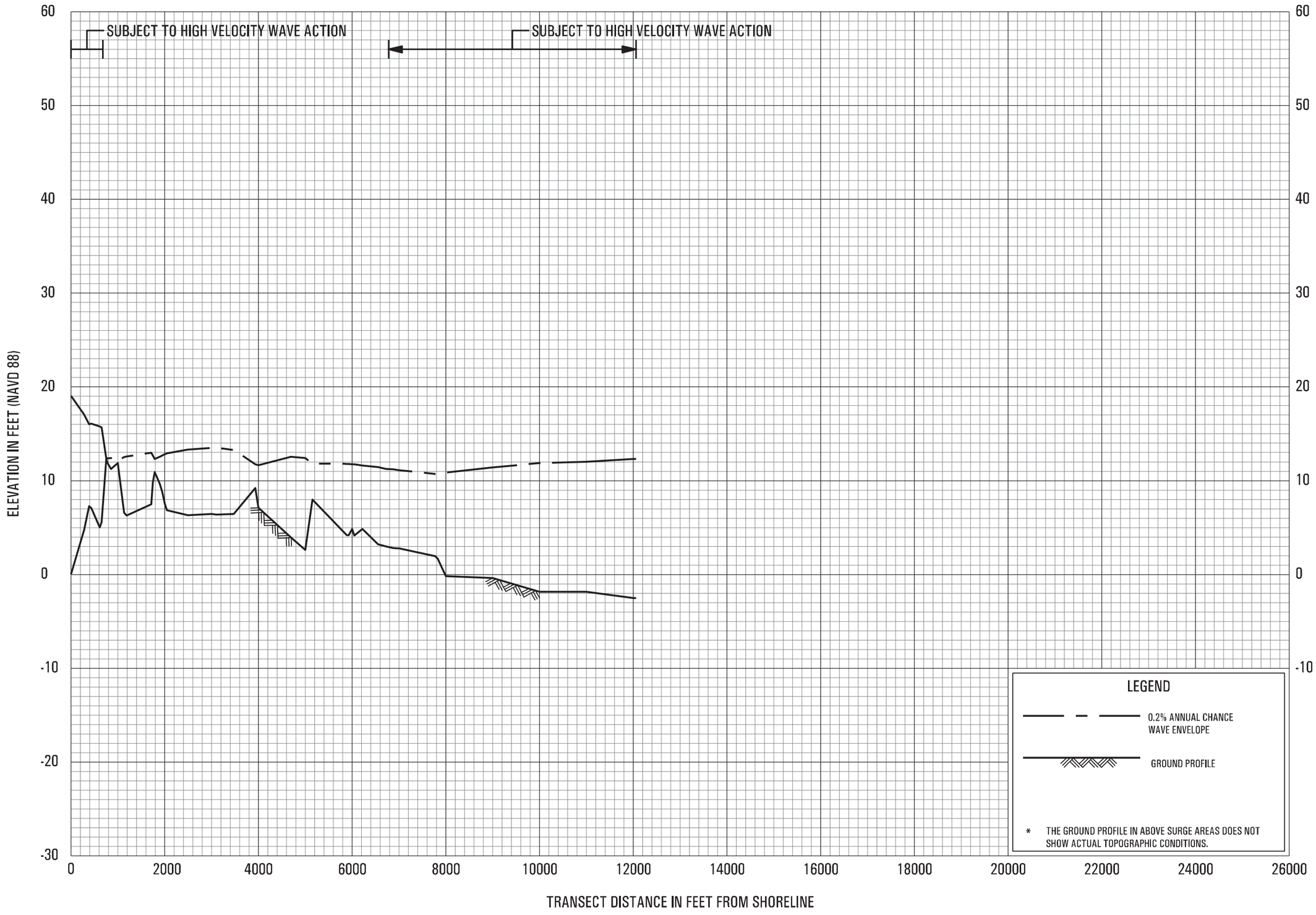
TRANSECT 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

03T



0.2% ANNUAL CHANCE WAVE ENVELOPE

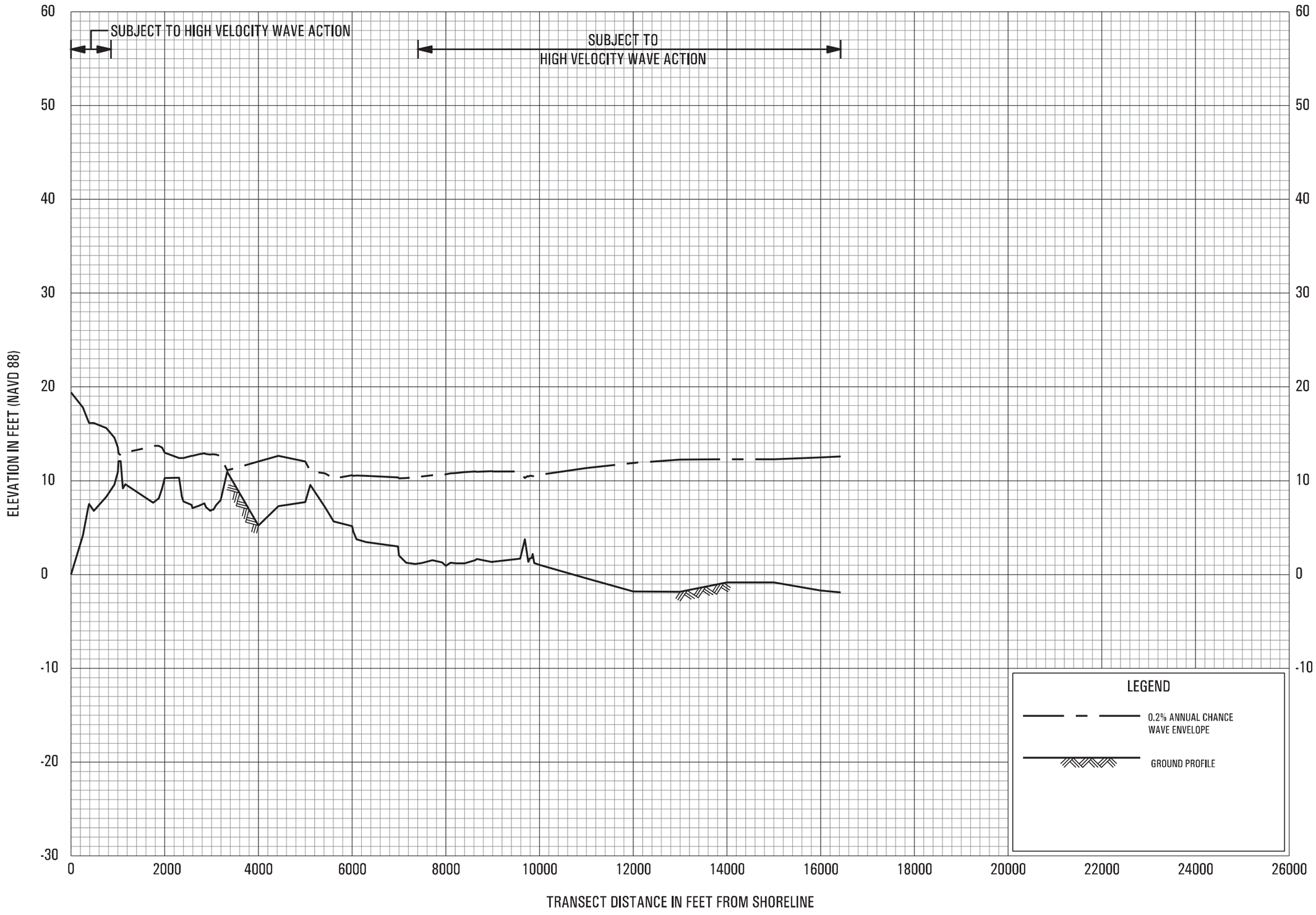
TRANSECT 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

04T



0.2% ANNUAL CHANCE WAVE ENVELOPE

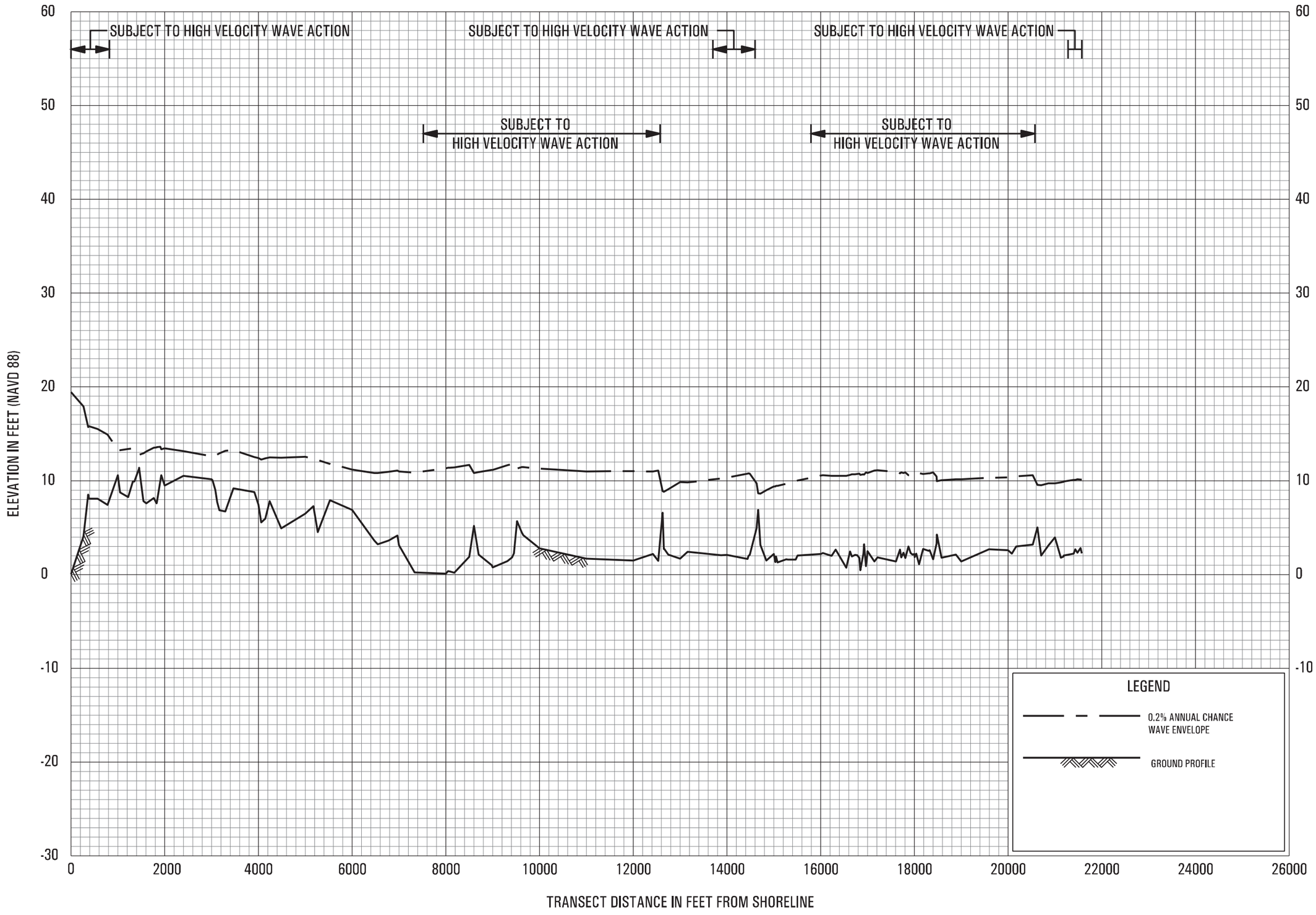
TRANSECT 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

05 T



0.2% ANNUAL CHANCE WAVE ENVELOPE

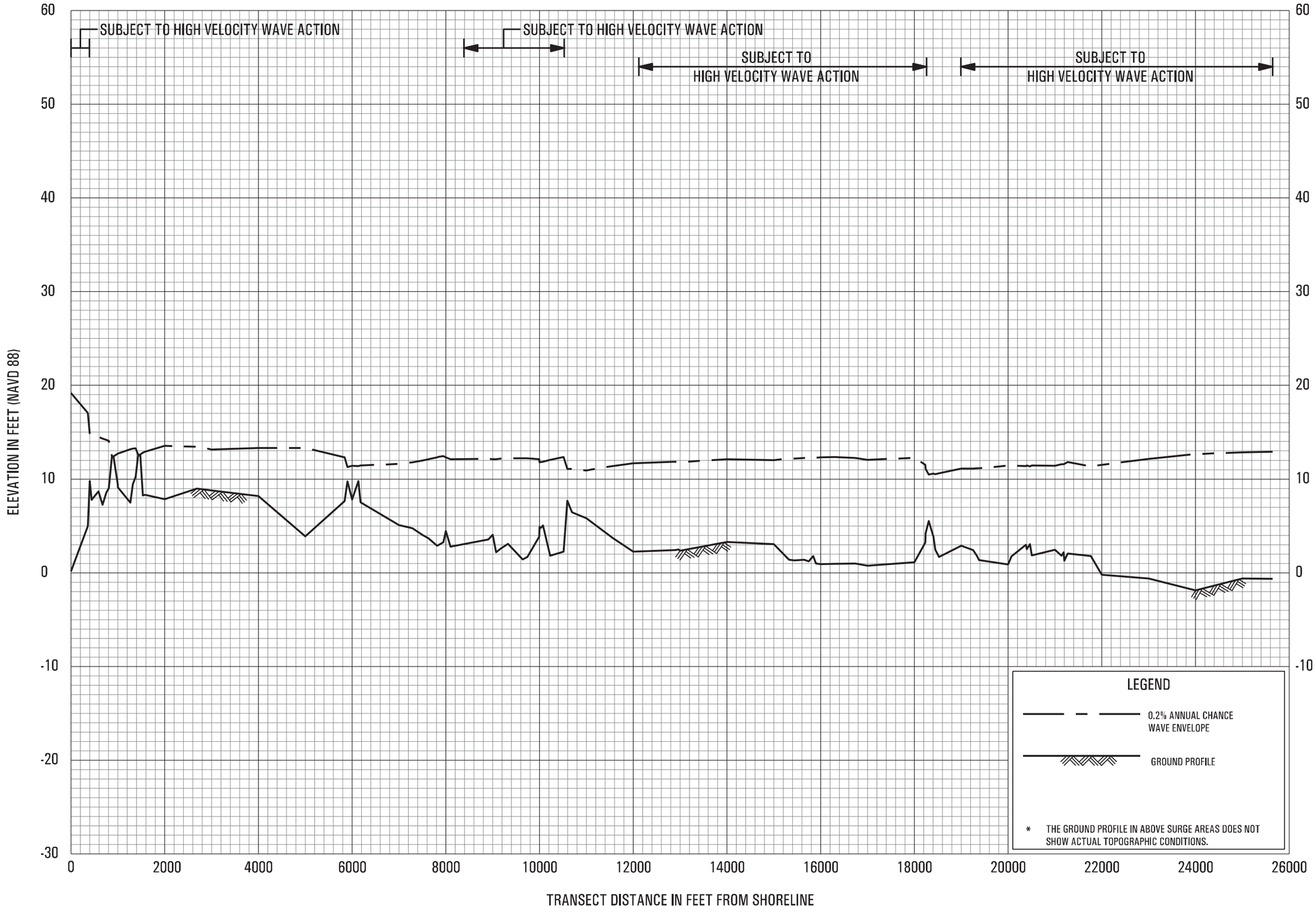
TRANSECT 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

06 T



0.2% ANNUAL CHANCE WAVE ENVELOPE

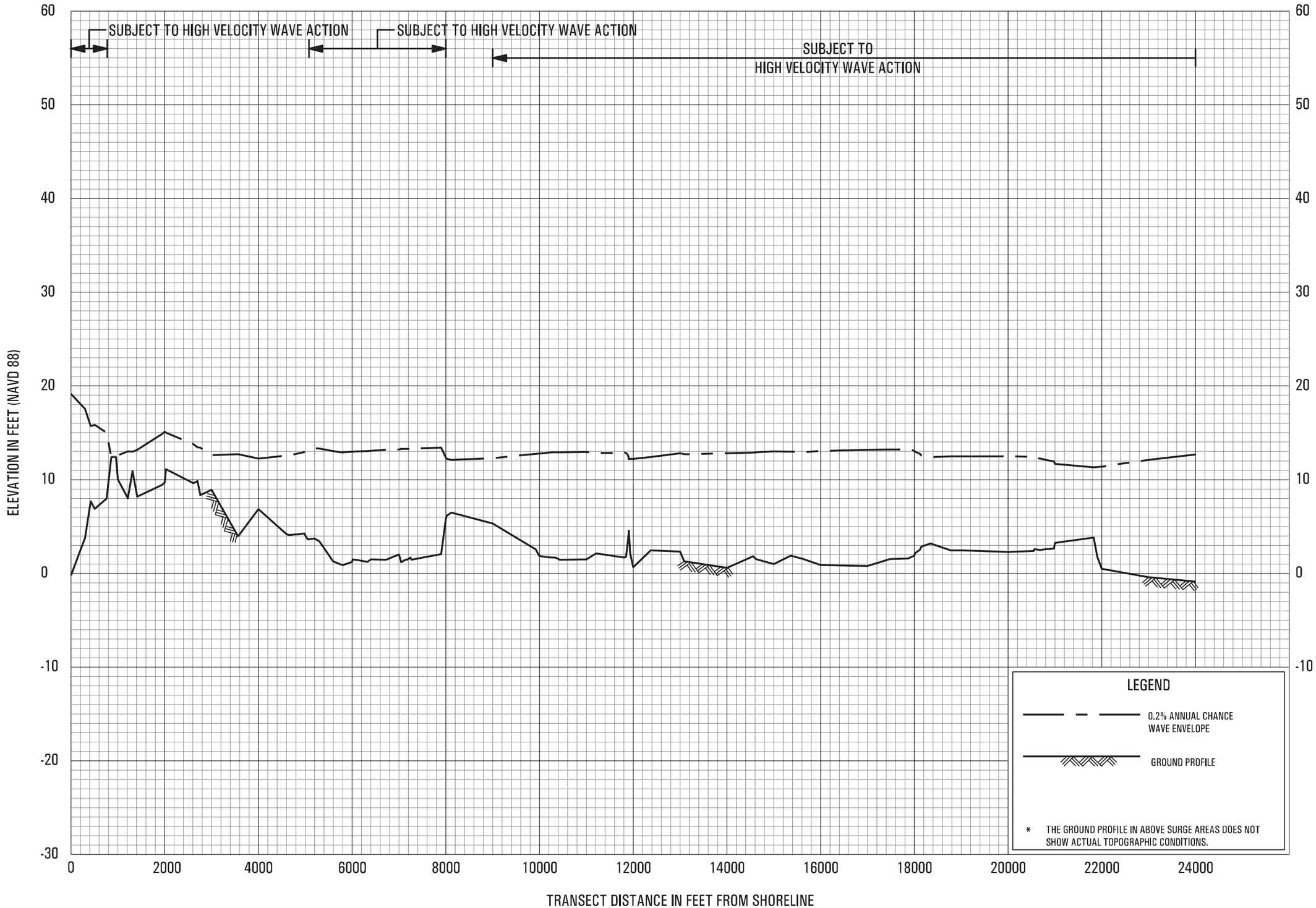
TRANSECT 7

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

07T



0.2% ANNUAL CHANCE WAVE ENVELOPE

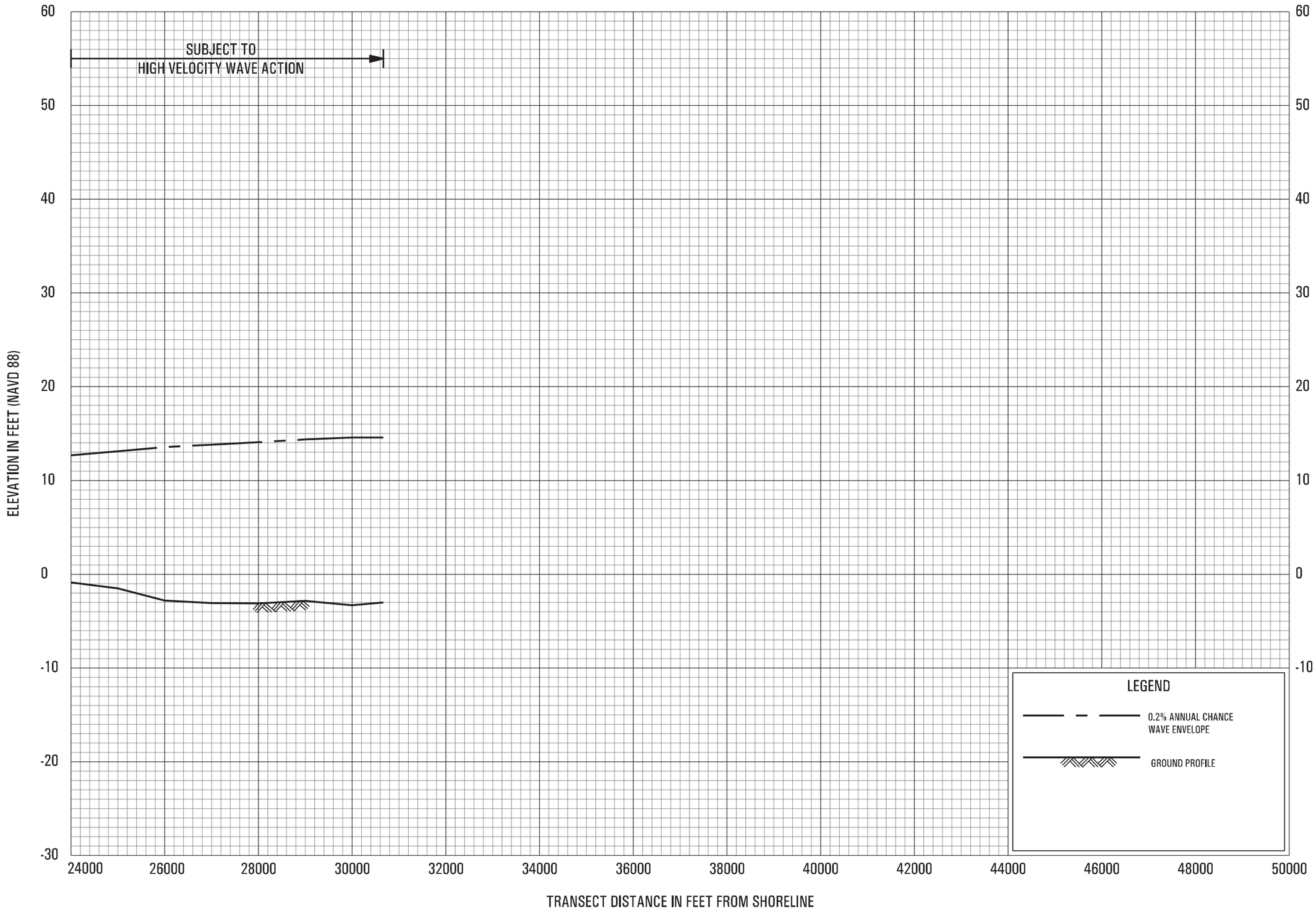
TRANSECT 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

08 T



0.2% ANNUAL CHANCE WAVE ENVELOPE

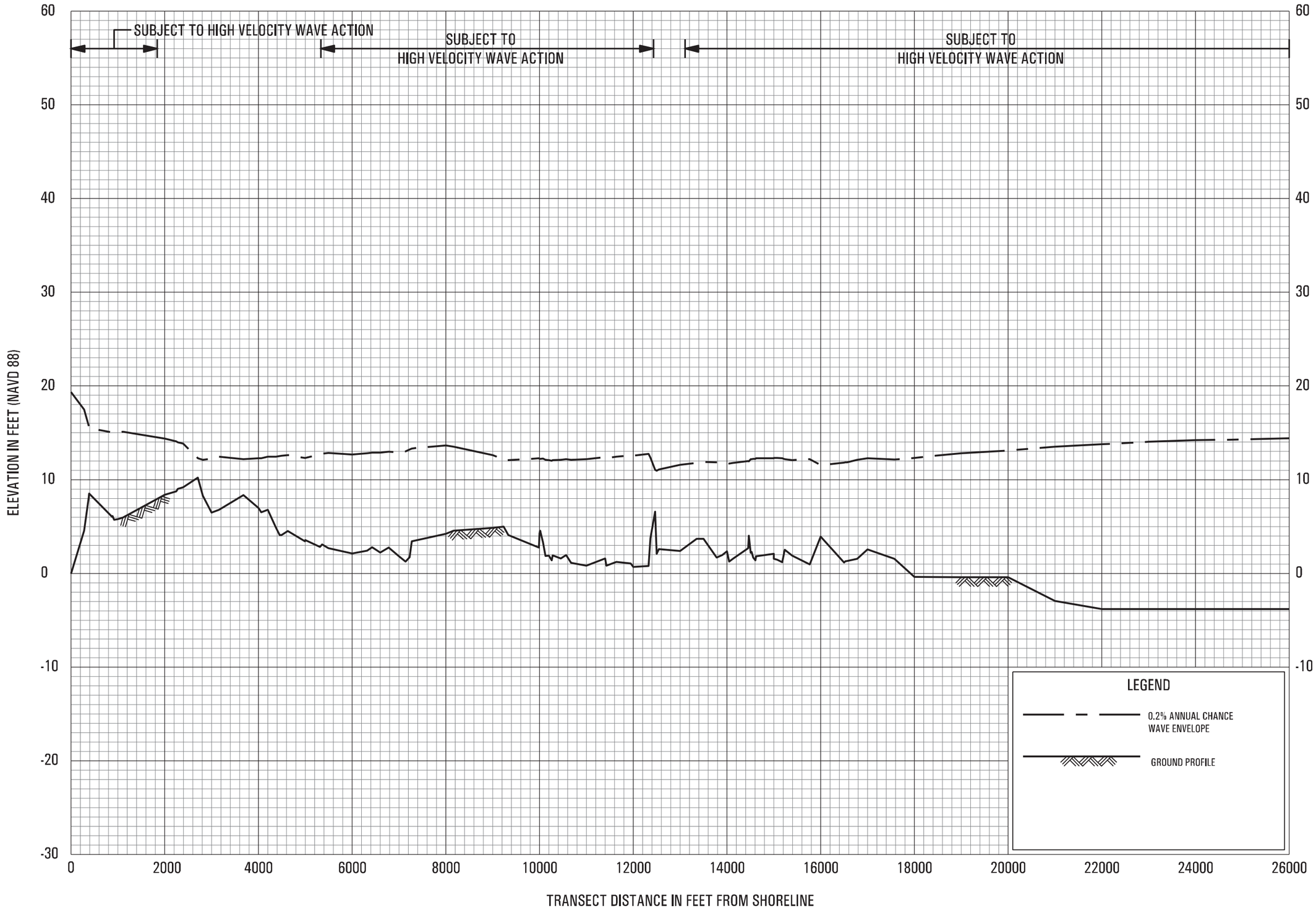
TRANSECT 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

09 T



0.2% ANNUAL CHANCE WAVE ENVELOPE

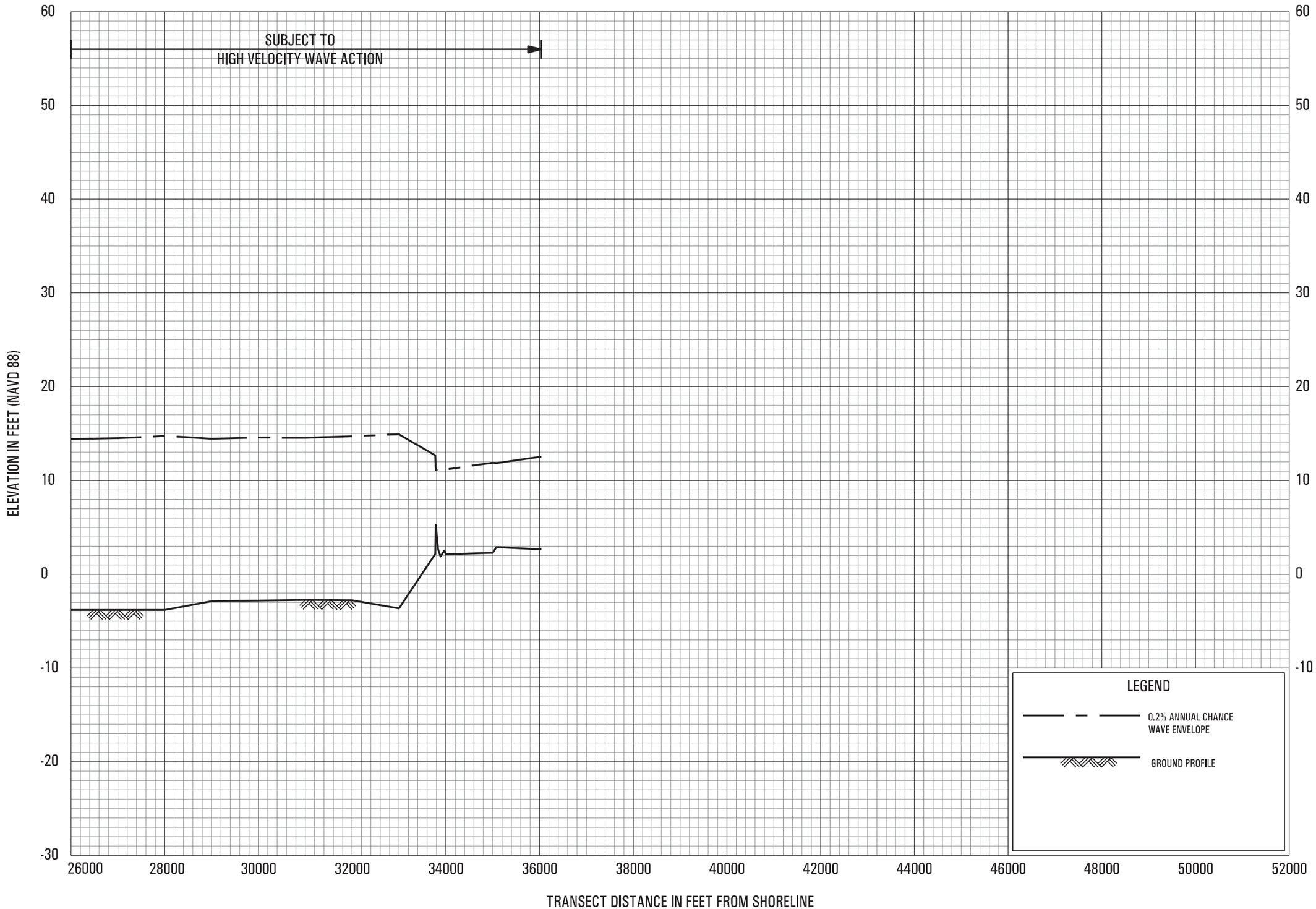
TRANSECT 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

10T



0.2% ANNUAL CHANCE WAVE ENVELOPE

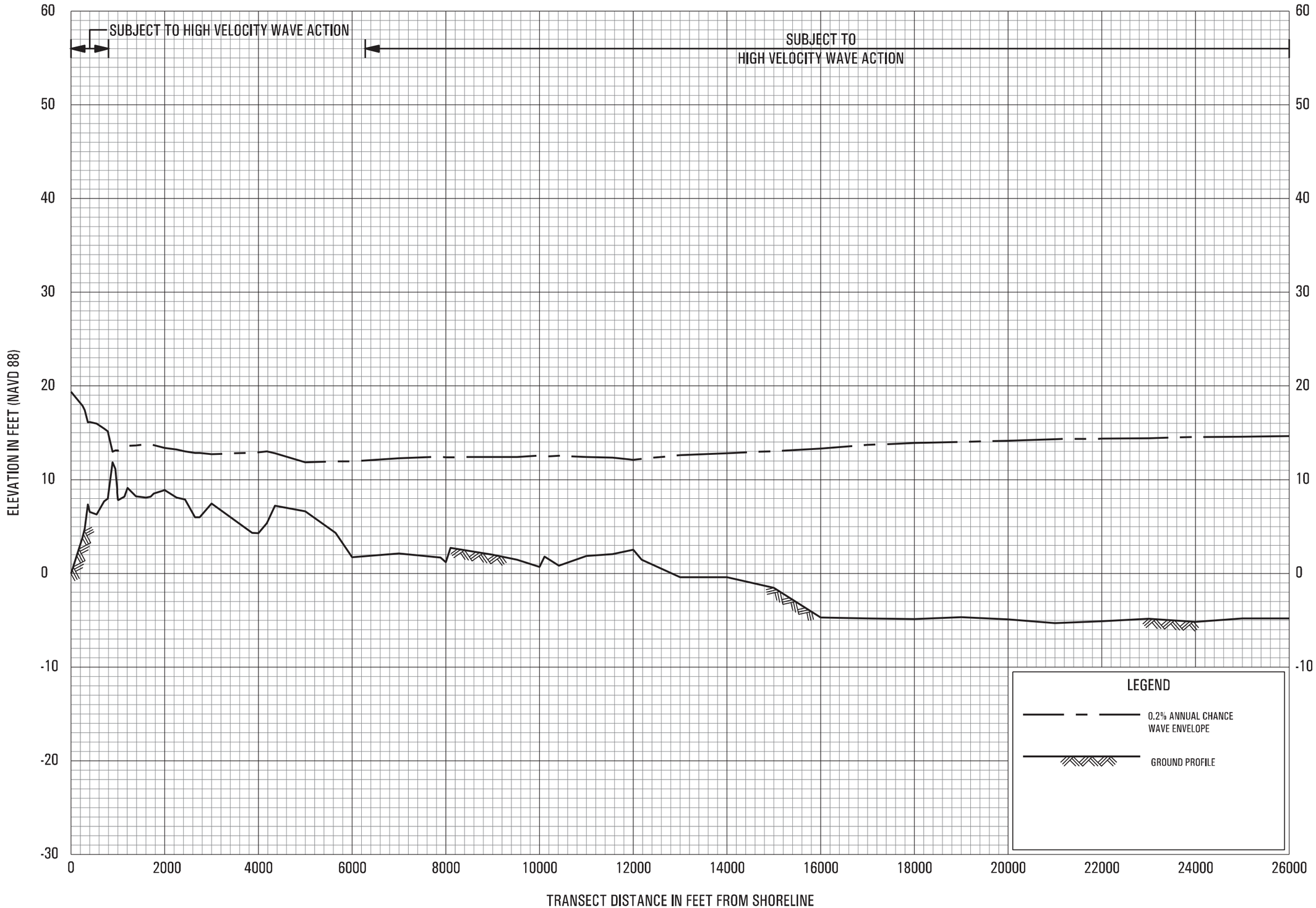
TRANSECT 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

11T



0.2% ANNUAL CHANCE WAVE ENVELOPE

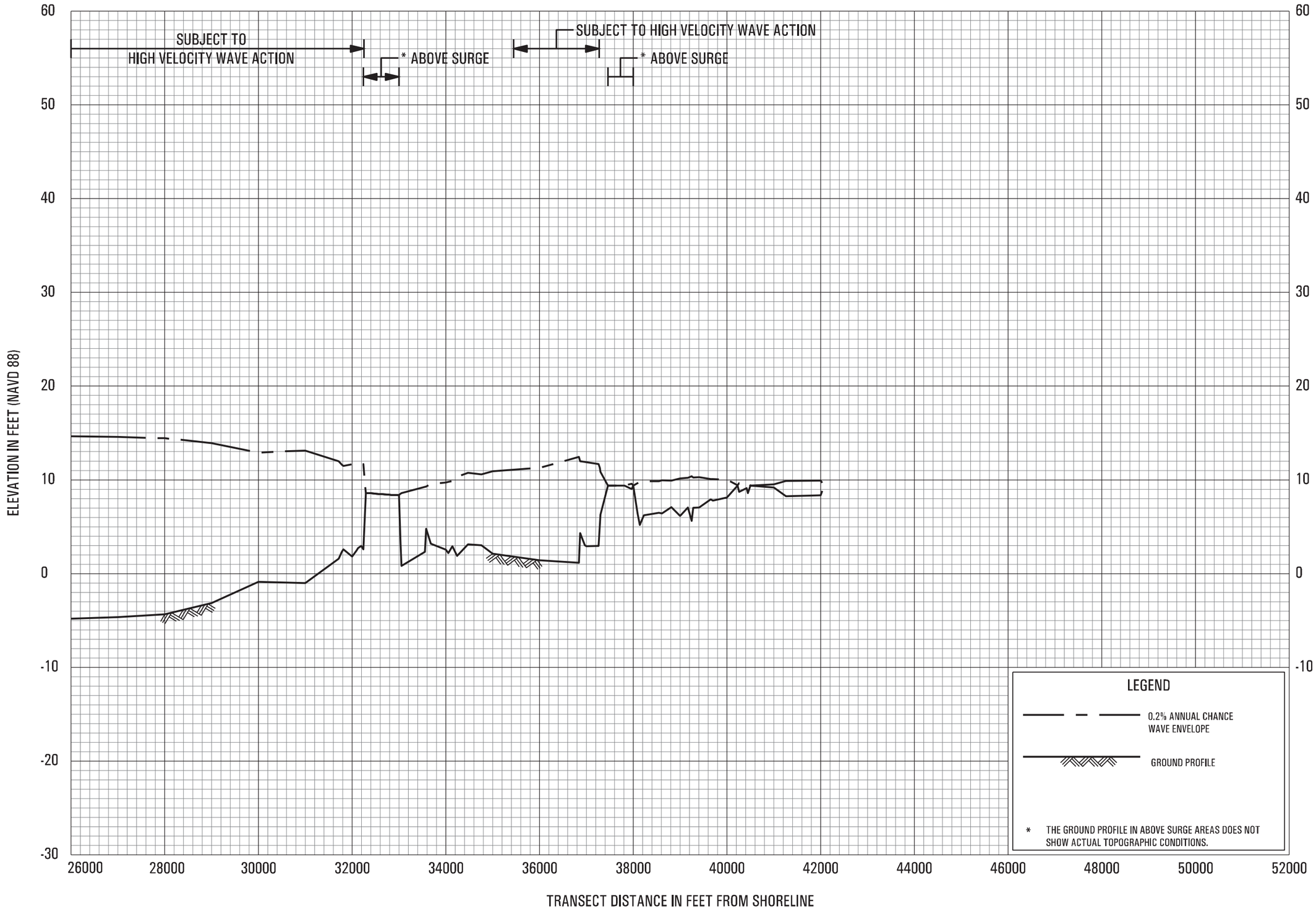
TRANSECT 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

12T



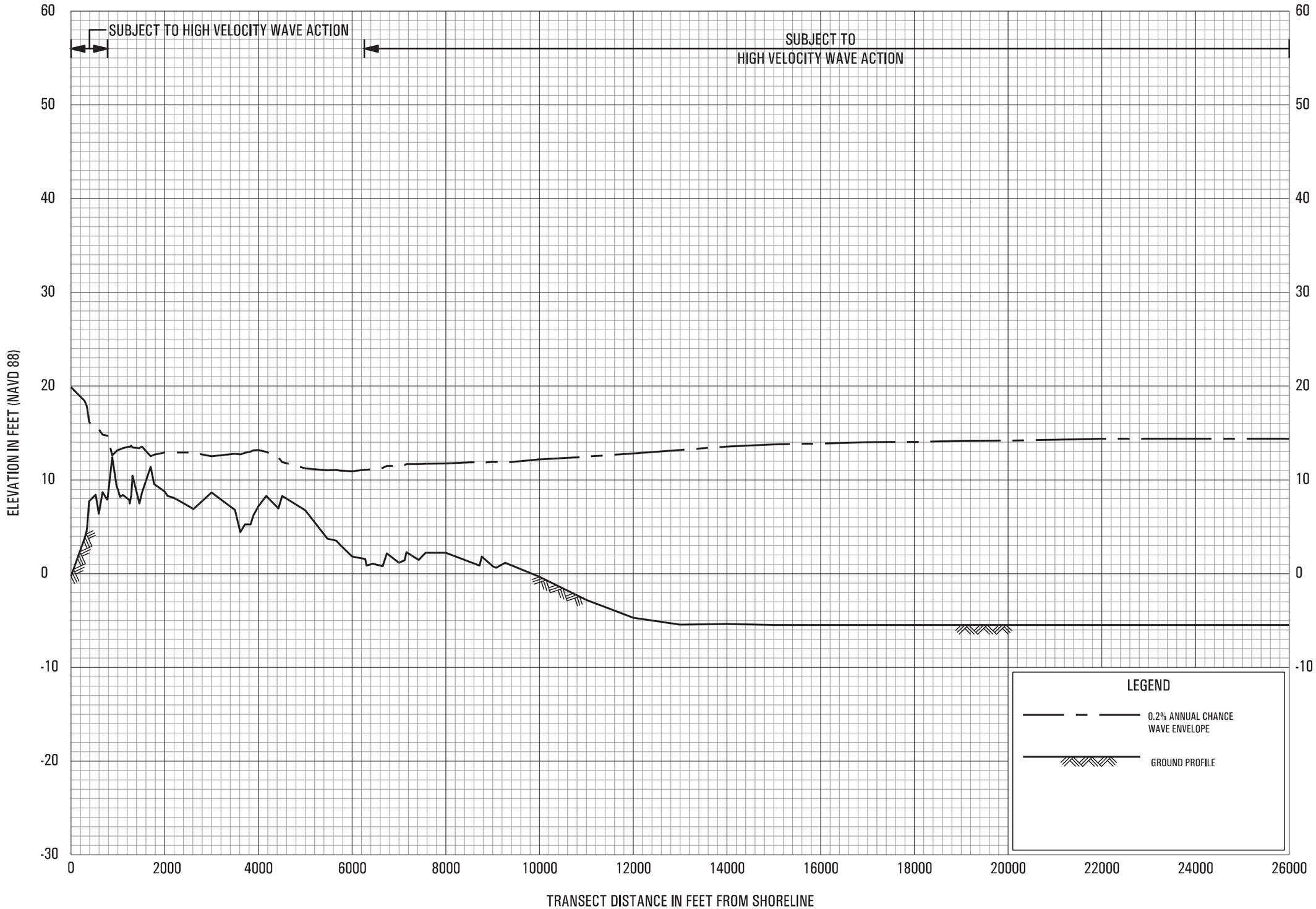
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX
AND INCORPORATED AREAS

13T



0.2% ANNUAL CHANCE WAVE ENVELOPE

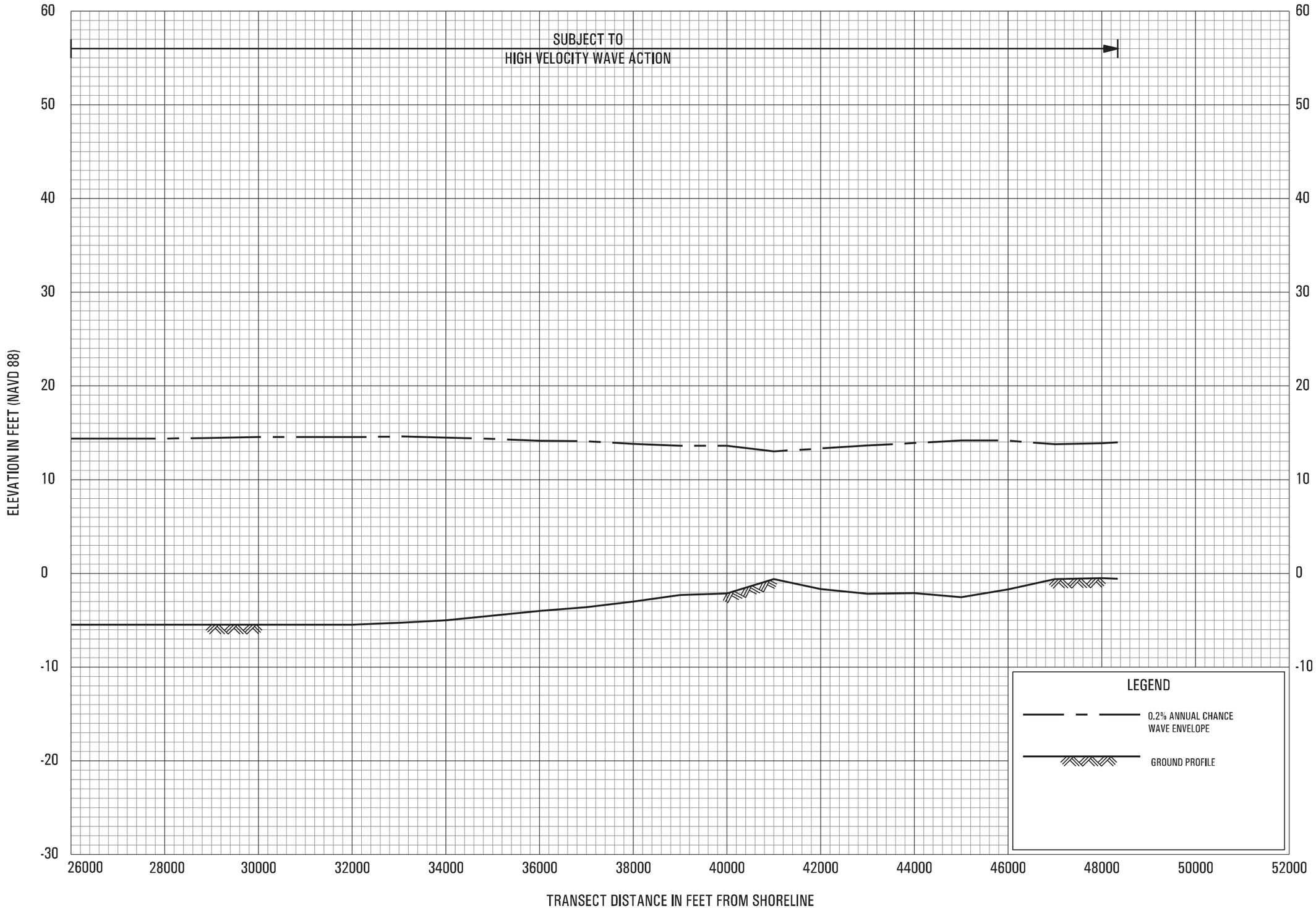
TRANSECT 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

14 T



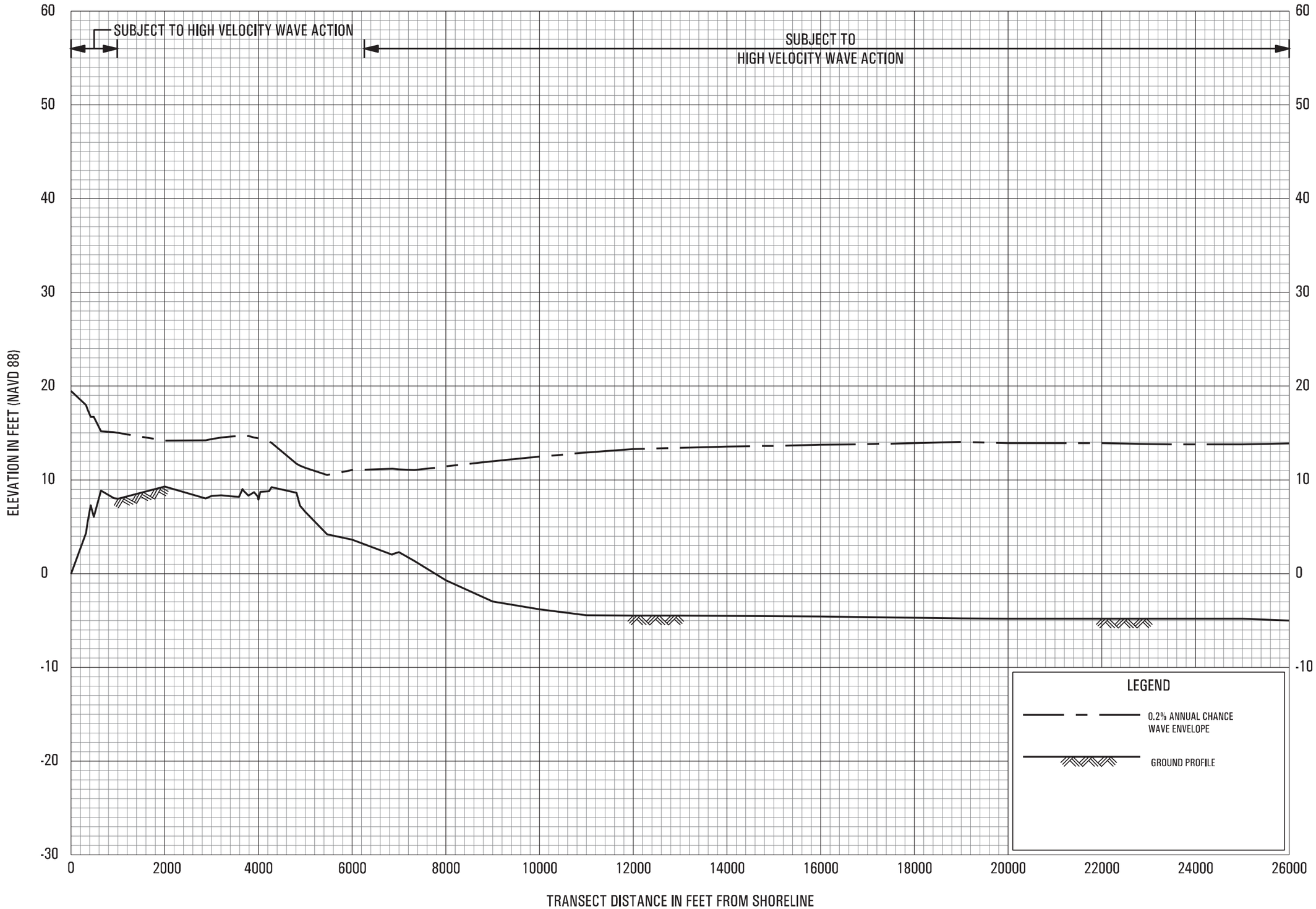
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



0.2% ANNUAL CHANCE WAVE ENVELOPE

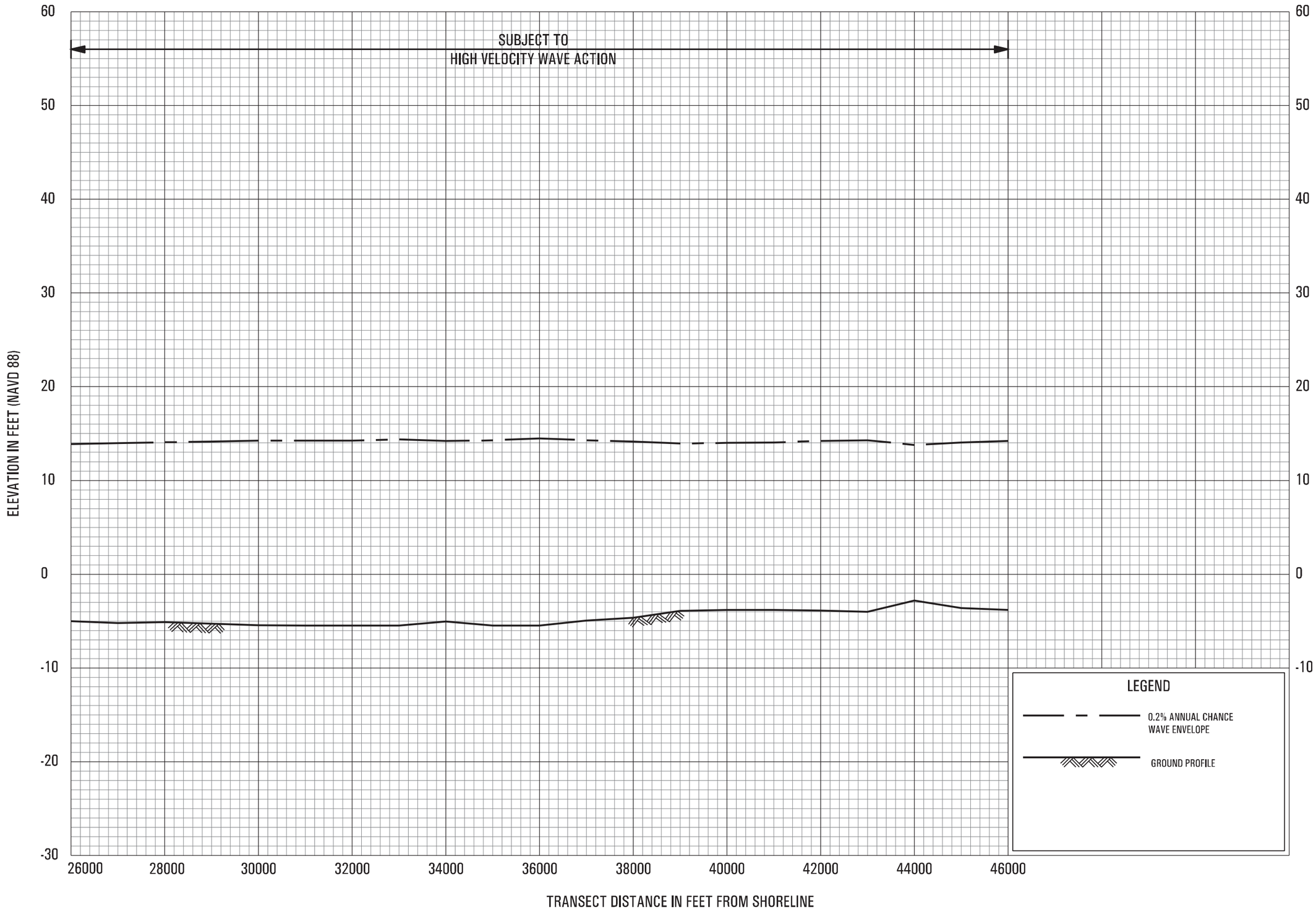
TRANSECT 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

16T



0.2% ANNUAL CHANCE WAVE ENVELOPE

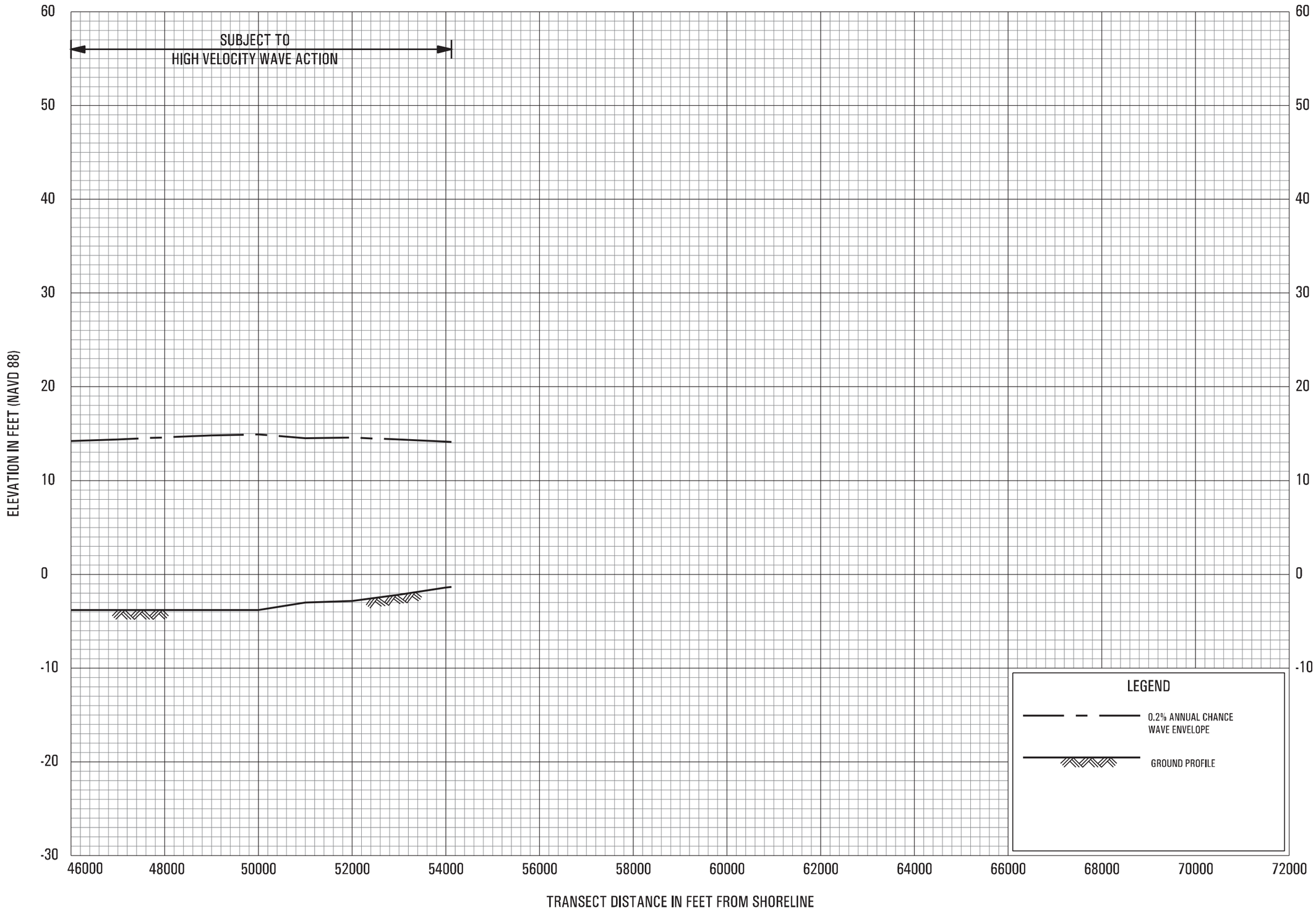
TRANSECT 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

17T



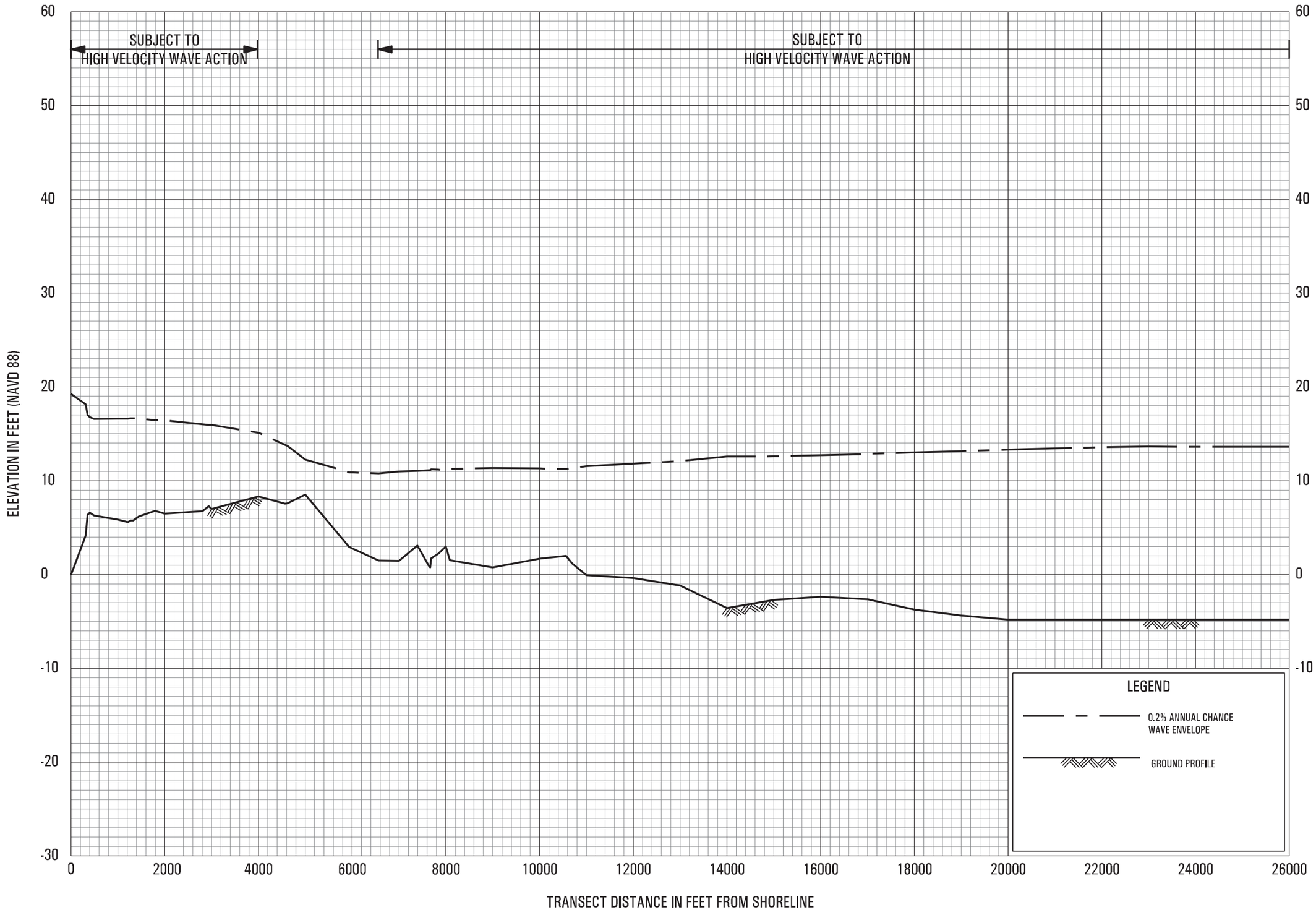
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



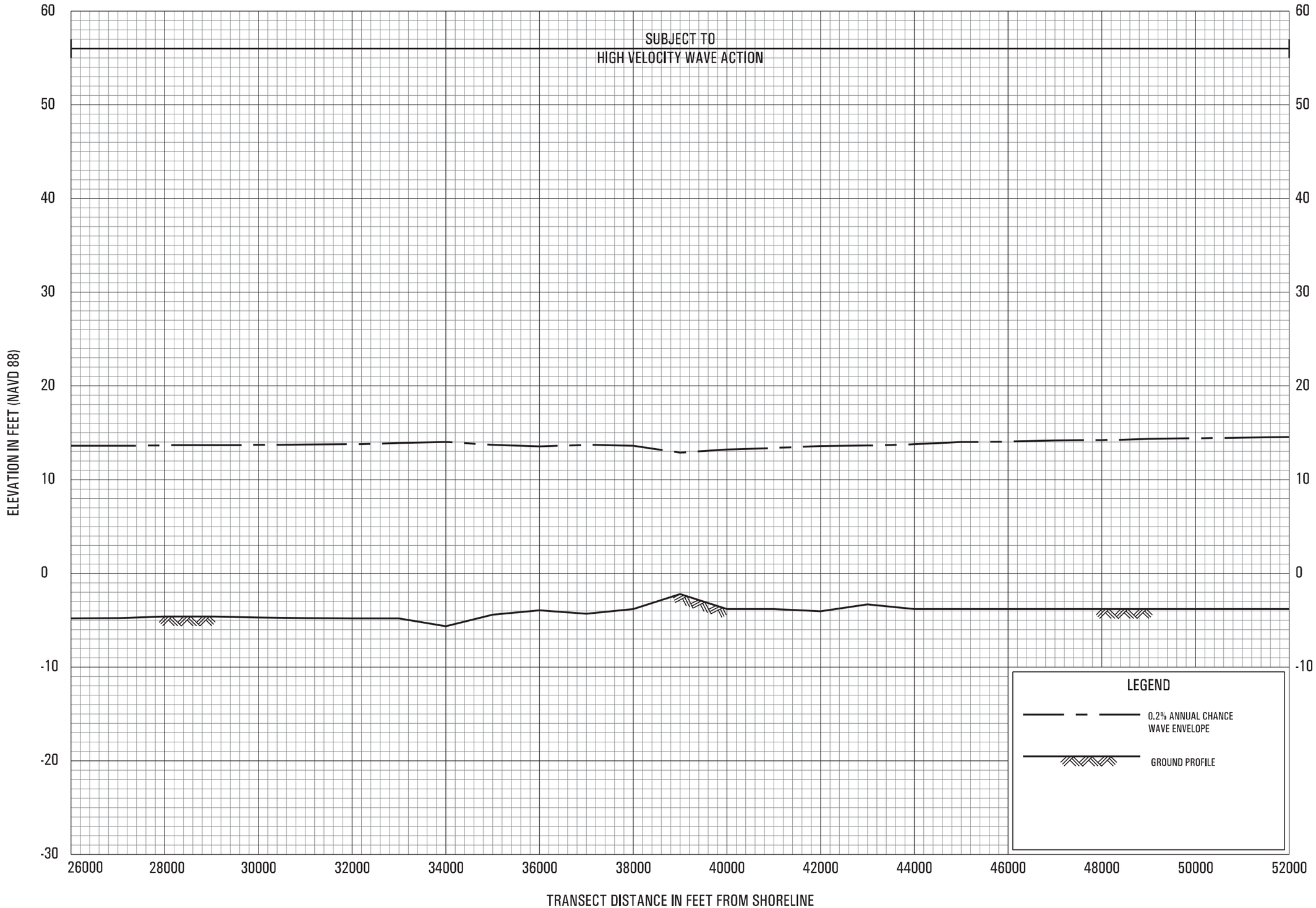
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



0.2% ANNUAL CHANCE WAVE ENVELOPE

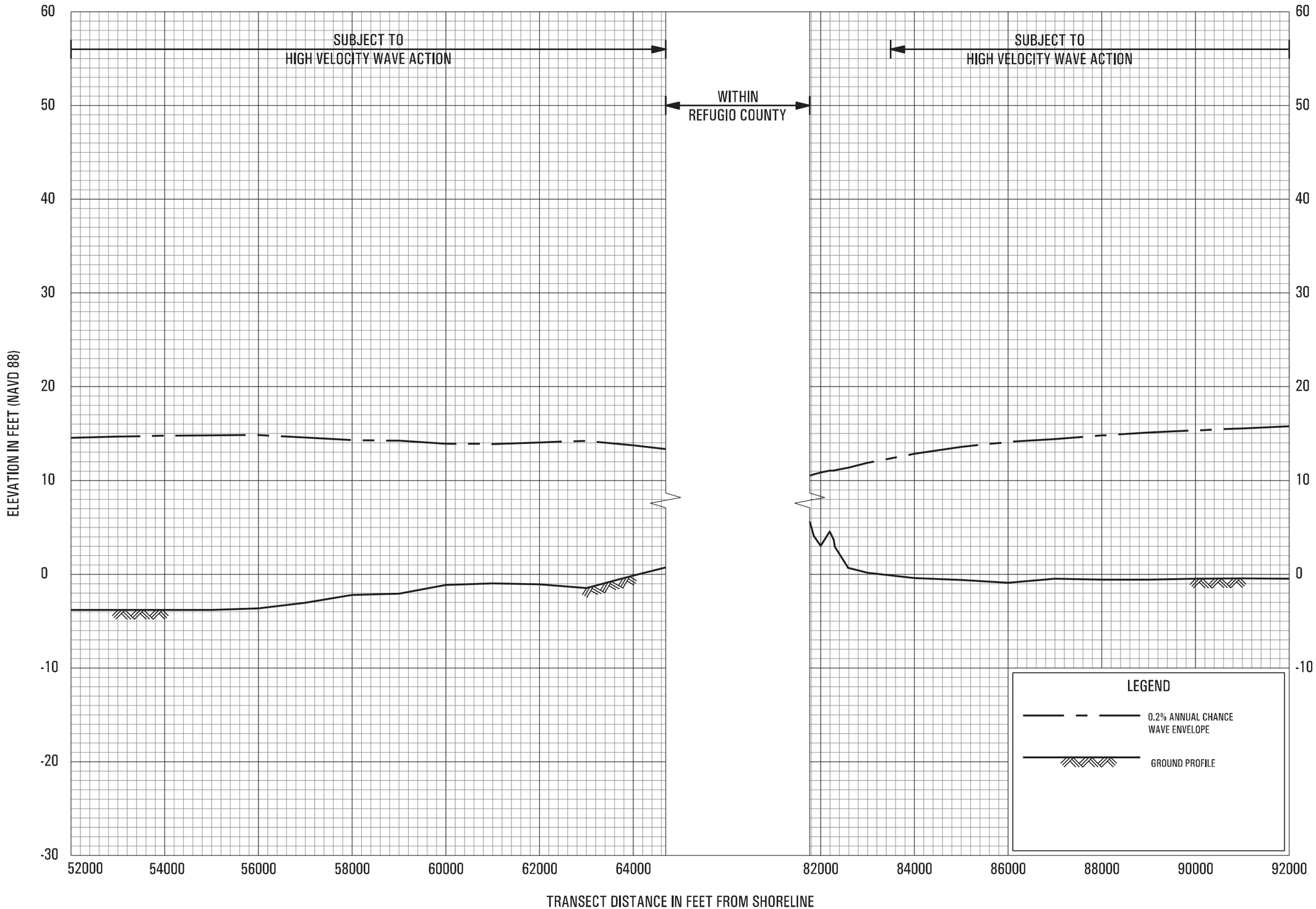
TRANSECT 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

20 T



0.2% ANNUAL CHANCE WAVE ENVELOPE

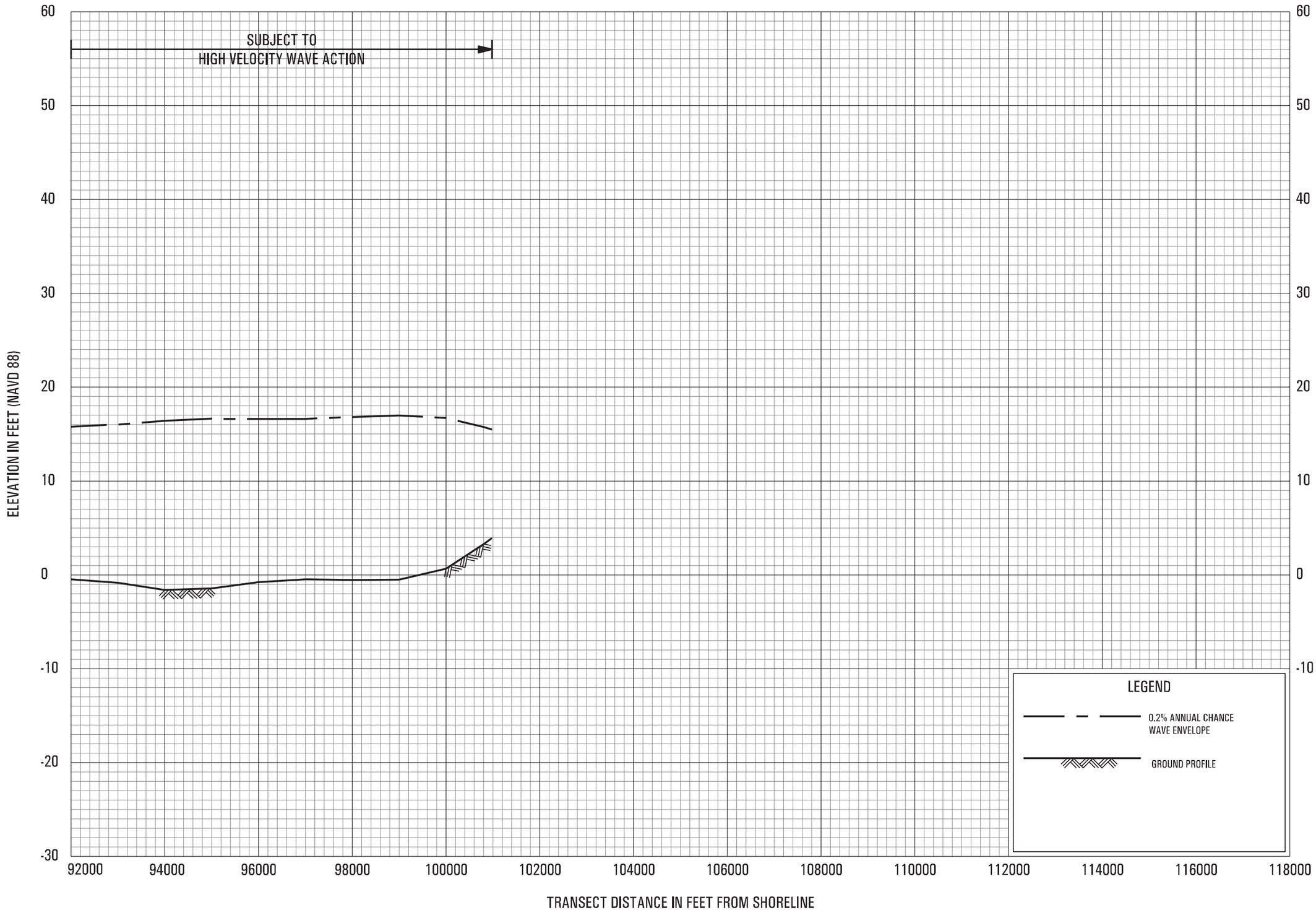
TRANSECT 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

21T



0.2% ANNUAL CHANCE WAVE ENVELOPE

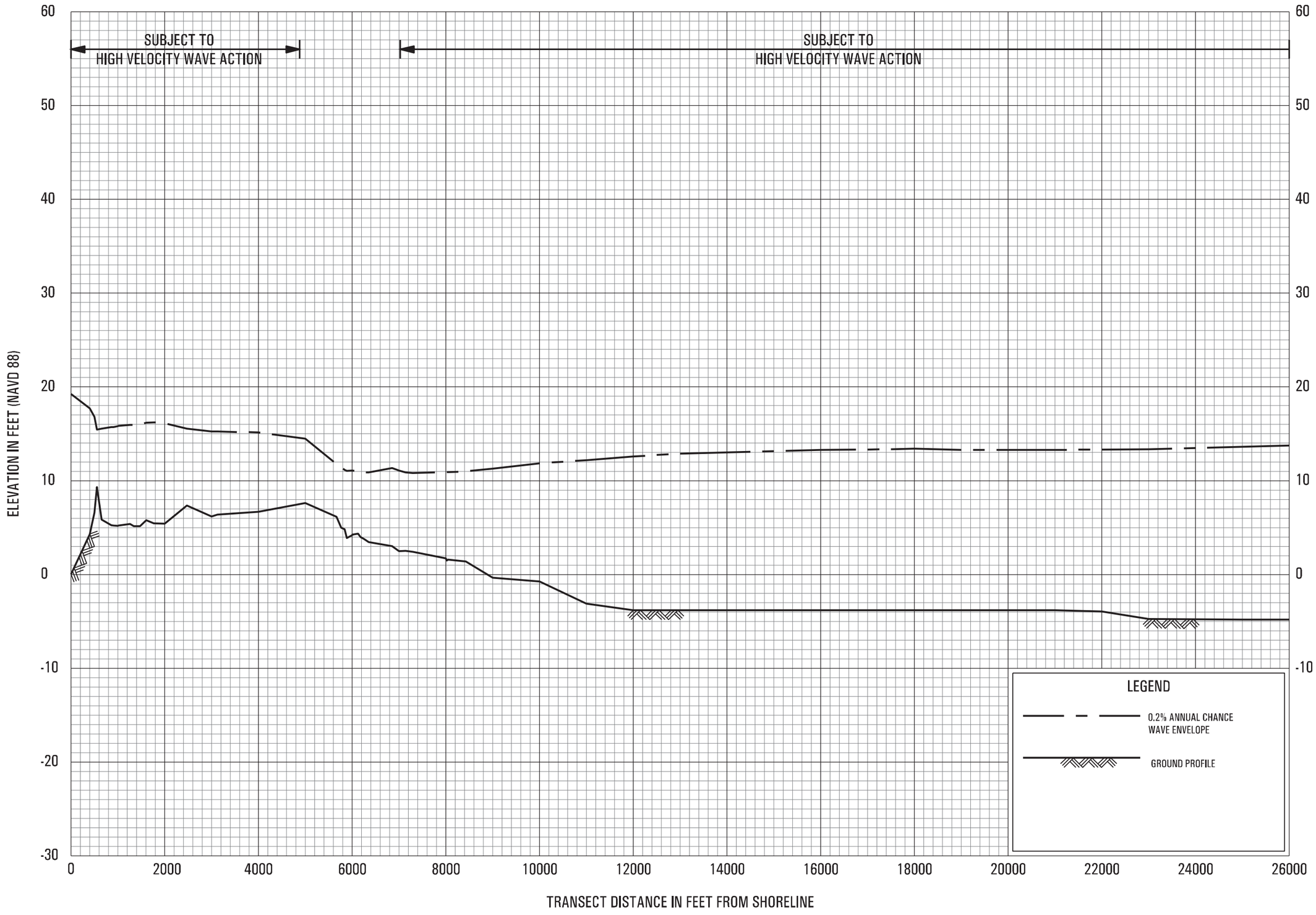
TRANSECT 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

22T



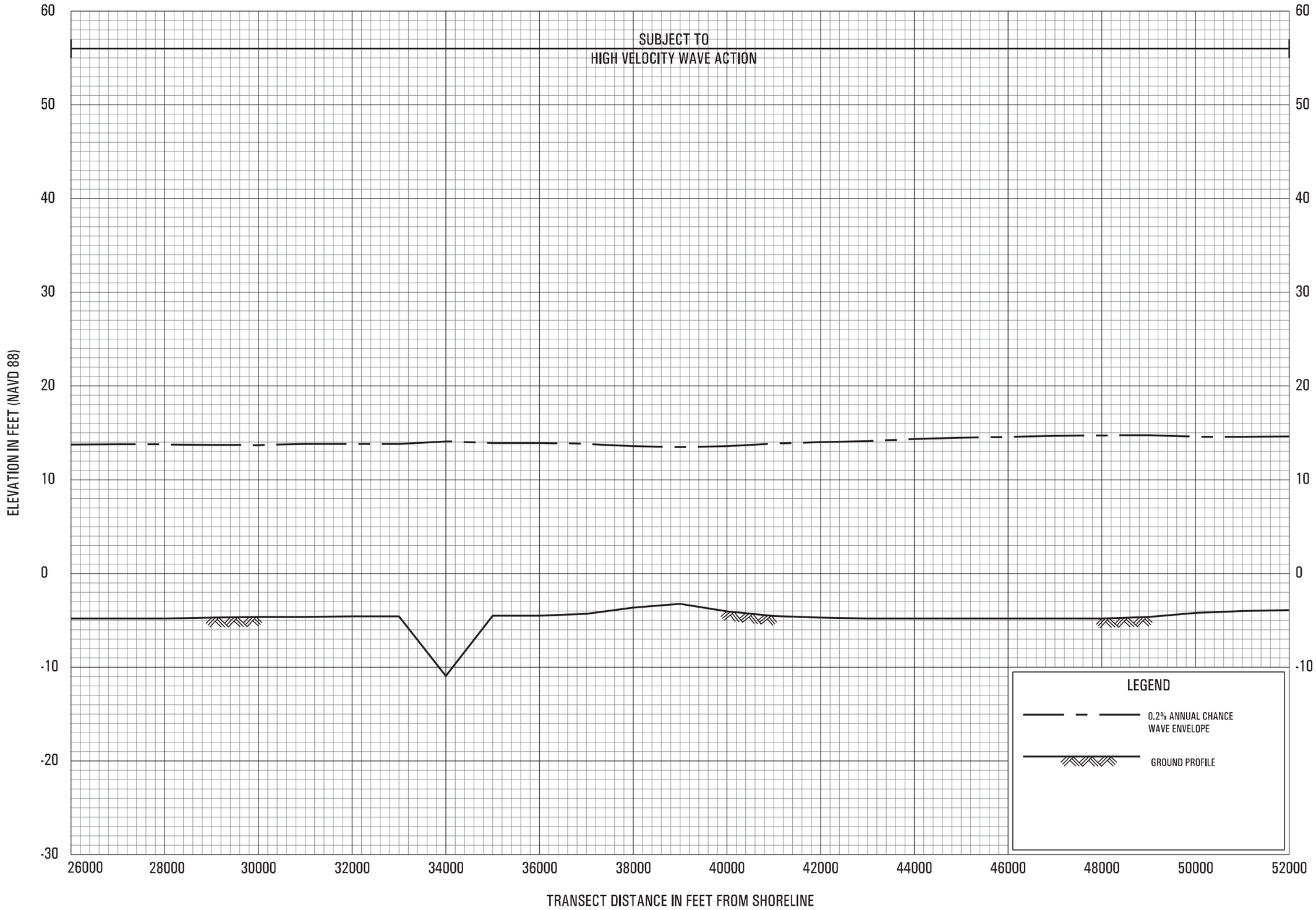
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 14

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



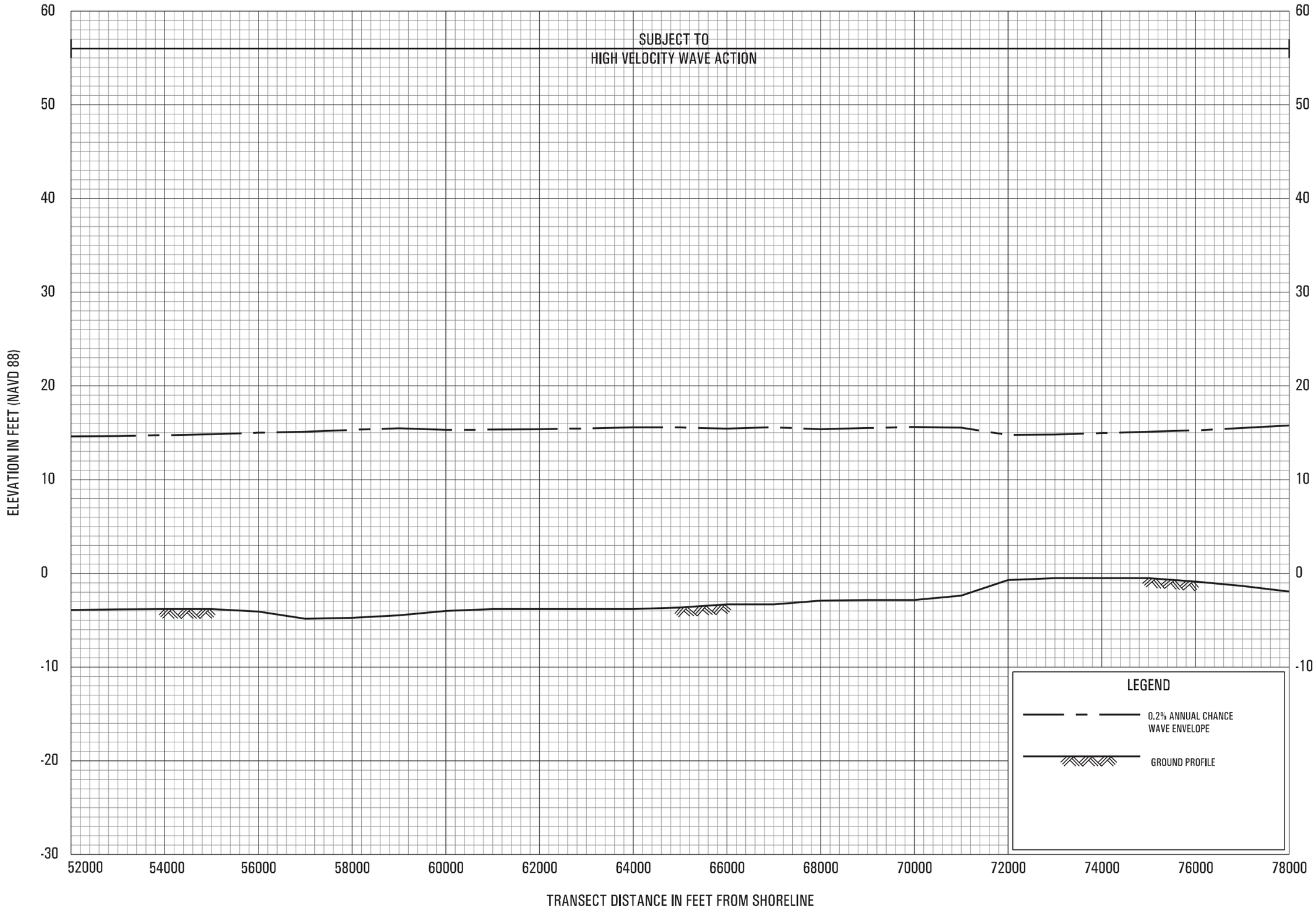
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 14

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



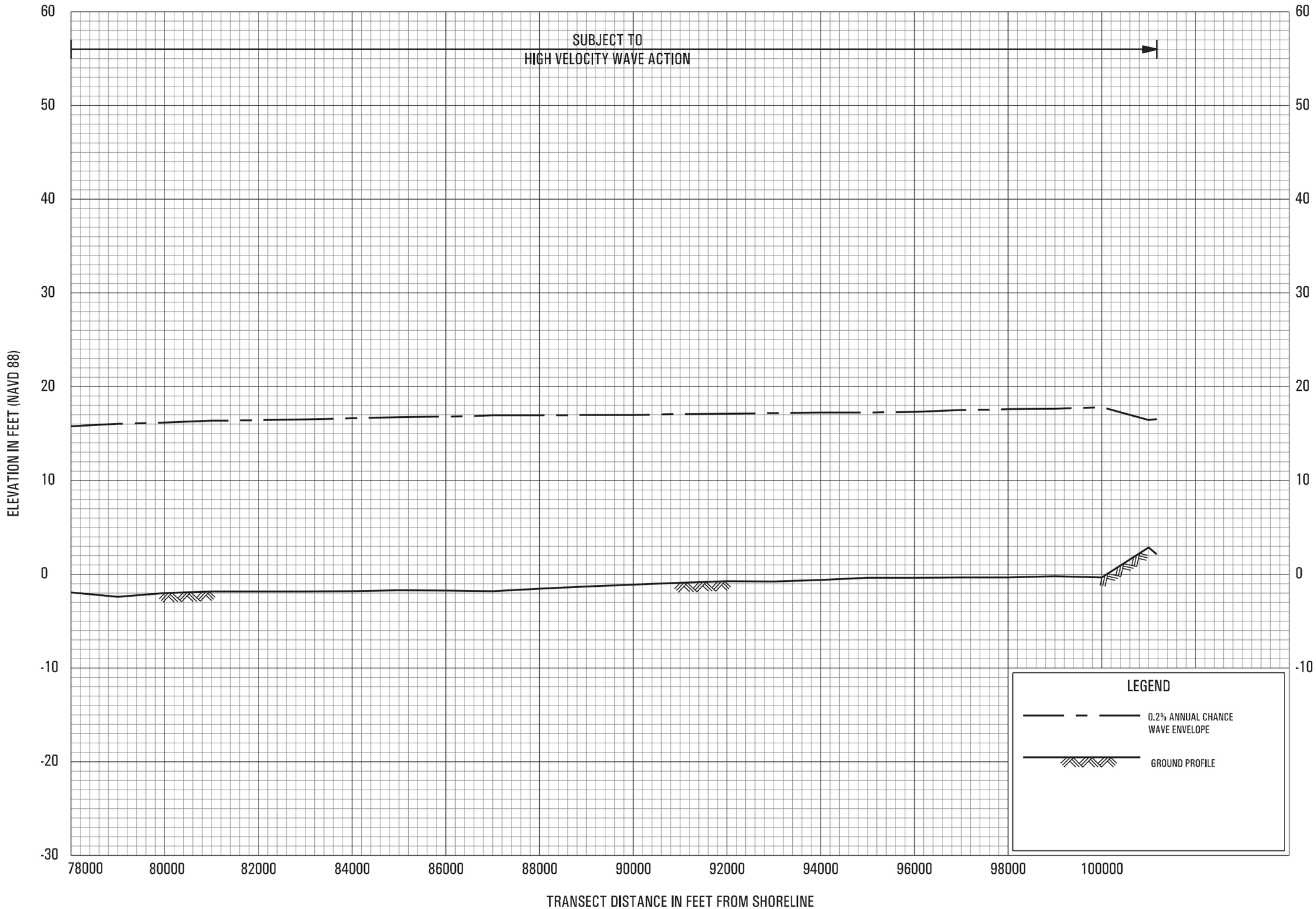
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 14

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



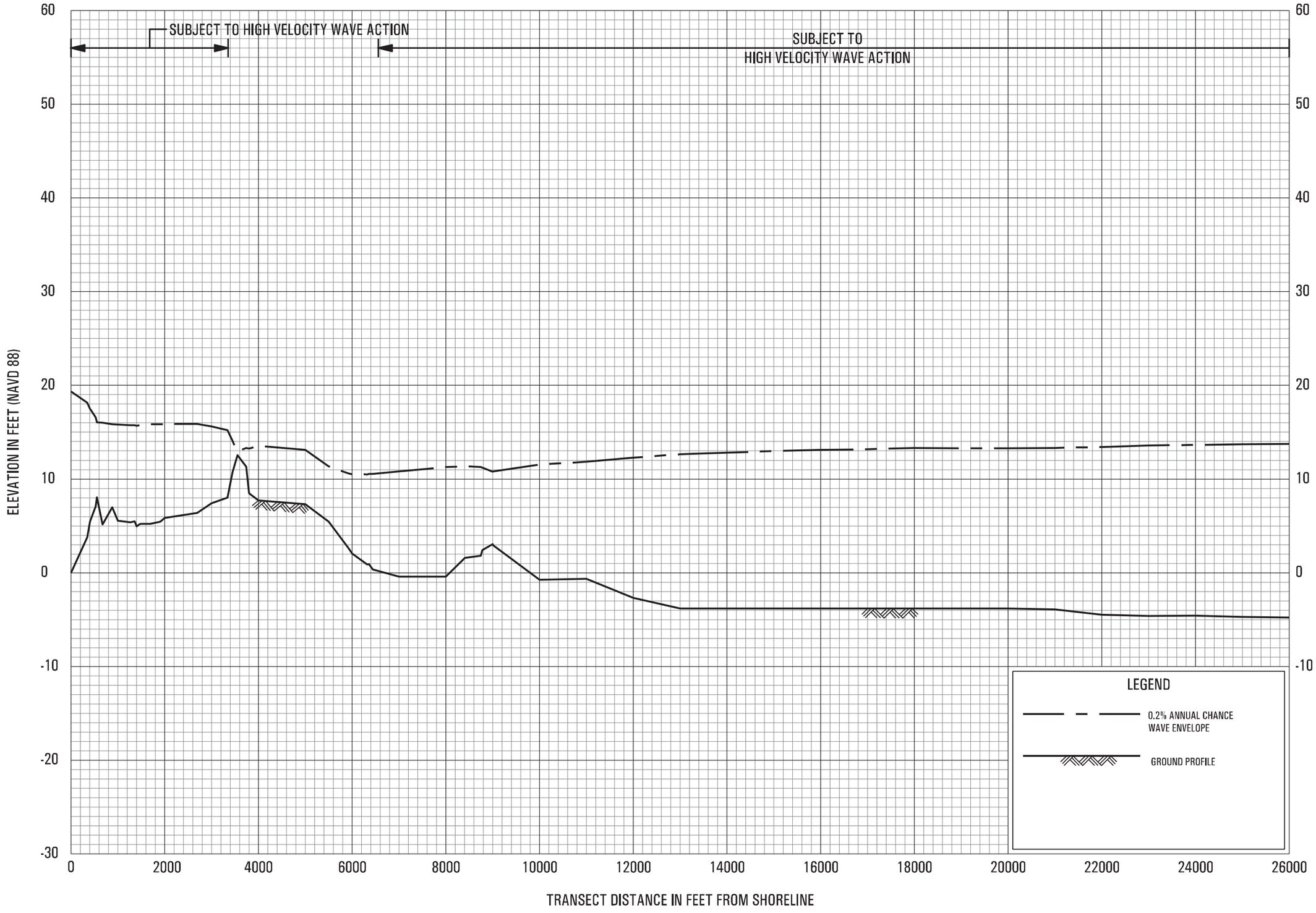
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 14

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



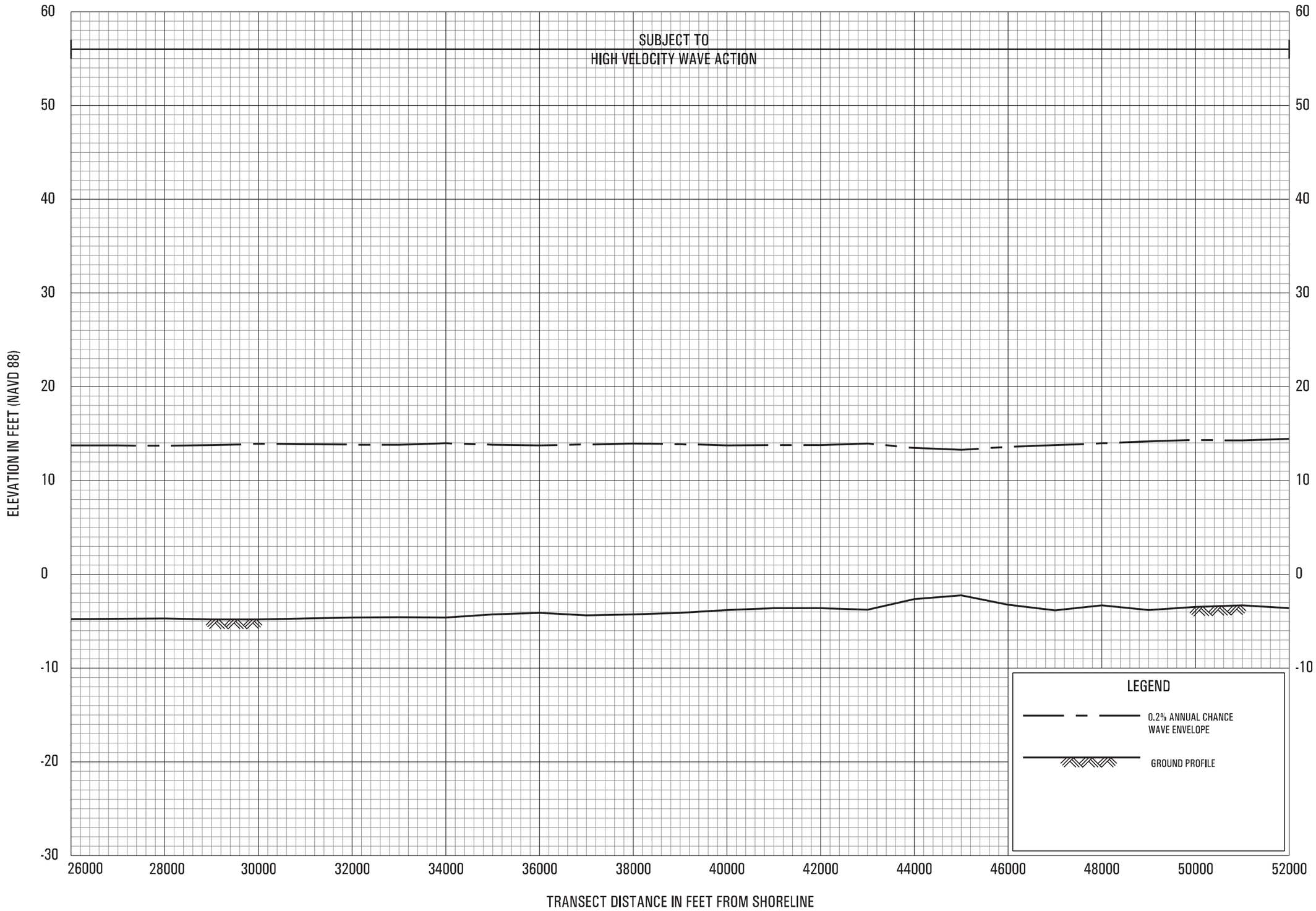
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



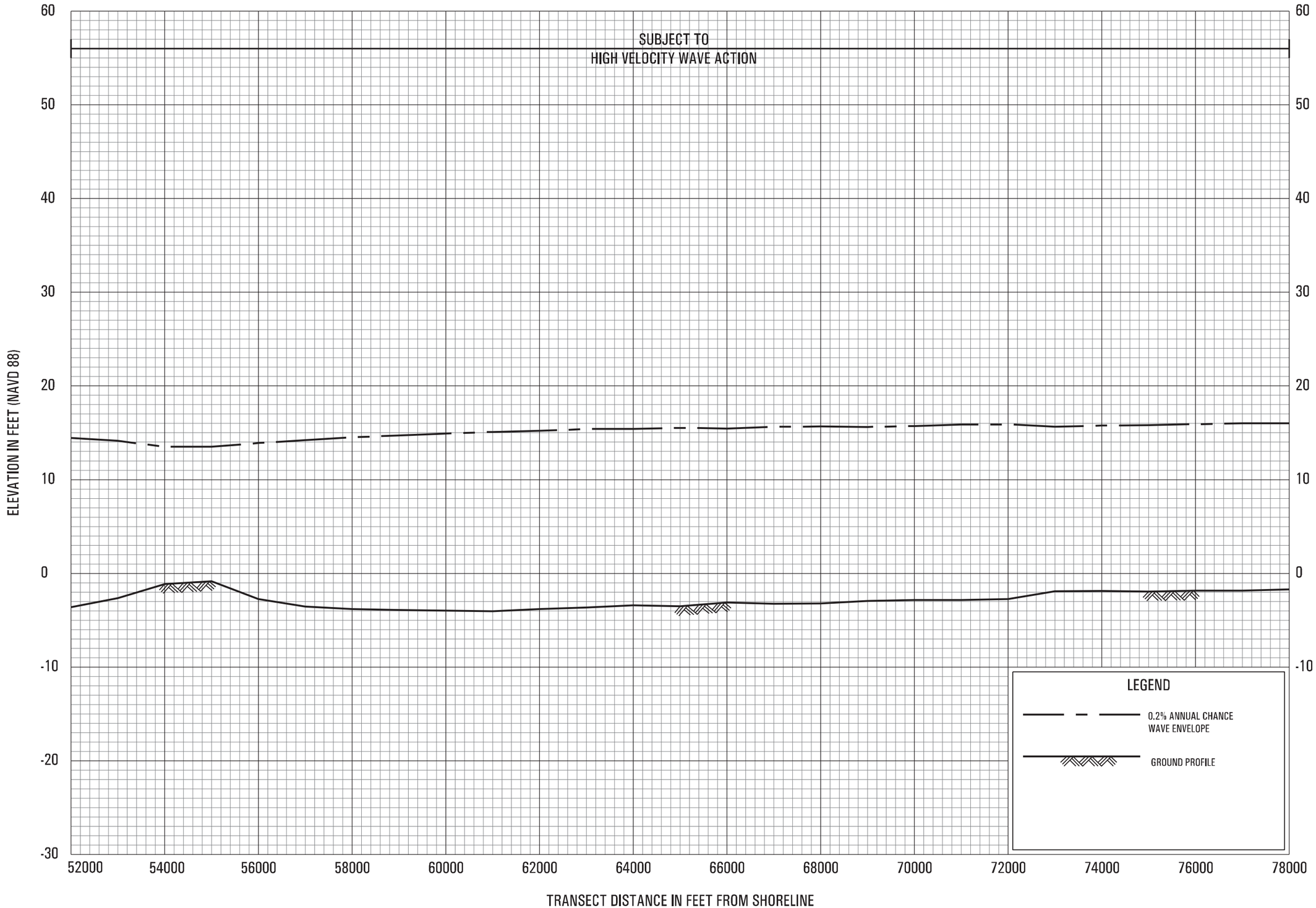
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



0.2% ANNUAL CHANCE WAVE ENVELOPE

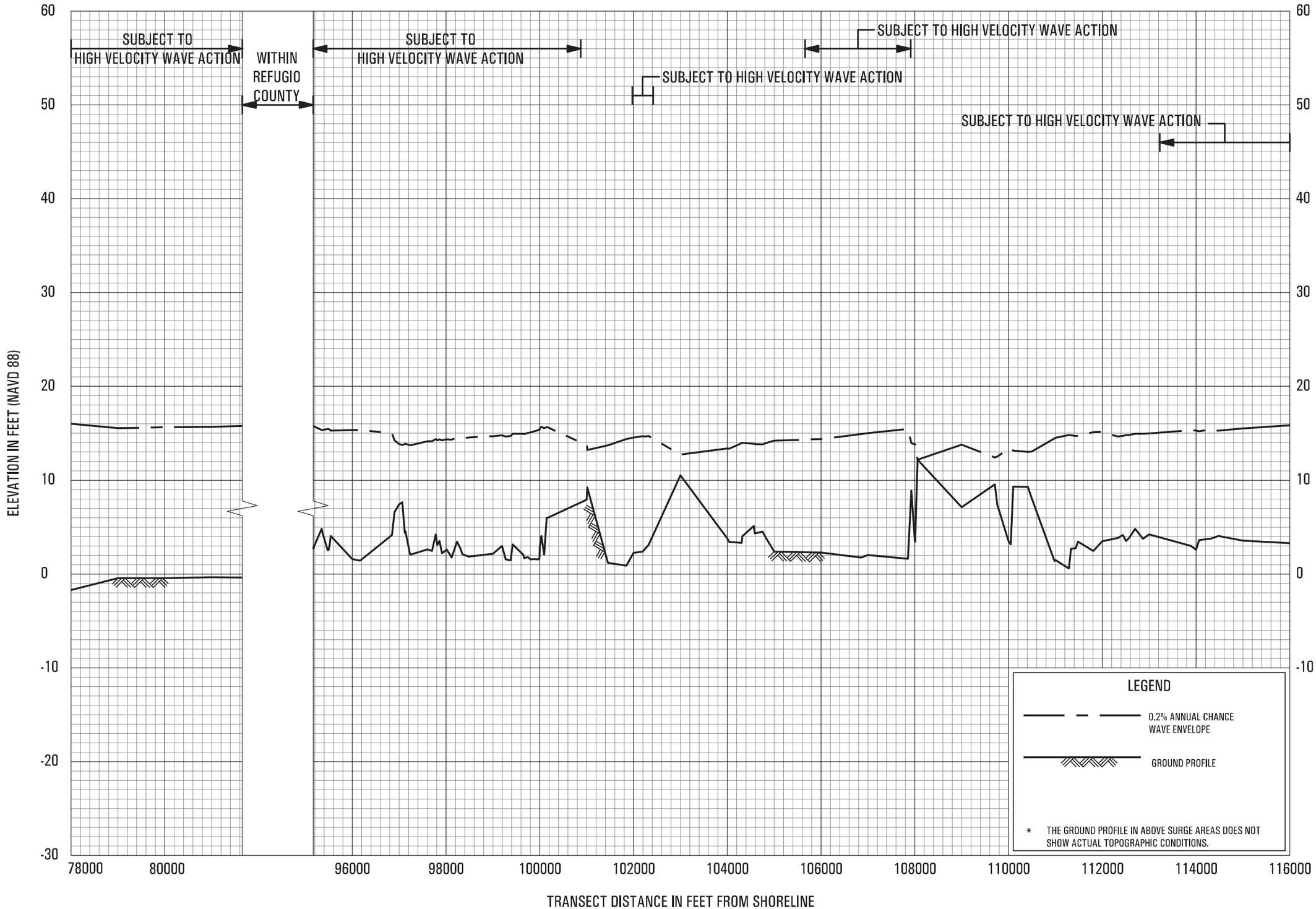
TRANSECT 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

29 T



0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

30T

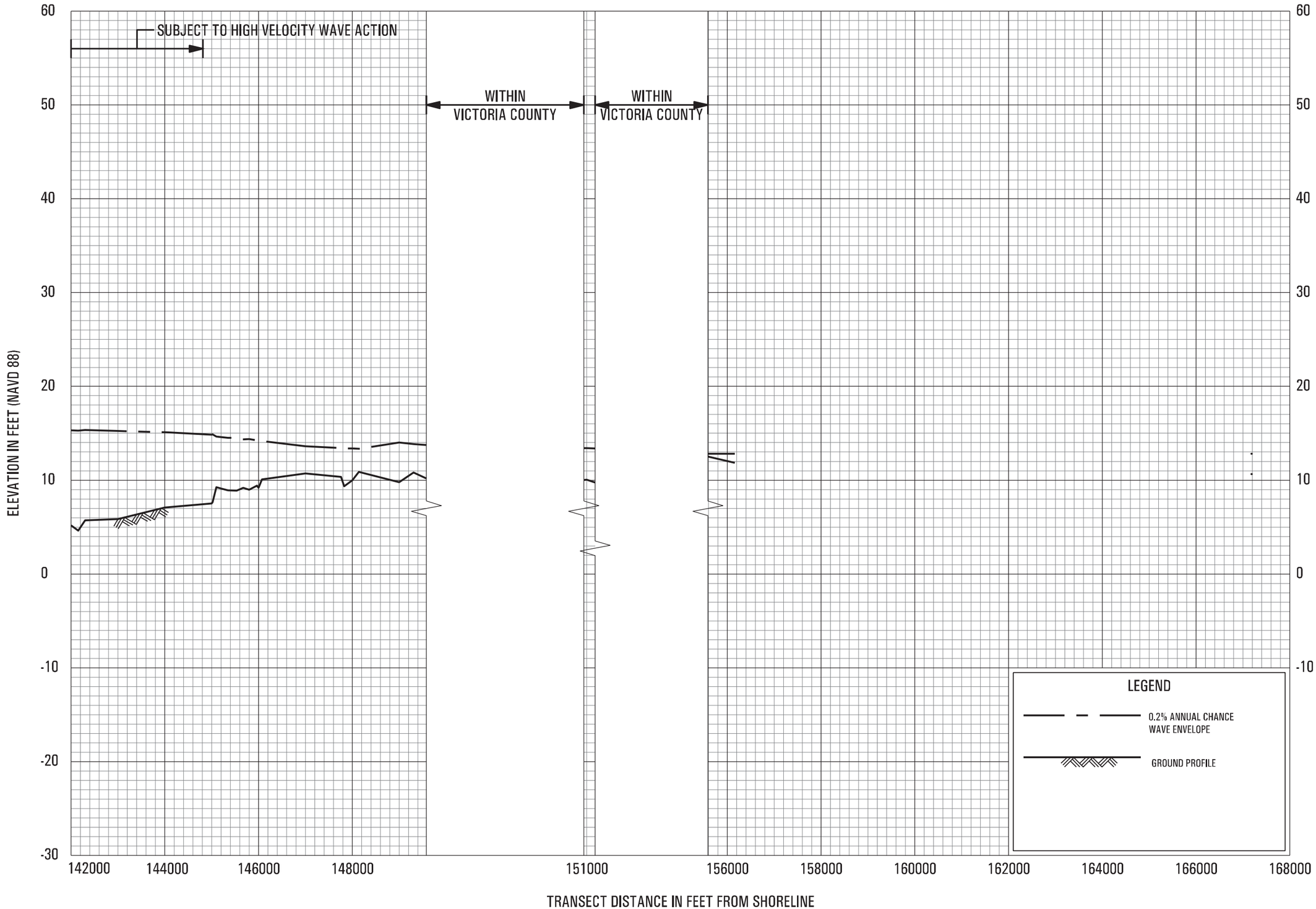
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

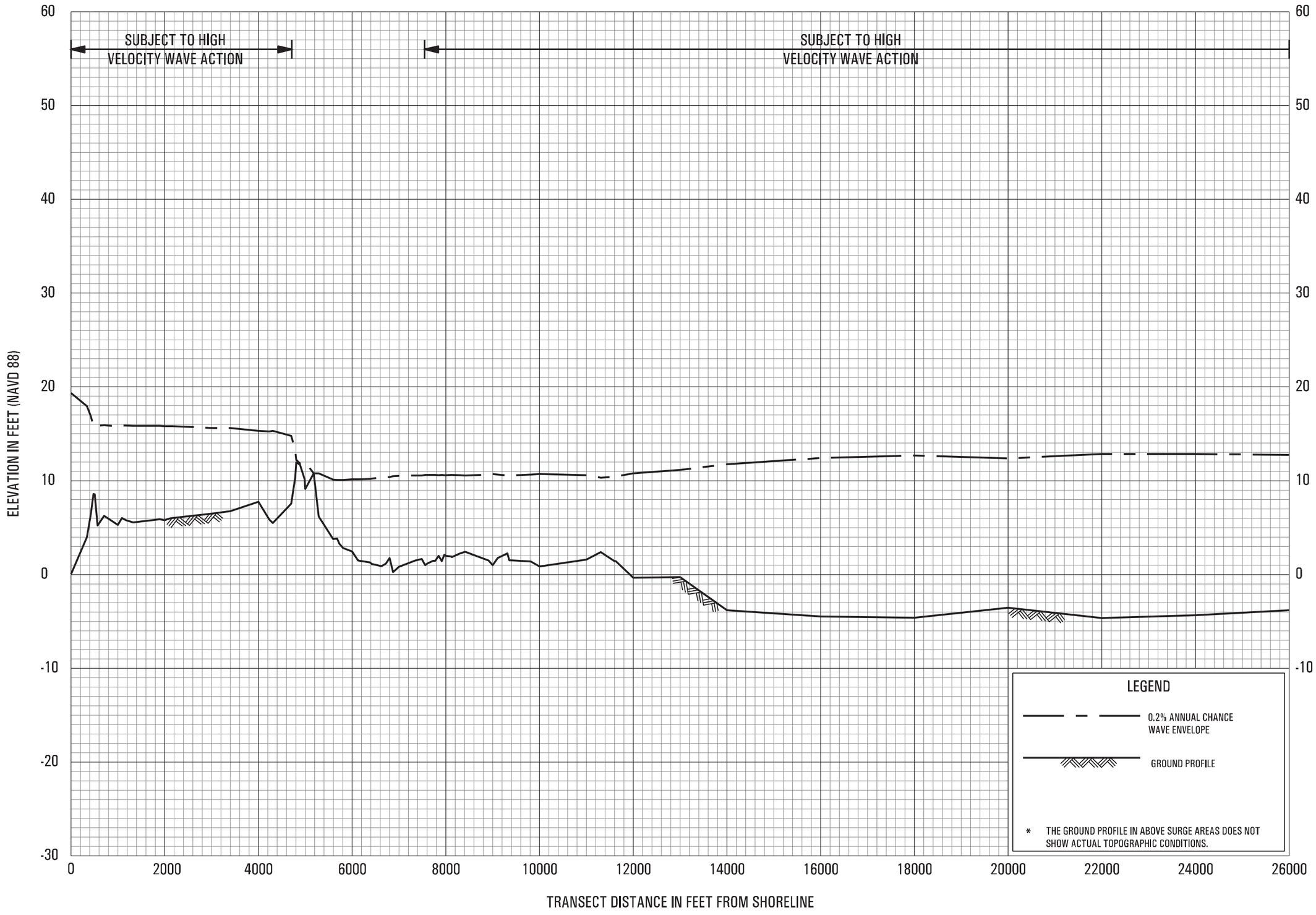


0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX
AND INCORPORATED AREAS



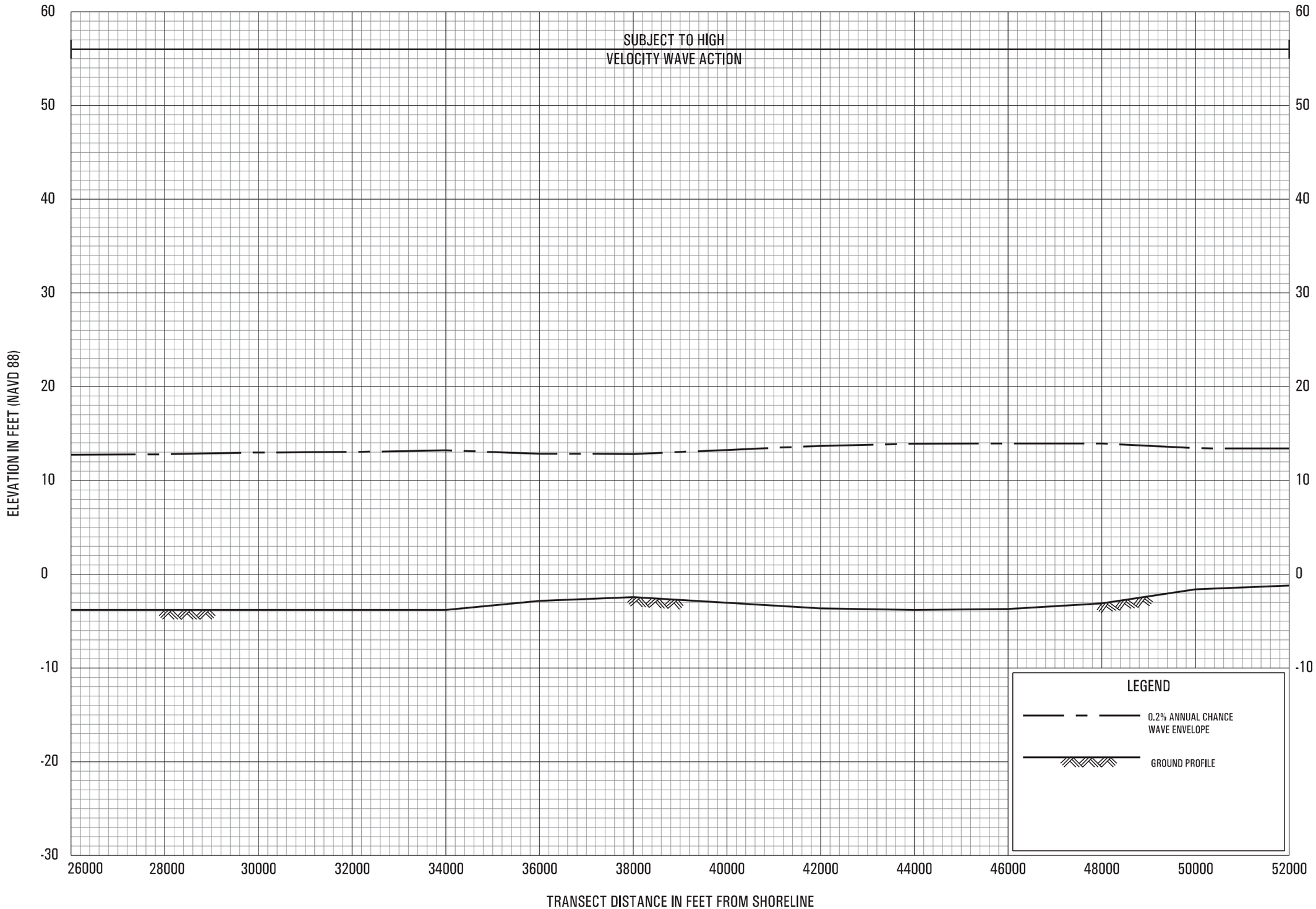
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 16

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



0.2% ANNUAL CHANCE WAVE ENVELOPE

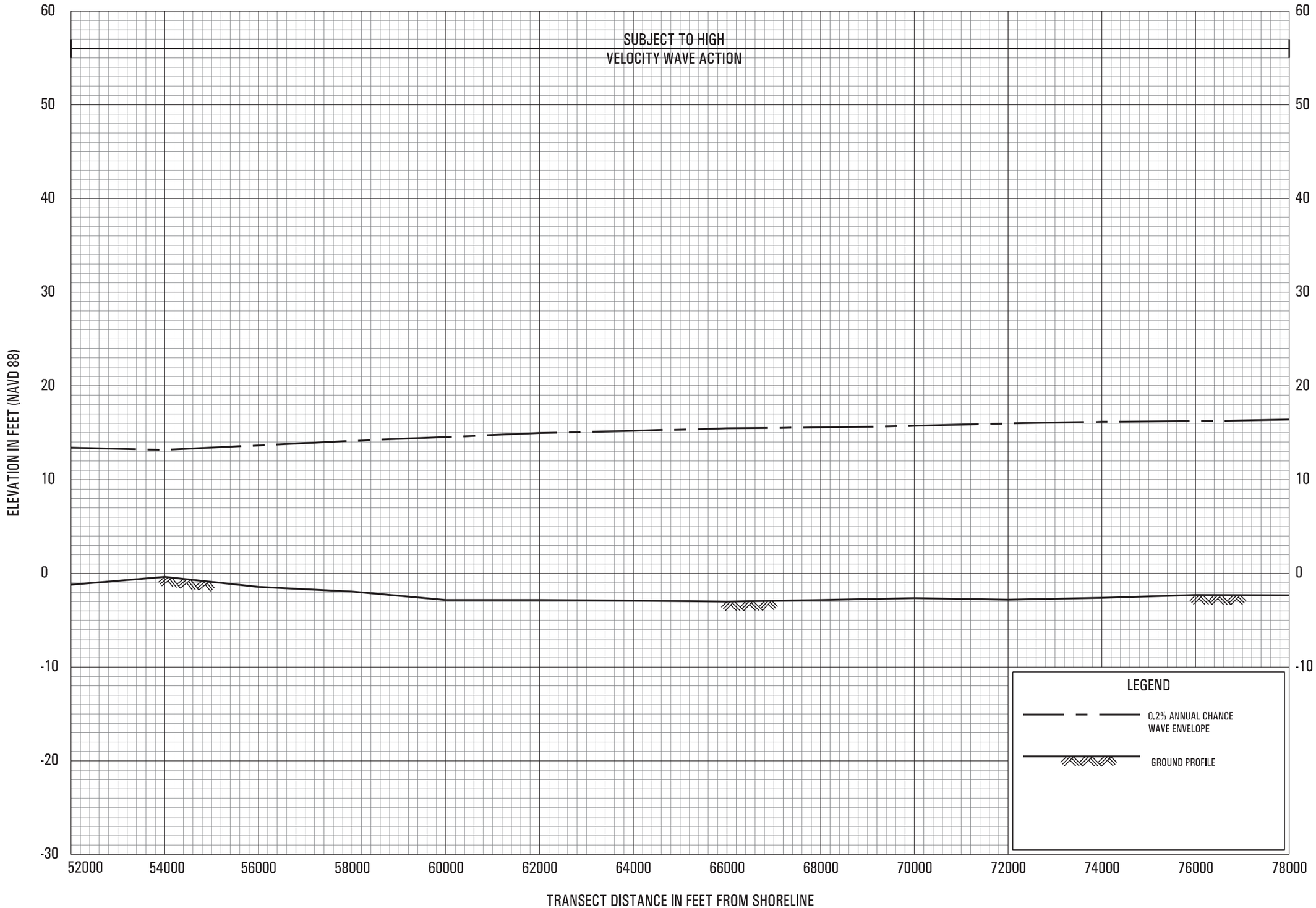
TRANSECT 16

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

34 T



0.2% ANNUAL CHANCE WAVE ENVELOPE

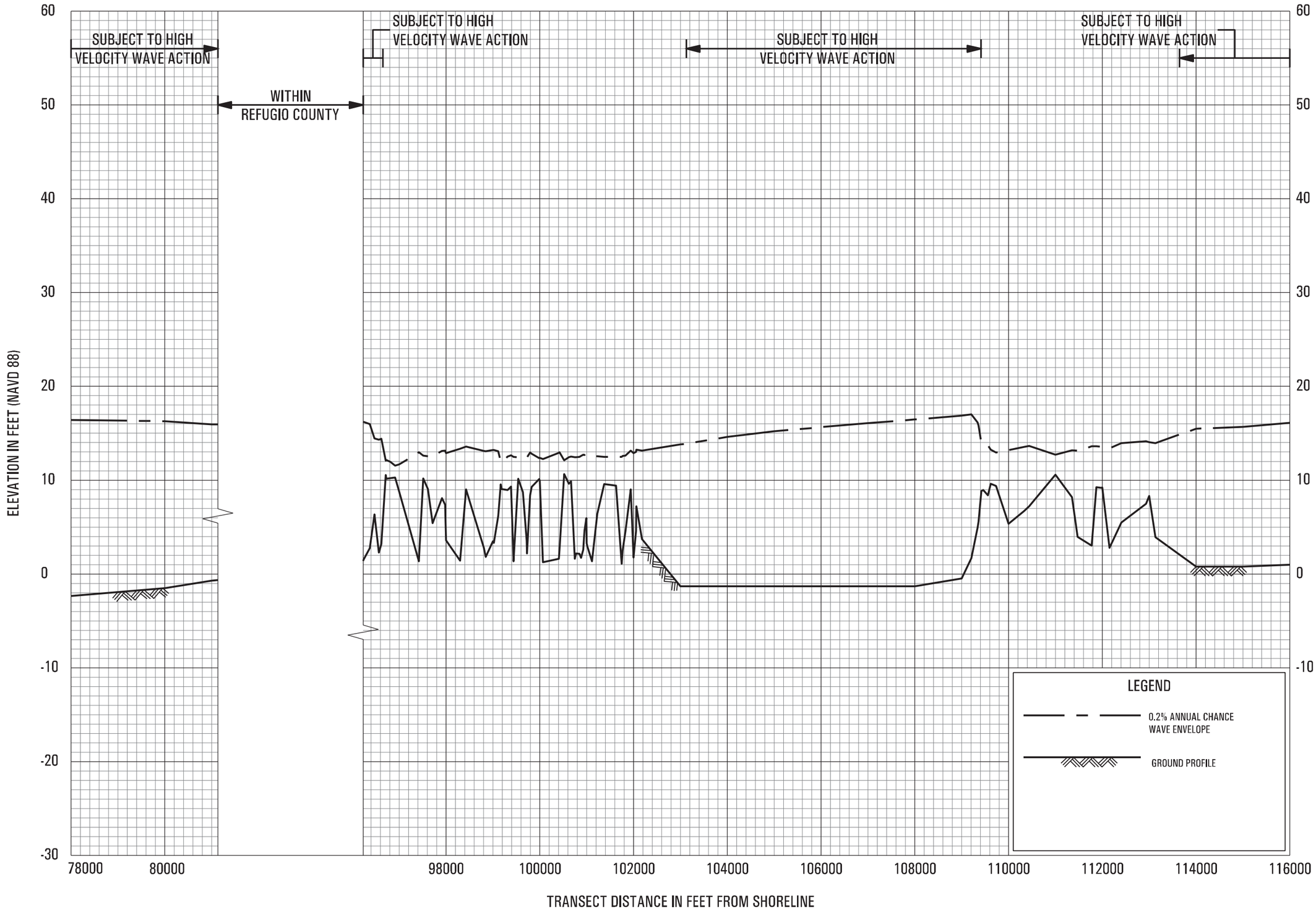
TRANSECT 16

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

35T



0.2% ANNUAL CHANCE WAVE ENVELOPE

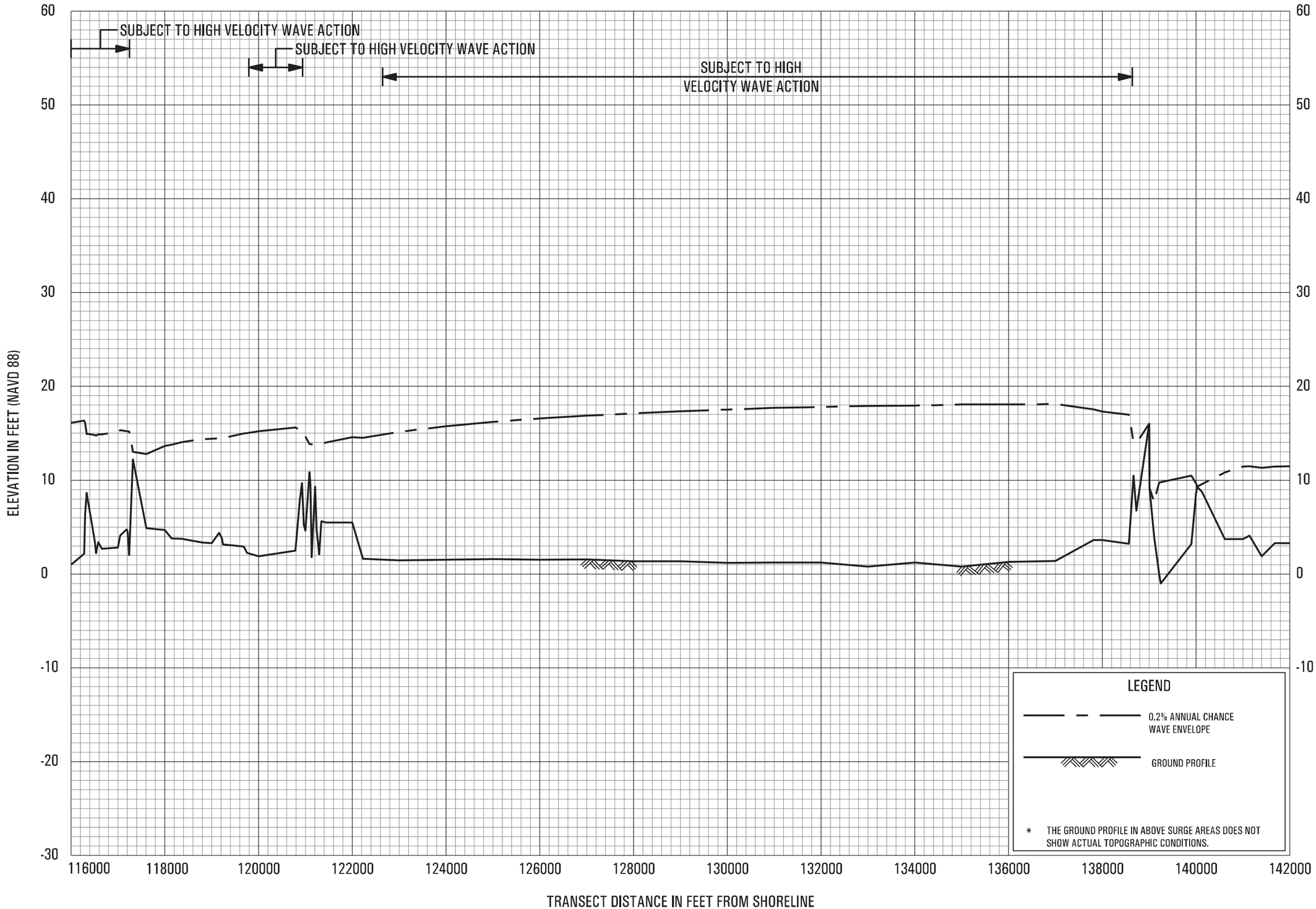
TRANSECT 16

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

36 T



0.2% ANNUAL CHANCE WAVE ENVELOPE

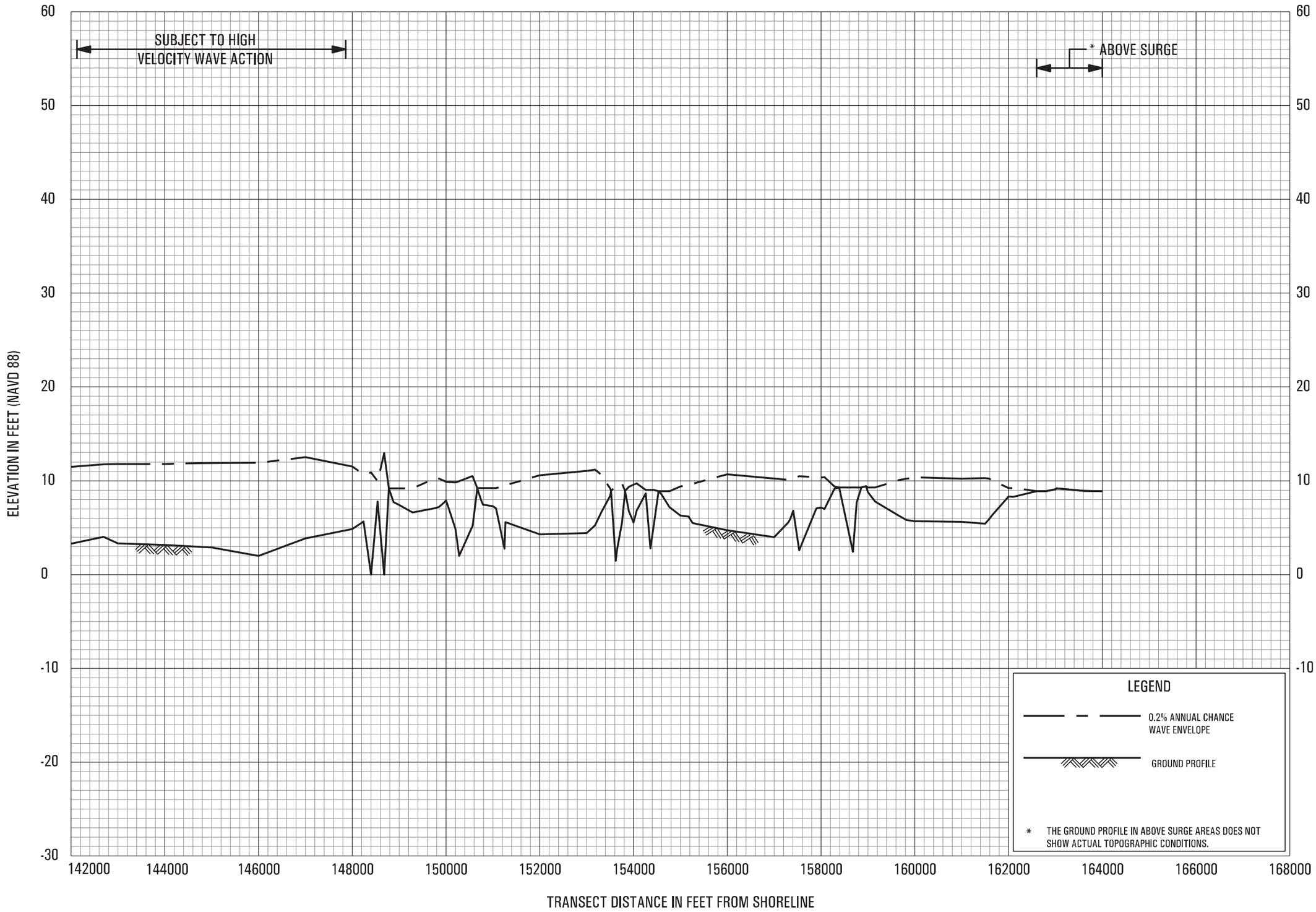
TRANSECT 16

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

37T



0.2% ANNUAL CHANCE WAVE ENVELOPE

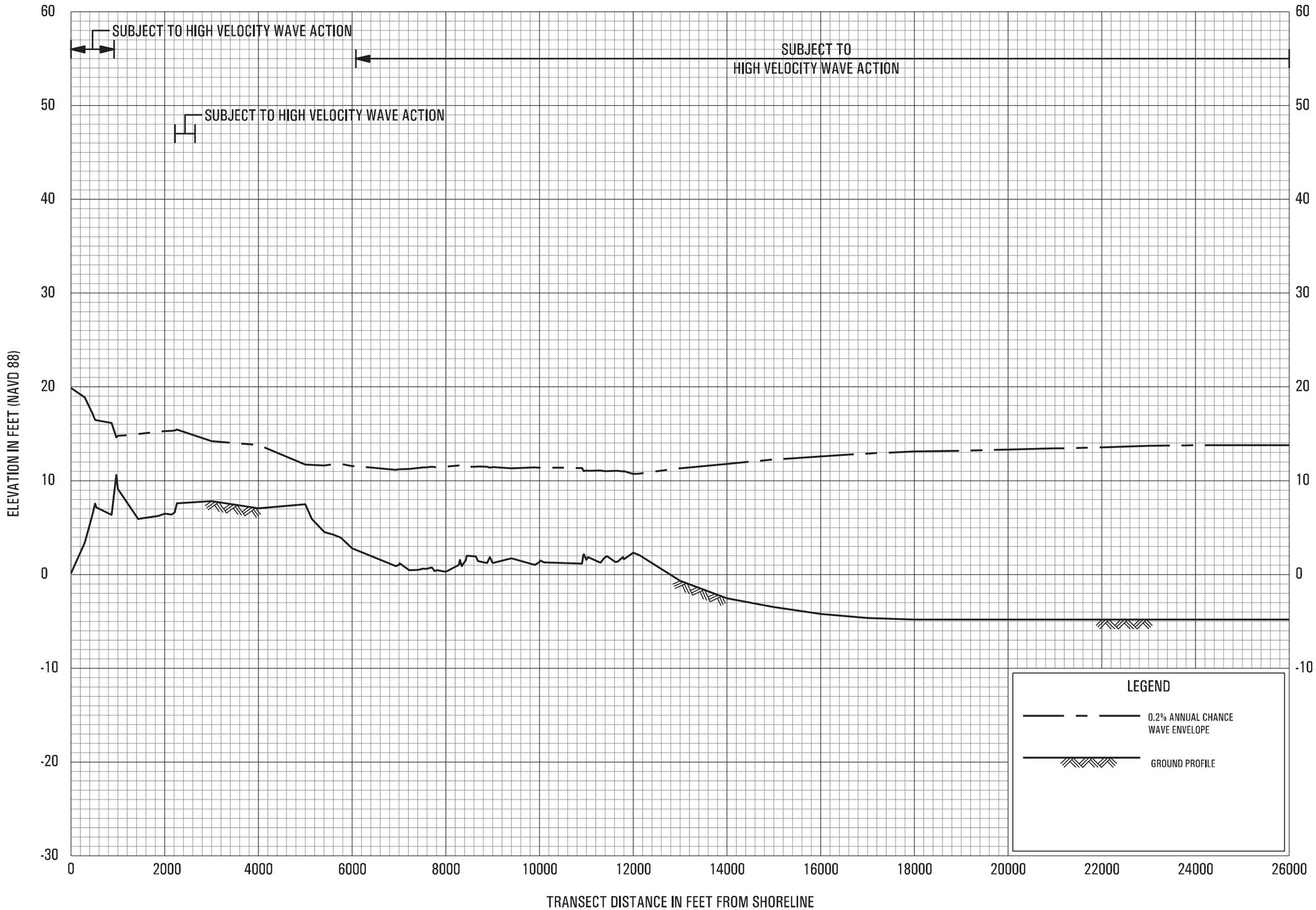
TRANSECT 16

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

38T



0.2% ANNUAL CHANCE WAVE ENVELOPE

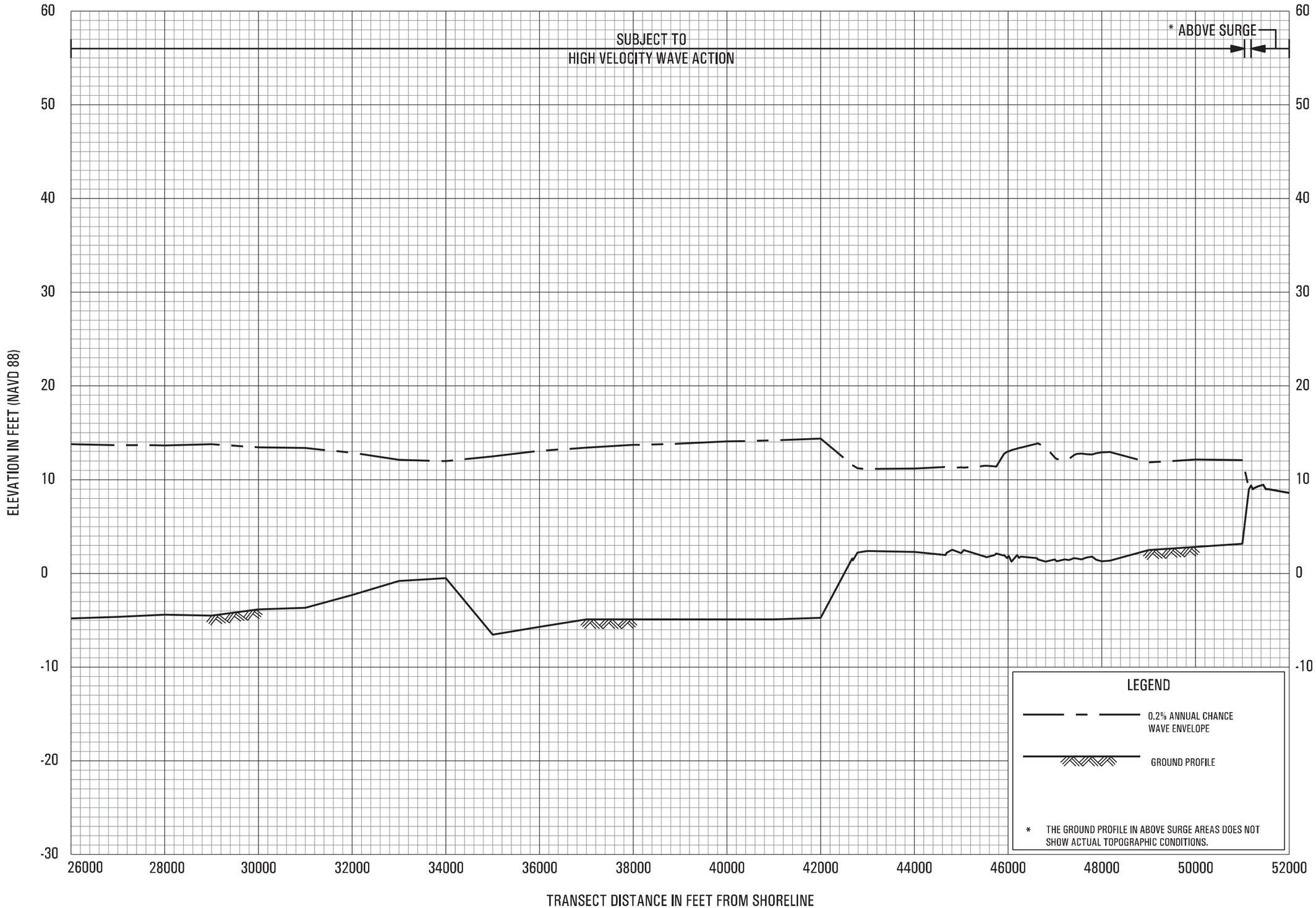
TRANSECT 17

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

39T



0.2% ANNUAL CHANCE WAVE ENVELOPE

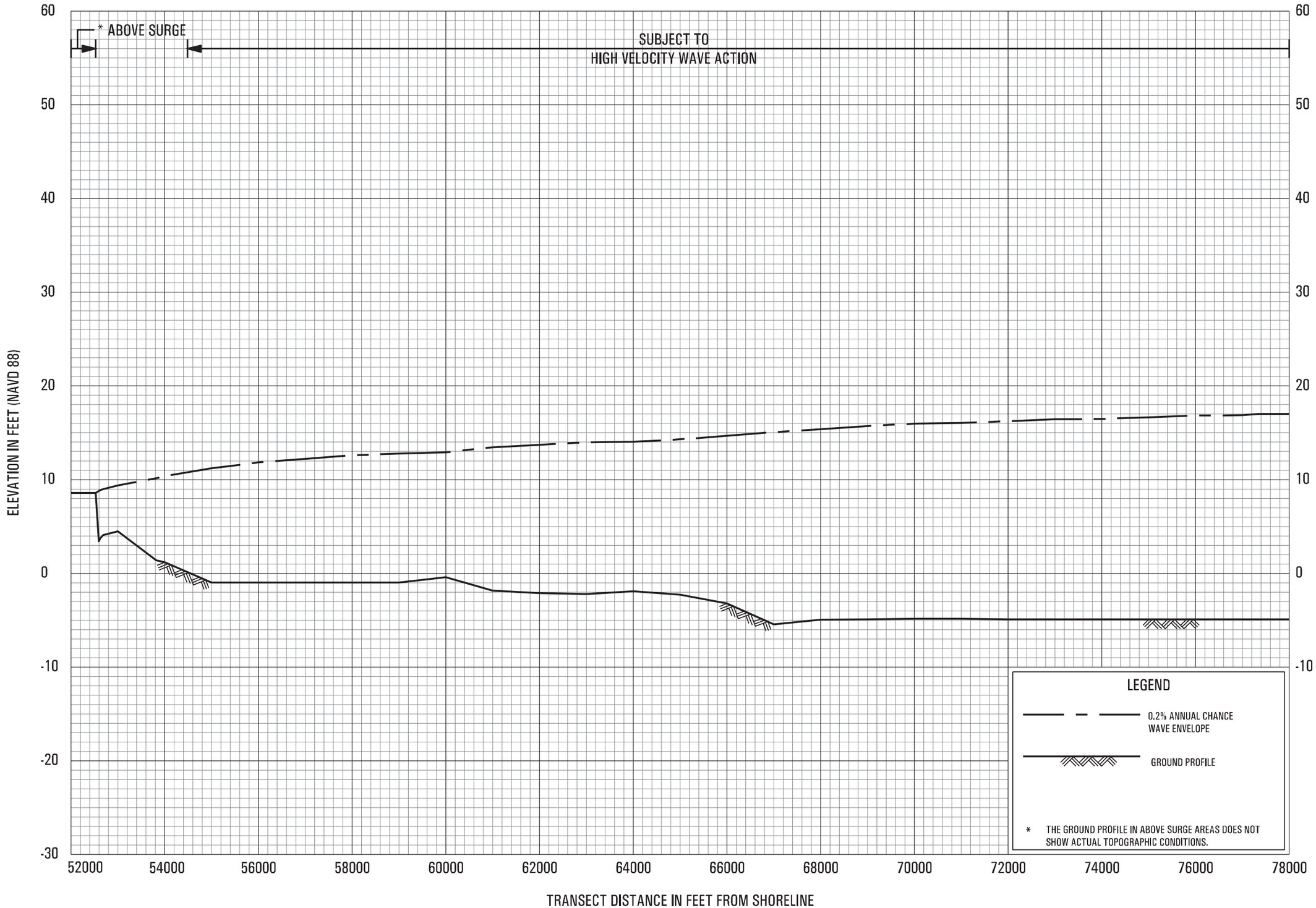
TRANSECT 17

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

40T



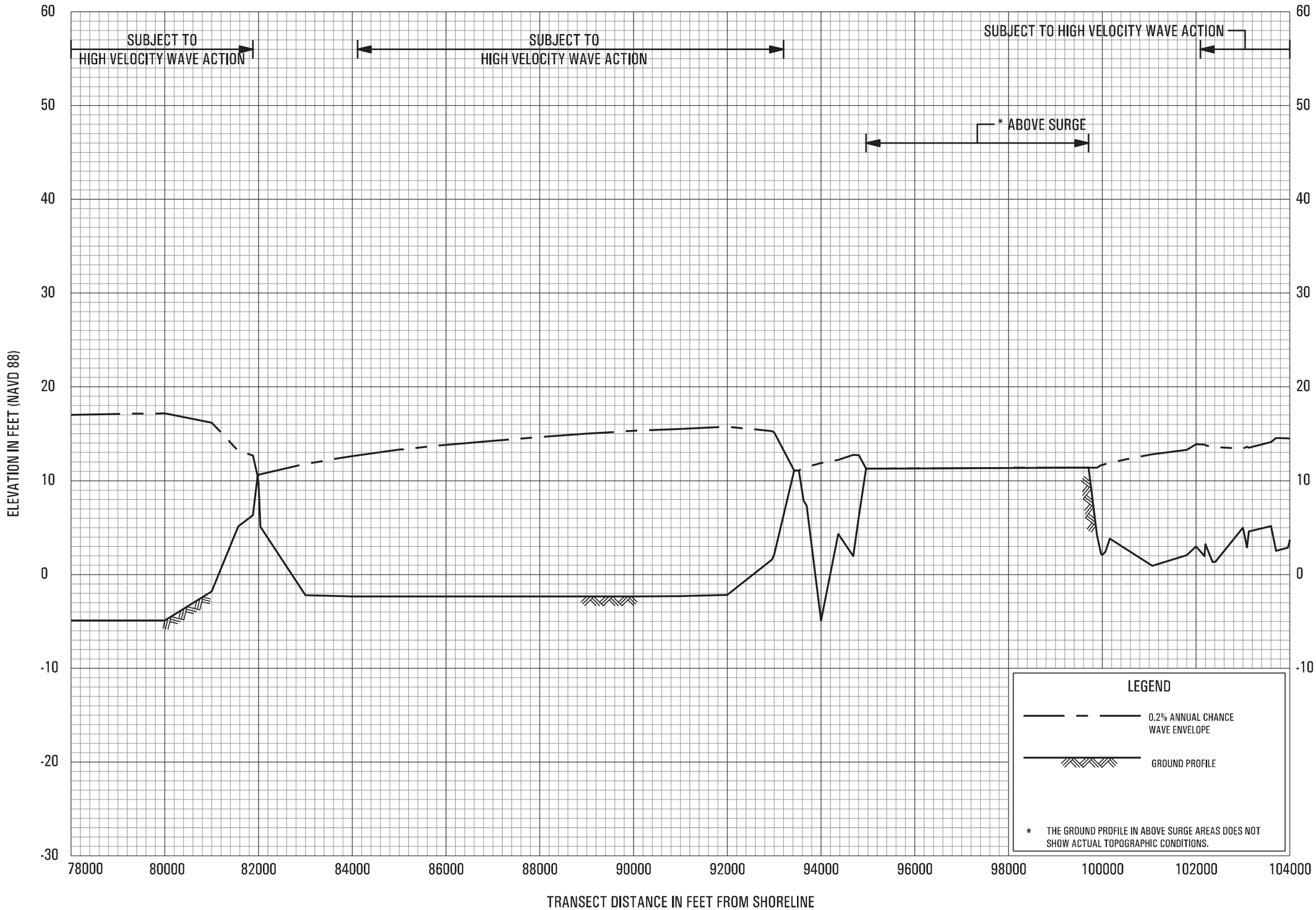
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 17

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

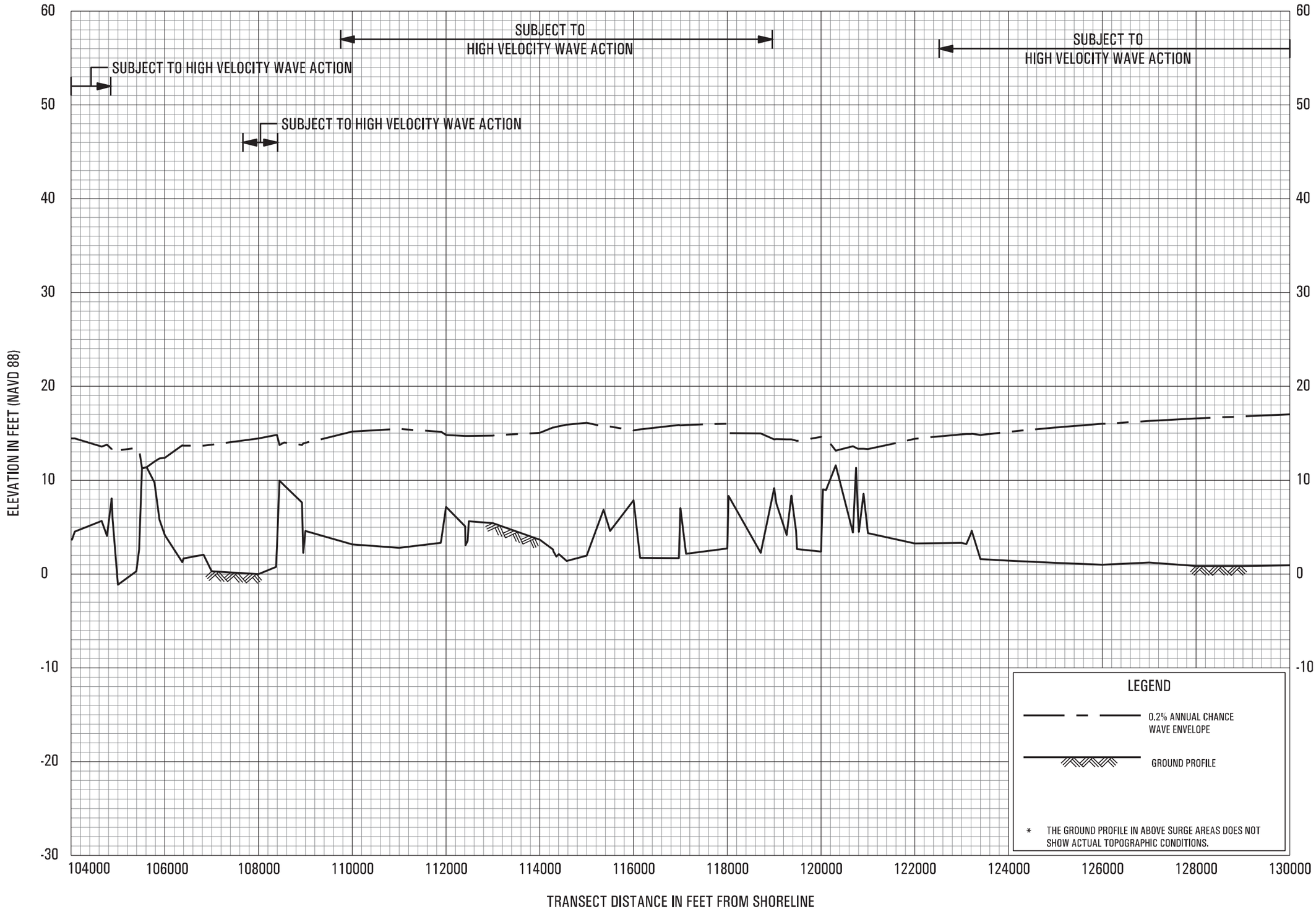


0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 17

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX
AND INCORPORATED AREAS



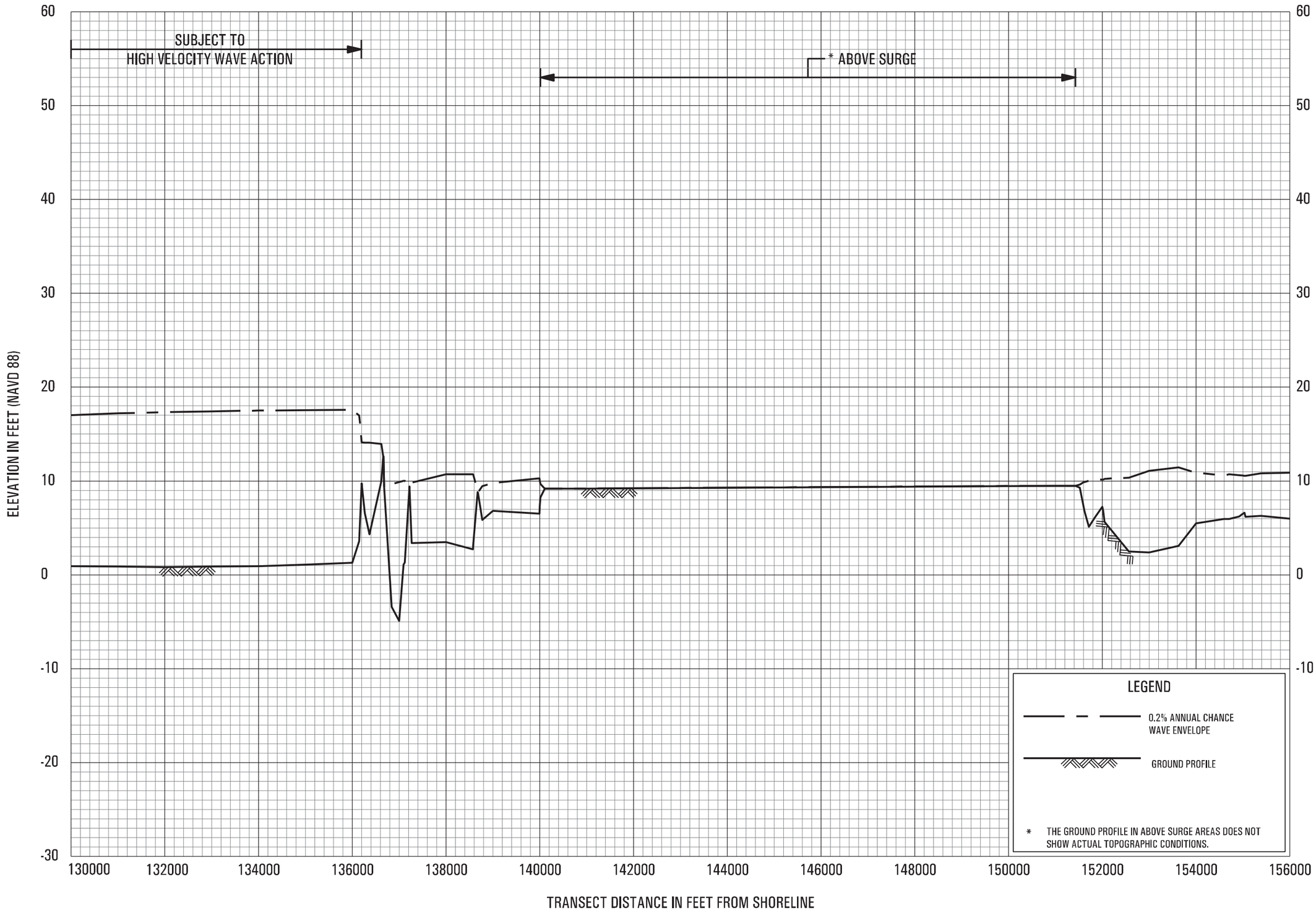
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 17

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



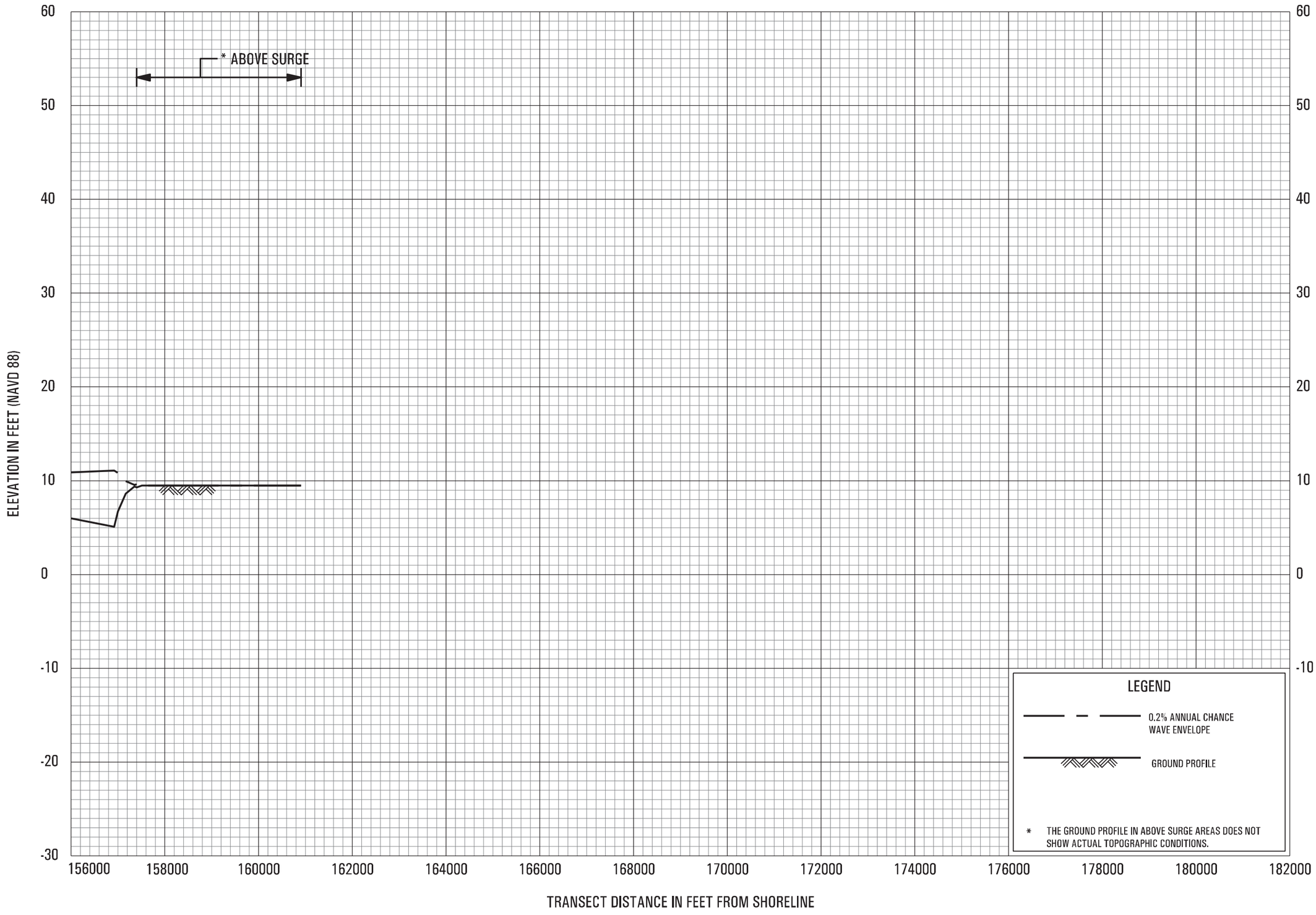
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 17

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



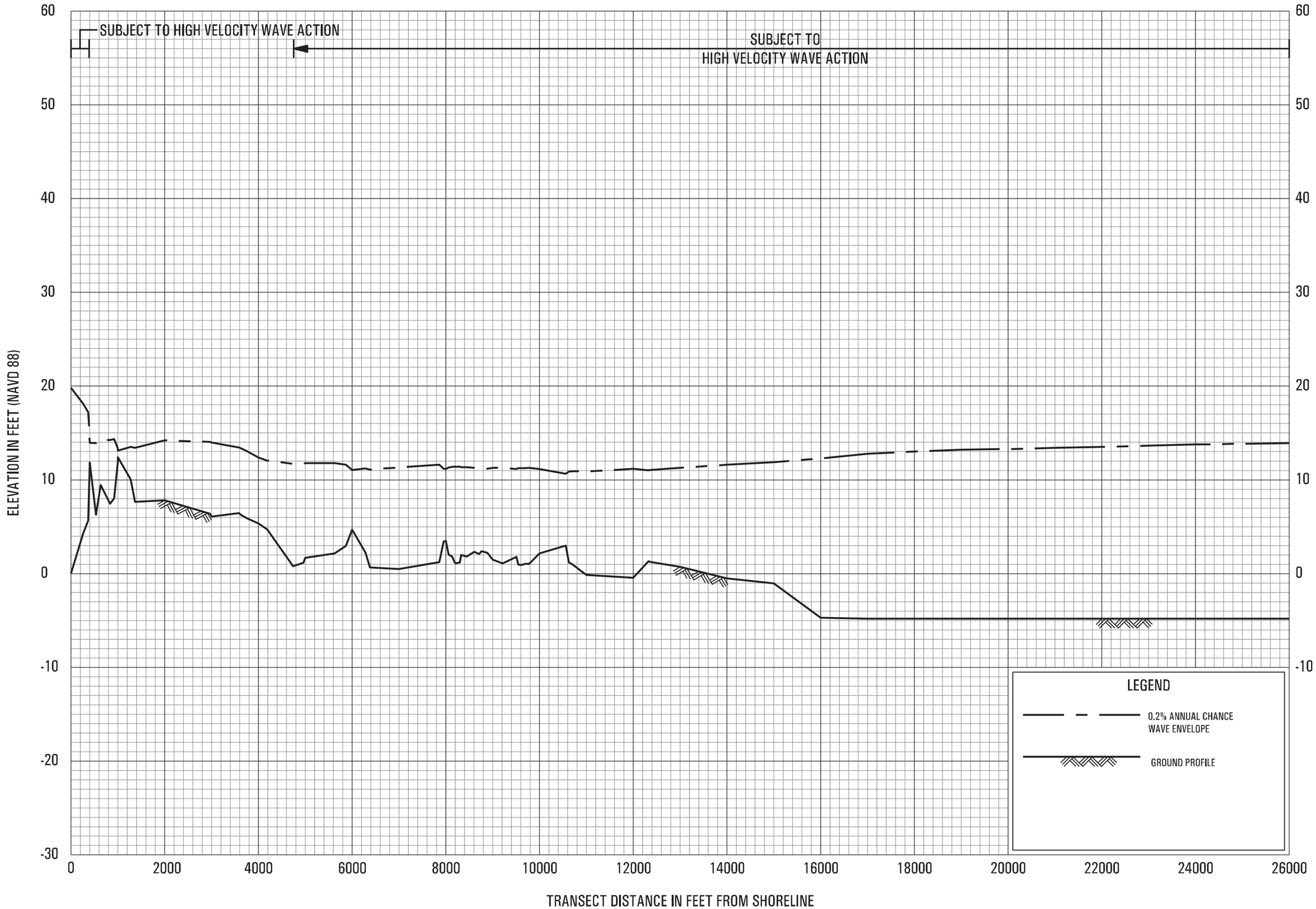
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 17

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



0.2% ANNUAL CHANCE WAVE ENVELOPE

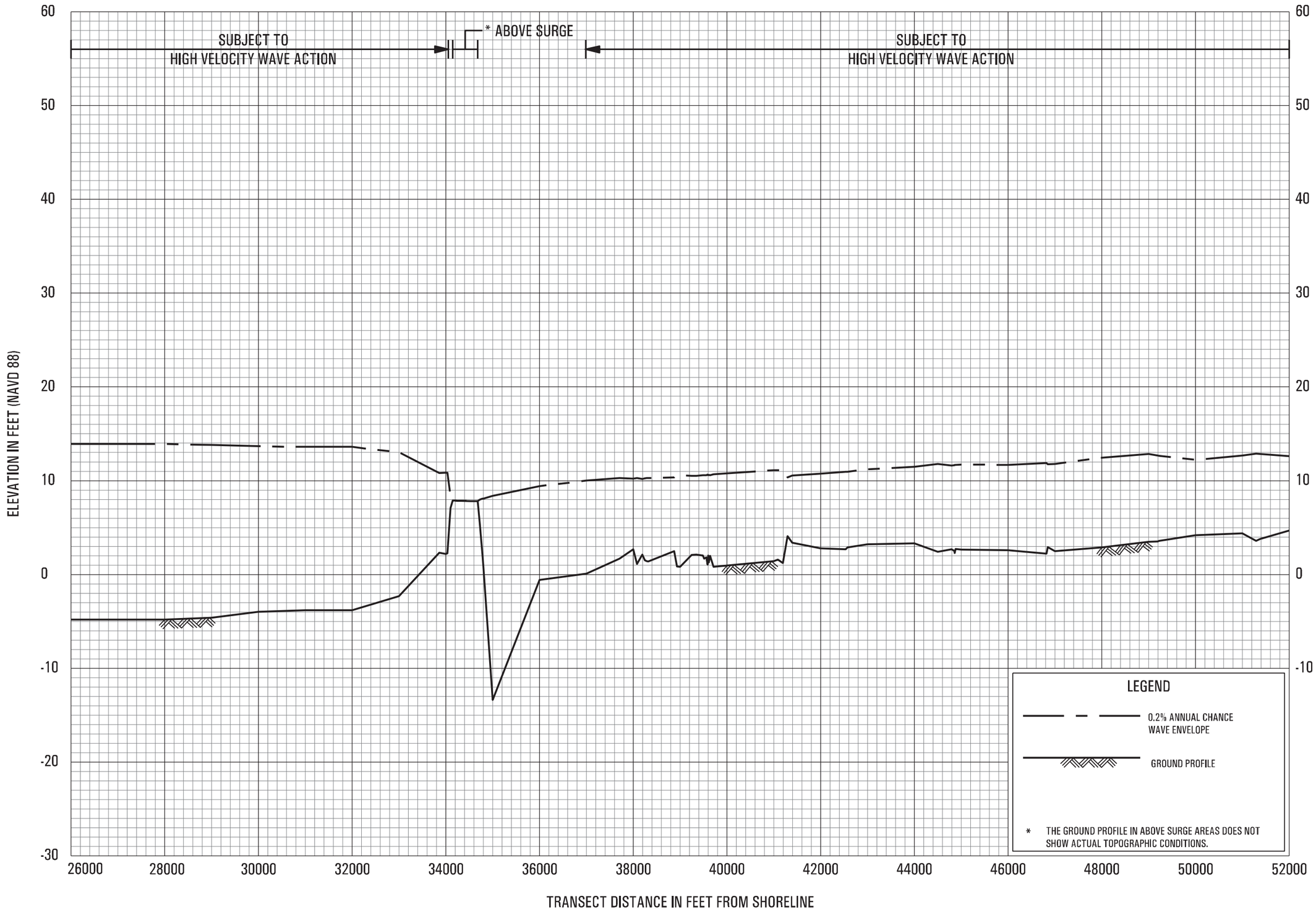
TRANSECT 18

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

46T

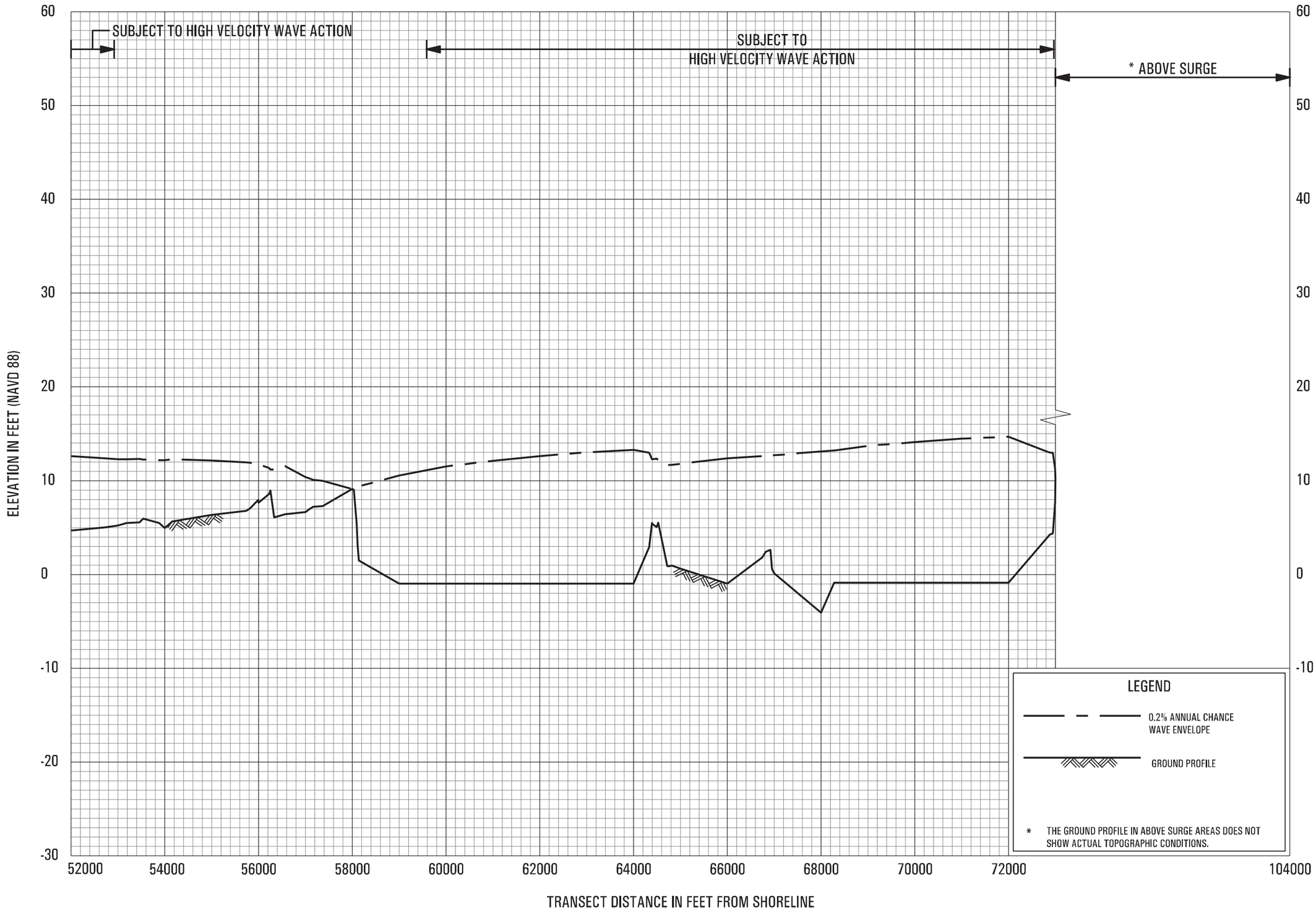


0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 18

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX
AND INCORPORATED AREAS

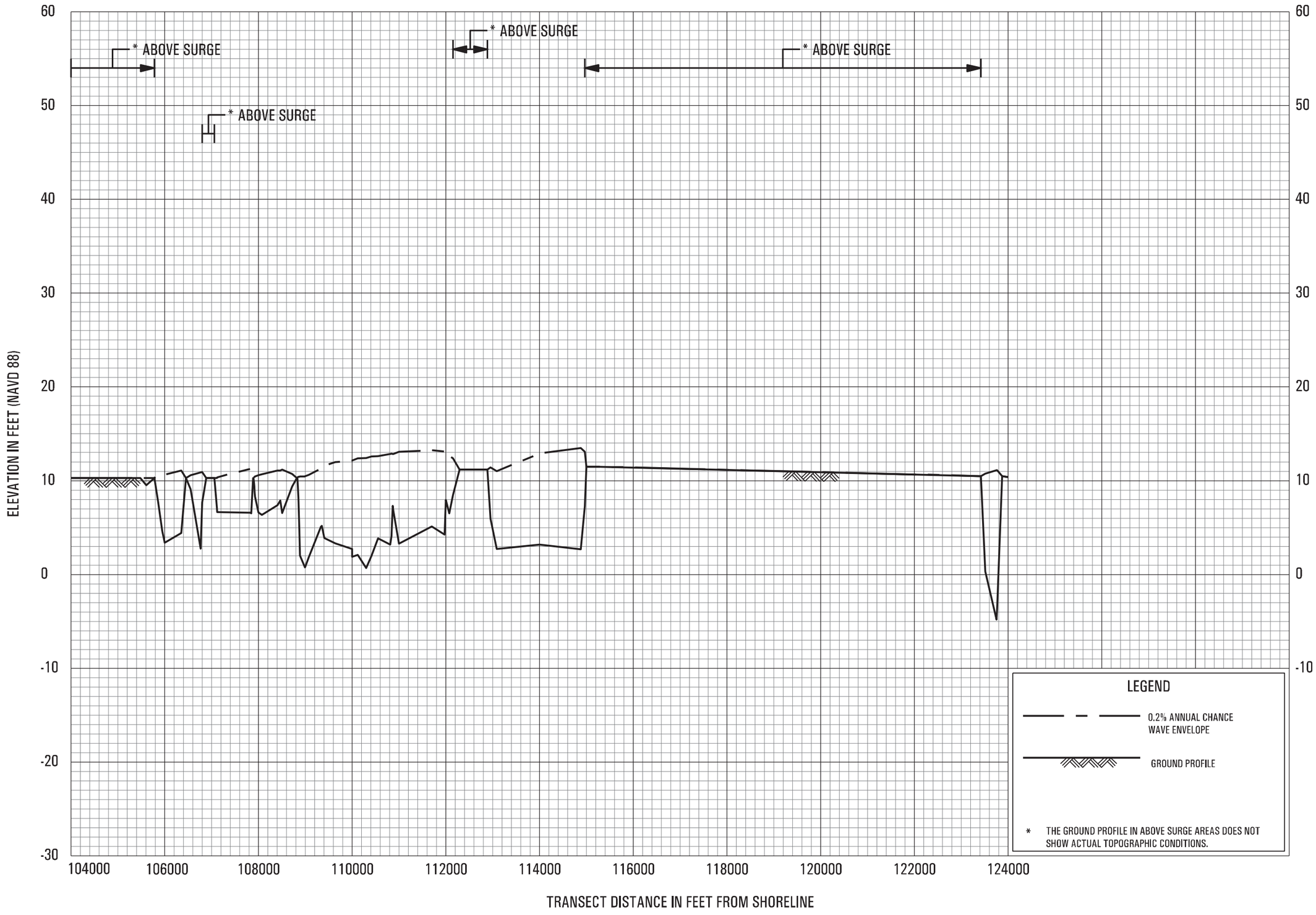


0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 18

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX
AND INCORPORATED AREAS



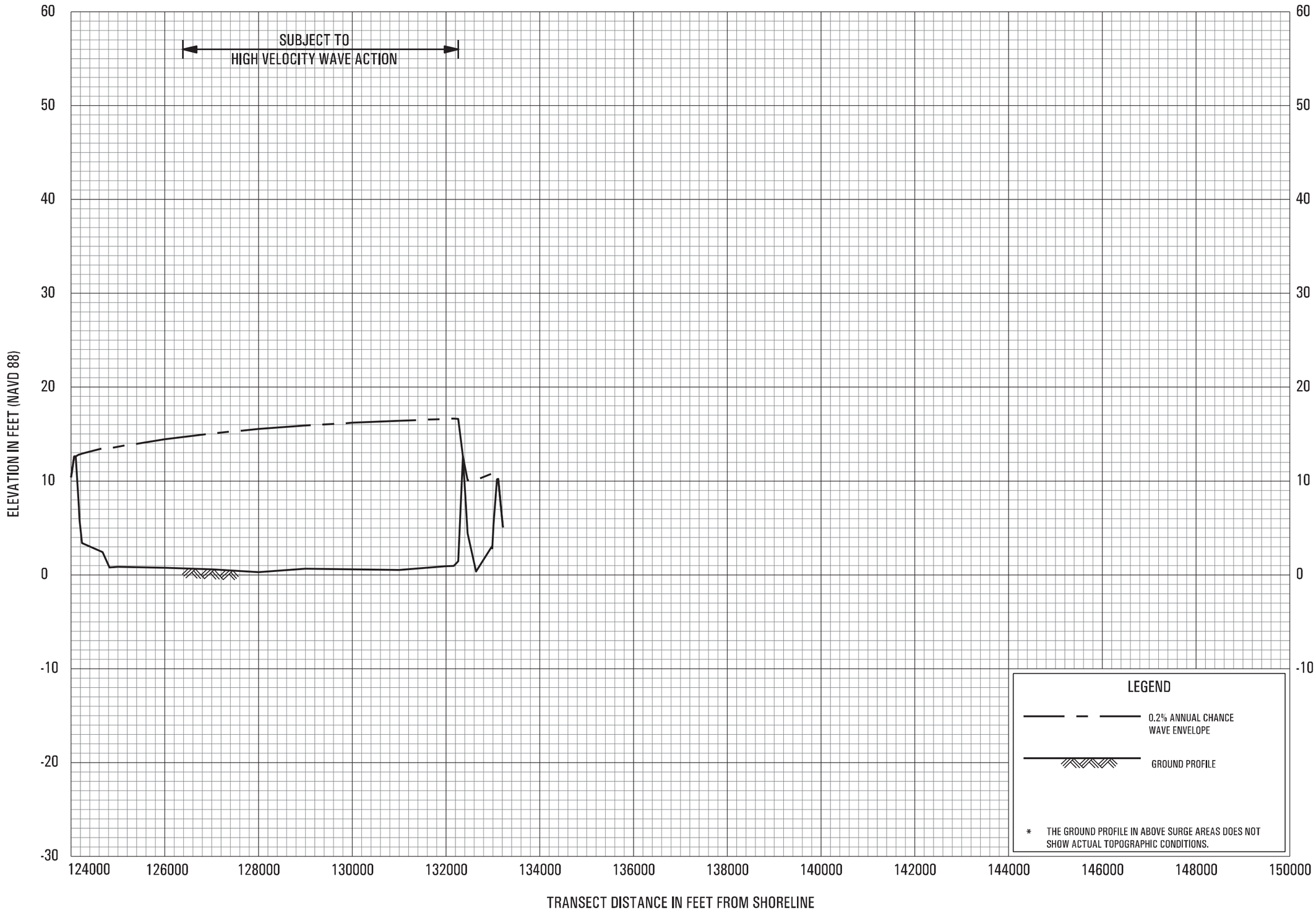
0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 18

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS



0.2% ANNUAL CHANCE WAVE ENVELOPE

TRANSECT 18

FEDERAL EMERGENCY MANAGEMENT AGENCY

CALHOUN COUNTY, TX

AND INCORPORATED AREAS

50T