TESTIMONY BY GORDON WELLS

Center for Space Research, The University of Texas at Austin

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Mr. Chairman and members of the committee:

Thank you for inviting me to join your discussion today.

My name is Gordon Wells, and I manage the real-time satellite Earth observation program at the University of Texas at Austin's Center for Space Research. For several years, I have served as a member of the Governor's Emergency Management Council and as science advisor to the Texas Division of Emergency Management. When a disaster threatens Texas, my team and I work with other scientists, such as the forecasters and modelers at the National Hurricane Center and West Gulf River Forecast Center, with first responders in the field, such as Texas Task Force 1, and with the emergency managers and public officials who guide the State's response to changing events during a crisis. Our primary mission is to interpret the information from numerical forecast models generated by supercomputers that we and other groups create as an early warning of an impending disaster. We then determine the geographic extent and magnitude of the damages that have occurred from a disaster based on satellite and aerial observations and impact modeling.

My testimony deals primarily with the Lower Rio Grande Valley and the threat of catastrophic flooding to Starr, Hidalgo, Cameron and Willacy counties. I want to address three questions:

1) In what ways does flooding impact the Lower Rio Grande Valley?

2) How did the region's flood control infrastructure perform following Hurricane Alex?

3) What challenges arise from the shared responsibility with Mexico to protect our populations from regional floods?

First, the Lower Rio Grande Valley represents a special case for coastal flooding in Texas. The region is located in the center of a large, naturally subsiding fan of sediments comprising the Rio Grande Delta. The main river channel and parts of the distributary system that were active in the recent geological past occupy the high ground with subsiding basins lying in between. Most of the population lives in the naturally subsiding basins. Circumstances are often made worse by networks of canals and transportation corridors that cross the terrain. In the Lower Rio Grande Valley, canal structures can represent the highest topographic features on the landscape and, therefore, create divides and obstructions to natural drainage. Fifty years ago, a sheet flood covering this landscape would have impacted agricultural fields, but suburban development (with accompanying impervious cover) places many residences and high-value commercial properties at high risk. Expanding development also adds to the complexity of modeling the region's vulnerability to future floods.

Topographic conditions conspire to expose the region to three different kinds of flooding. An illustration (Exhibit 1) included in my written testimony shows the surfaces subject to inundation according to historical experience and recent numerical modeling. The Lower Rio Grande Valley can be impacted by coastal storm surge from hurricane landfall, local sheet flooding from torrential rainfall and river flooding from the main stem of the Rio Grande and from combinations of all three kinds of flooding. Hurricane Beulah in September 1967 created the most damaging example of the combined impacts.

The greatest flood risk arises from river flooding that triggers the diversion of Rio Grande floodwaters into the interior floodway system of the bi-national Lower Rio Grande Flood Control Project of control structures and earthen levees. River flooding in the aftermath of Hurricane Beulah reached 220,000 cubic feet per second (cfs) at Rio Grande City and completely overwhelmed the original Lower Rio Grande Flood Control Project destroying thousands of Valley residences from Mission to Harlingen. In the 1970s, the project was reconstructed and fortified to accommodate floods of the magnitude created by Hurricane Beulah. Over the past twenty years, potential design flaws detected by modeling studies and confirmation of the deterioration of earthen levees by the collection of extremely accurate elevation surveys using aerial laser terrain mapping techniques have demonstrated that components of the Lower Rio Grande Flood Control Project are functioning at levels well below their original design capacity.

Since 2006, the International Boundary and Water Commission has taken initial steps to identify and begin repairs on the sections of the levee system most in need of rehabilitation. This effort encompasses both the primary levee bounding the main river channel and the levees along the interior floodway in Hidalgo, Cameron and Willacy counties. A significant portion of the early costs of levee repairs was borne by local jurisdictions in the Valley to accelerate the levee improvements before the next large-scale flood event. As an addendum to my written testimony, I have included a time line for the development of flood control infrastructure in the region that provides further details.

You might ask how well the flood control system fared in the aftermath of Hurricane Alex which made landfall last June 29.

Hurricane Alex was a very large storm that produced the second lowest surface pressure for a June storm in the history of the Atlantic-Gulf Basin. Very little rain from Alex fell directly over the Lower Rio Grande Valley. Instead, the dissipation of Hurricane Alex produced three separate flood waves from exceptionally high rainfall over areas in northern Mexico and the Big Bend Region in Texas. Flooding occurred immediately to produce a massive flood wave along the Rio San Juan and its tributaries in Nuevo Leon and Tamaulipas. Upstream from Laredo to the Big Bend above Amistad Reservoir, a second flood wave originated. And in the interior of Coahuila along the Rio Salado and its tributaries, truly extraordinary rainfall events created a third flood wave that did not reach the main stem of the Rio Grande for over a week after Alex's landfall. The three flood waves converged on the Lower Rio Grande Valley.

The magnitude of the flood waves prompted the emergency release of floodwater from Mexican dams in Nuevo Leon, Tamaulipas and Coahuila and from the International Falcon Reservoir, which reached its highest pool elevation in history on July 17. For the first time since Hurricane

Gilbert in September 1988, floodwaters were diverted into the interior floodways of the Lower Rio Grande Flood Control Project beginning on July 8, a process that has continued even as recently as the past week. The discharge of the Rio Grande at Rio Grande City reached a maximum of approximately 102,000 cfs, less than one-half of the flow that occurred following Hurricane Beulah in 1967, but sufficient to test many segments of the interior floodway system. Fortunately, as a consequence of the efforts of the local jurisdictions to fund recent repairs made to the most vulnerable levee sections, serious flooding was averted. I have included an illustration (Exhibit 2) of one of the critical repairs made to the levee along the Main Floodway located north of the City of Hidalgo.

Some local flooding did impact areas near the primary river levee at Havana, La Joya and Penitas, but major breaches did not occur. The Rio Grande at Rio Grande City stood above major flood stage for 26 consecutive days (July 9 - August 3). So much water entered the Rio Grande floodplain that unusual backflow conditions developed. These conditions were unanticipated and little understood by local officials. For instance, at Rio Grande City, the initial river crest of nearly 58 feet occurred after floodwater from the Rio San Juan entered the dry Rio Grande floodplain. The river rose quickly to major flood level, but did not threaten structures. Several days later following the emergency releases from Falcon Dam, the floodwaters had completely inundated Rio Grande floodplain, and a nearly equivalent river stage of over 57 feet at Rio Grande City resulting from backflow conditions produced widespread flooding across the entire floodplain near the town. County and municipal officials were puzzled why the same river stage would result in such different impacts. This highlights a problem with the standard practice of issuing flood alerts based upon river stage forecasts of the type developed by the West Gulf River Forecast Center. Operationally, the use of river stages in flood forecasts complicates and sometimes obscures the information that local officials need to take appropriate actions. A better warning system would employ advanced hydrodynamic modeling to issue inundation forecasts that specify the geographic area that will be covered by floodwater, its depth and duration. I have included a graphic (Exhibit 3) that we produced during the event to provide guidance to the public officials in Starr County and Rio Grande City.

Another issue that is raised in discussions about the Lower Rio Grande Valley is whether "pass-through flooding" is a problem. "Pass-through flooding" in the classic sense of the construction of upstream structures that magnify the impacts of flooding downstream do not exist in the region. While local development practices, including the construction of canals, causeways, highway ramps, etc., may serve to obstruct flows there is no organized attempt to "pass" floodwaters downstream or downslope to unprotected neighboring areas. There are some prevalent opinions in the Valley concerning what occurred following Hurricane Beulah in 1967 that might lead one to believe that floodwaters were deliberately diverted at the expense of downstream communities, but a careful inspection of engineering reports indicates that only unintentional structural failures occurred, and that the most famous of these at the Mercedes diversion from the Main Floodway to the Arroyo Colorado likely reduced the total impact of flooding downstream.

I would like to conclude my testimony today by considering the challenges presented by our shared responsibility for regional flood control with the nation of Mexico.

Hurricane Alex offers a great example of the problems associated with bi-national management of water resources particularly with regard to the observation and reporting of regional flooding. The vast majority of water entering the Rio Grande originates from sources in the mountains and interior basins of Mexico. With few exceptions, these inflows are unobserved or "under-observed" until they reach the main stem of the Rio Grande.

Even in the case of the most important reports issued from the major Mexican dams in Nuevo Leon, Tamaulipas and Coahuila, many hours of delay can occur between the time a measurement is made in Mexico and the information is relayed through the International Boundary and Water Commission in El Paso to the modelers at the West Gulf River Forecast Center in Fort Worth. I have included an illustration (Exhibit 4) of such a time delay in data from dam releases that occurred during a critical phase of the flooding affecting the Rio San Juan on July 1-3. When information of this kind is missing, flood forecast models can yield results that do not have an upper limit. We cannot determine if Texas will be dealing with a flood of 100,000 cfs, 200,000 cfs or a greater deluge in the Lower Rio Grande Valley. It becomes impossible to issue guidance about the level of impending threat.

In an age of near-instantaneous communications with satellite phones available, we should never experience delays in the delivery of such important reports about dam releases in Mexico.

Moreover, basic hydrographic conditions within the major Mexican tributary basins are currently not quantified. Over a week after the landfall of Hurricane Alex, the lower reach of the Rio Salado became inundated after choke flow conditions resulted in the formation of a temporary "lake" with a surface area comparable to the size of Falcon Reservoir that flooded the city of Anahuac more than 50 miles upstream from the constriction. I have included satellite images (Exhibits 5 & 6) of the new lake on the Rio Salado. The existence of this hydraulic impoundment was completely unknown in Mexico or the United States before Hurricane Alex because Mexican data for topographic elevations and river channel geometry are so poor. In this instance, the unknown and never modeled conditions happened to work to our benefit by delaying the arrival of the flood wave entering Falcon Reservoir from the Rio Salado. We may not be so fortunate during future floods in the region, when our ignorance of hydrodynamic conditions in Mexico may cause us to make an inaccurate forecast of the threat to the Lower Rio Grande Valley.

In essence, we are not going to be able to anticipate and plan for the threats posed by future floods along the Rio Grande until we have a uniform baseline of topographic and hydrographic information from which to model the entire contributing basin.

In conclusion, I hope the committee would urge the exploration of better modeling and simulation techniques to identify the full range of flood threats that could possibly impact the region. Plans for flood control infrastructure need to be based on supercomputing methodologies that represent hundreds of different flooding scenarios. I would also ask that the committee encourage the near real-time transmission of critical information from observations occurring in Mexico, preferably from data gathered by a more widespread reporting network of stream gauges along the major Mexican tributaries.

ADDENDUM TO TESTIMONY BY GORDON WELLS (UT-AUSTIN)

CHRONOLOGY OF FLOOD CONTROL LEVEE CONSTRUCTION AND INTERIOR FLOODWAY DEVELOPMENT IN THE LOWER RIO GRANDE VALLEY

1922 A near-record flood along the Rio Grande breaches the local levee at Mission leading to widespread property loss.

1924 The first local bond is passed to fund construction of a flood control levee along the Rio Grande from Donna to Brownsville.

1932 Under an agreement negotiated through the International Boundary Commission, the United States and Mexico agree to pursue mutual flood control projects on the Lower Rio Grande that would contain a design storm flood of 187,000 cfs measured at Rio Grande City. The system that includes river levees constructed along the Rio Grande and the development of interior floodways in Texas and Mexico becomes known as the Lower Rio Grande Flood Control Project.

1933 Following serious river flooding after a hurricane, the federal government begins to fund projects leading to a comprehensive flood control system in the Lower Rio Grande Valley of Texas. A series of WPA and military projects improves levees from Rio Grande City to Brownsville.

1944 Under the Water Treaty governing the Utilization of Waters of the Colorado and Tijuana Rivers and the Rio Grande, the International Boundary and Water Commission assumes responsibility for the construction and coordination of flood control measures in the United States and Mexico.

1951 Work is completed on the Lower Rio Grande Flood Control Project as conceived in 1932. The Mission Inlet is designed to divert water from the Rio Grande into the Interior Floodway in Hidalgo County.

1953 Construction of the International Falcon Reservoir is completed, providing storage capacity for 3.1 million acre-feet of water and offering flood protection from storm events affecting the main stem of the Rio Grande and its major Mexican tributary, the Rio Salado.

1967 Catastrophic river flooding following Hurricane Beulah overwhelms the levees along the Mission Inlet of the Interior Floodway causing widespread damage in Hidalgo County. The control structure at Mercedes regulating the flow of floodwater between the North Floodway and Arroyo Colorado fails causing extensive damage in the Harlingen area of Cameron County. The river discharge at Rio Grande City reaches 220,000 cfs exceeding the engineering design of the 1932-51 Lower Rio Grande Flood Control Project.

1969 Construction of the International Amistad Reservoir is completed, providing storage capacity for 5 million acre-feet of water and offering additional flood protection for events along the main stem of the Rio Grande and its major Mexican tributary, the Rio Conchos.

1970 The United States and Mexico agree to improve the infrastructure of Lower Rio Grande Flood Control Project to accommodate a design storm flood of 250,000 cfs measured at Rio Grande City. The IBWC supervises the design and construction of the Retamal Dam diversion in Tamaulipas and the Anzalduas Dam diversion in Hidalgo County. The Mission Inlet is abandoned. Construction occurs along the Main Floodway and North Floodway in Hidalgo and Cameron counties.

1988 Following the landfall of Hurricane Gilbert, floodwaters from the Rio San Juan cause the Rio Grande discharge at Rio Grande City to rise to 51,000 cfs. The Interior Floodway system is used for the first time since Hurricane Beulah. No failures occur in the system.

1992 The first modern hydraulic modeling study conducted by the U.S. Army Corps of Engineers concludes that the Lower Rio Grande Flood Control Project fails to meet its design criteria, and that levees are inadequate over 35 miles of the 274 total miles of levees in the system.

2004 A comprehensive hydraulic modeling study by the U.S. Army Corps of Engineers concludes that the Lower Rio Grande Flood Control Project would be overtopped along 38 miles of levees primarily upstream from Anzalduas along the Rio Grande and two miles of levee along the U.S. Interior Floodway. LiDAR elevation survey data collected by the University of Texas indicates additional areas where levee crests fail to meet their design height.

2006 The International Boundary and Water Commission releases the Rio Grande Flood Control System Rehabilitation Plan that identifies $125 million in levee construction projects in the Lower Rio Grande Valley. The report uses data from LiDAR elevation surveys to designate the sections most in need of repair.

2009 Congress appropriates $224 million to repair levees in the Lower Rio Grande Flood Control Project and build additional flood control infrastructure.

2010 Floodwaters from the dissipation of Hurricane Alex cause the Rio Grande discharge to rise to 102,000 cfs at Rio Grande City. Floodwater is diverted into the Interior Floodway system for the first time since Hurricane Gilbert.

Summary

The large-scale flood control system in the Lower Rio Grande Valley has developed in three phases: **1)** The 1932-51 design and construction of the original Lower Rio Grande Flood Control Project believed to be capable of containing a flood of 187,000 cfs measured at Rio Grande City.

This system failed catastrophically in the aftermath of Hurricane Beulah in 1967. **2)** The redesign and construction of new flood control infrastructure beginning in 1970 to accommodate a flood of 250,000 cfs. The new system diverted floodwater to the Interior Floodway in 1988 following Hurricane Gilbert, when river discharge at Rio Grande City reached approximately one-fifth of the new design criteria. **3)** The identification of design flaws and physical limitations of the modern flood control system using hydraulic modeling techniques beginning in 1992 and aerial LiDAR elevation surveys in 2004. Further modeling has identified the levee sections most in need of rehabilitation.

During the development of the flood control system, metropolitan populations in the Lower Rio Grande Valley have increased by factors of 6-10 (1930 population: Brownsville 22,021; McAllen 9,074; 2000 population: Brownsville 139,722; McAllen 106,414). The flood control system originally protecting farmland now must protect large suburban populations.