Expert Report

of

Robert Glenn Bea, Ph.D., P.E.

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Katrina Canal Breaches Consolidated Litigation
[Civil Action Number: 05-4182 "K" (2)]

United States District Court
Eastern District of Louisiana

Pertains to MR-GO, Robinson

(C. A. No. 06-2268)

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DECLARTIONS (attached)

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III. Engineering forensic studies of performance of the man-made features bordering the Mississippi River – Gulf Outlet (MR-GO) during 'Neutral' MR-GO Hurricane Katrina Conditions.

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PREFACE

This Expert Report is submitted on behalf of the Plaintiffs in *Robinson v. United States* (Civil Action No. 06-2268, US District Court for the Eastern District of Louisiana, Section "k"(2), Judge Duval). The purpose of this Expert Report is to define and characterize the multiple adverse effects the Mississippi River Gulf Outlet ("MR-GO") itself, as well as its accompanying authorization for replacement of the Inner Harbor Navigation Canal ("IHNC") Lock, had on the performance of the Lake Pontchartrain, and Vicinity, Hurricane Protection Project ("LPV") Reach 1, Reach 2, and IHNC hurricane flood protection structures (Figure 1) during Hurricane Katrina. The Report consists of three (3) main Declarations and six (6) supporting Technical Reports (Figure 2).

The Declarations provide engineering forensic studies relative to:

(i) the performance of the hurricane flood protection structures along Reach 2 of the MR-GO during Hurricane Katrina Conditions, the reasons for breaches, failures, and overtopping that developed with respect to those features, and the role that the MR-GO played in the development of breaches, failures, and overtopping along Reach 2 (Declaration No. 1);

(ii) the particular impact of the IHNC Lock Replacement Project activities on the breaching / failure of the hurricane flood protection structures on the east bank of the IHNC along the Lower 9th Ward (Declaration No. 2); and

(iii) breaches, failures, and overtopping which would have occurred during Hurricane Katrina Conditions had the MR-GO been properly designed, constructed and maintained, *i.e.* during 'Neutral' MR-GO Hurricane Katrina Conditions (Declaration No. 3).

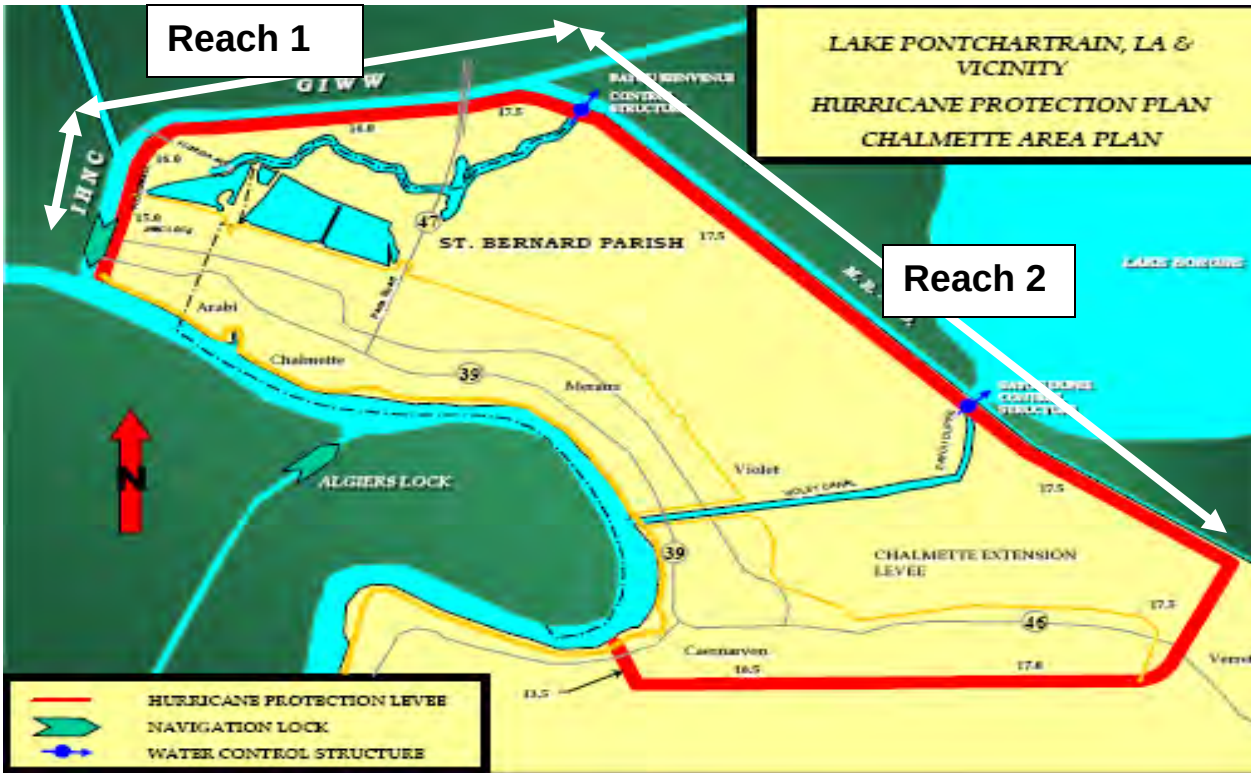


Figure 1: MR-GO Reach 1 and Reach 2 (USACE IPET 2007).

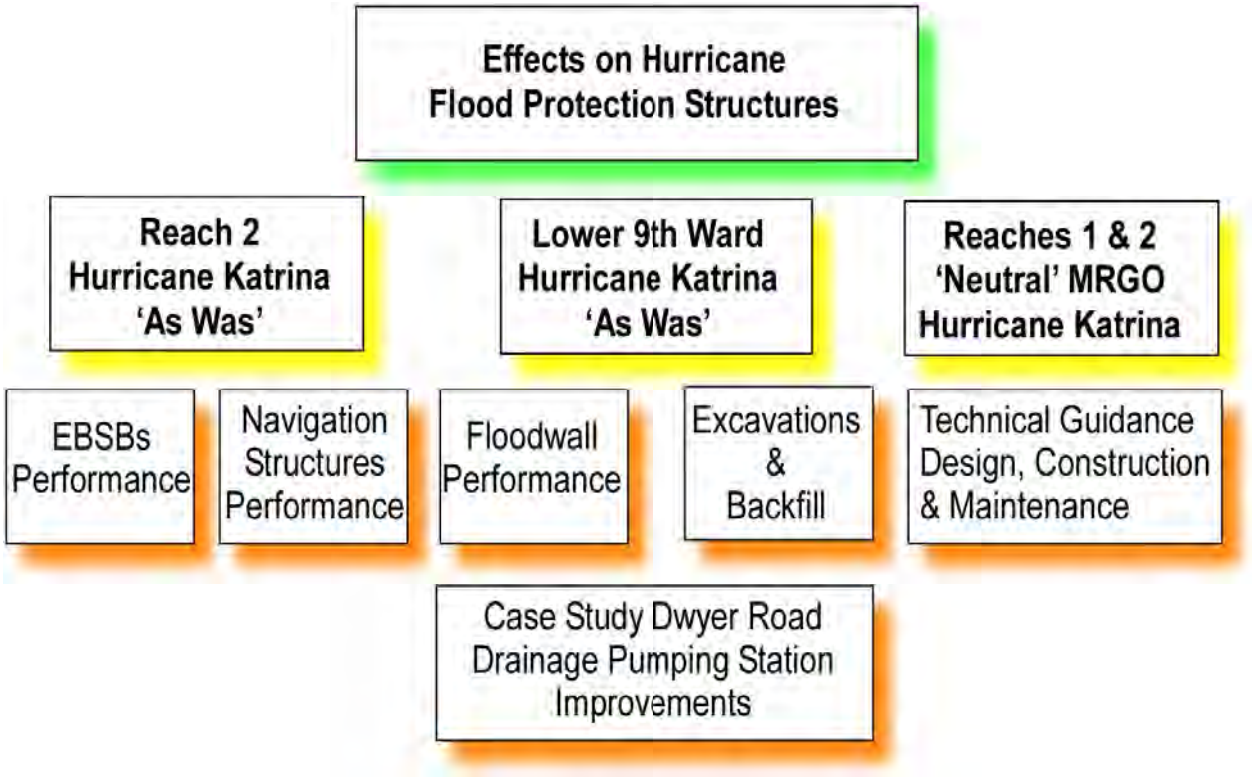


Figure 2: Structure of Declarations and Technical Reports.

The Technical Reports (Figure 2) summarize detailed studies to evaluate the:

(i) performance of the Reach 2 earthen man-made flood protection structures during Hurricane Katrina and during 'Neutral' MR-GO Hurricane Katrina Conditions (Technical Report No. 1);

(ii) performance of the Reach 2 navigation structures at Bayou Dupre and Bayou Bienvenue during Hurricane Katrina (Technical Report No. 2);

(iii) performance of the man-made flood protection structures adjacent to the Lower 9th Ward during Hurricane Katrina (Technical Report No. 3);

(iv) excavation and backfilling guidelines and procedures appropriate for activities adjacent to man-made flood protection structures (Technical Report No. 4);

(v) knowledge and technology available to properly address design, construction, operation, and maintenance of channels and coastal protection structures (Technical Report No. 5); and

(vi) Case Study of the SELA Dwyer Road Drainage Pumping Station Improvement, Discharge Tubes, and Canal (Technical Report No. 6).

In addition to my own forensic engineering studies, this Expert Report is founded and relies on data, information and knowledge contained in the following Expert Reports that are also submitted on behalf of the Plaintiffs in *Robinson v. United States* (Figure 3):

- *Impact of the Mississippi River Gulf Outlet: Geology & Geomorphology* (FitzGerald, Penland, Milanes, Miner, Westphal 2008);
- *Effects of the Mississippi River Gulf Outlet on Coastal Wetlands and other Ecosystems in Southeastern Louisiana* (Day and Shaffer 2008);

- *Survey and Spatial Data in the Vicinity of the Mississippi River Gulf Outlet* (Morris 2008);
- *Flow Modeling New Orleans – Mississippi River Gulf Outlet* (Wit, Maaskant, Kok, Vrijling 2008);
- *Wave Modeling New Orleans – Mississippi River Gulf Outlet* (Gautier, Kok, Vrijling 2008);
- *Mississippi River Gulf Outlet - Effects on Storm Surge, Waves, and Flooding during Hurricane* (Kemp 2008); and
- *Polder Flood Simulations for Greater New Orleans: the Neutral MR-GO Scenario* (Kok, Aalberts, Kanning, Maaskant, de Wit et al 2008).

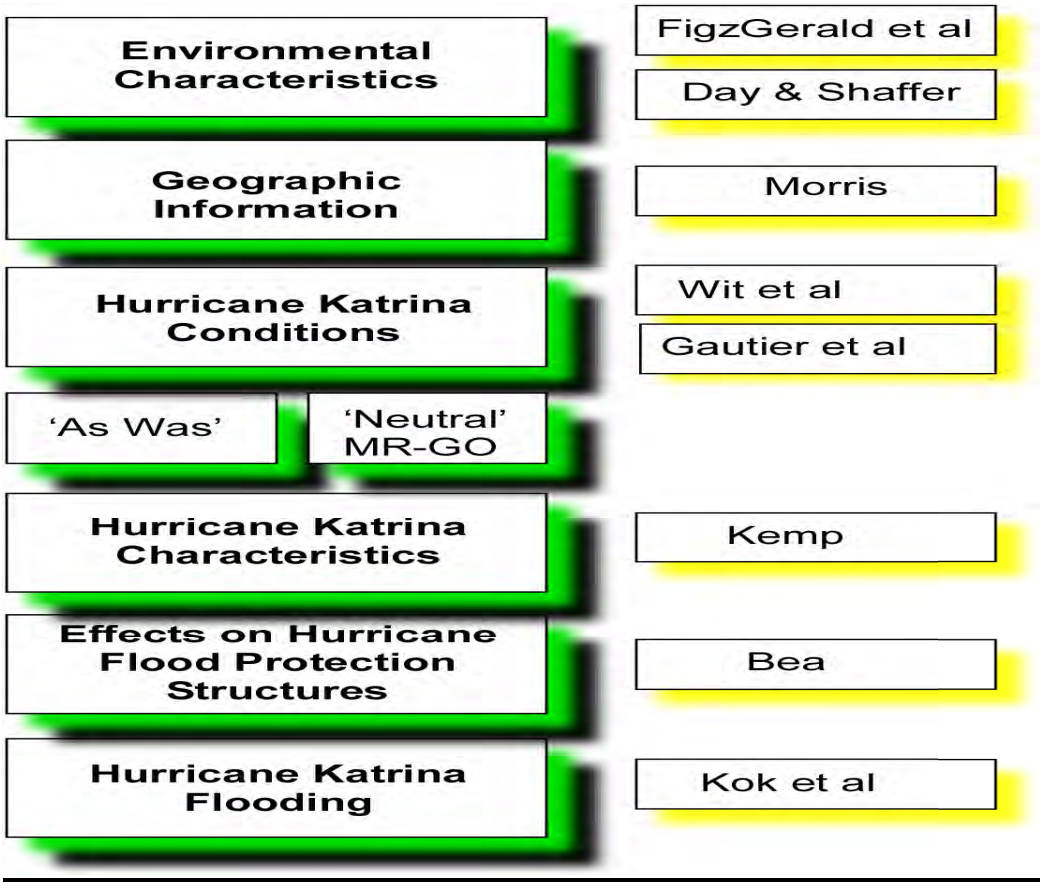


Figure 3: Structure of Expert Reports.

SUMMARY AND CONCLUSIONS

1. It is my conclusion, based on my experience, my observations and analyses, and my forensic engineering studies, that the primary cause for the breaches of the man-made features along Reach 1 and Reach 2 of the MR-GO was the design, construction, and maintenance of the MR-GO itself from 1958 to the date of Hurricane Katrina. Decisions of the USACE that resulted in the breaching and the catastrophic flooding of St. Bernard Parish, the Lower 9th Ward, New Orleans East, and portions of New Orleans Metro (Figure 1) include the following:

(a) to construct a deep-draft navigation channel in the immediate vicinity of Lake Borgne that would foreseeably connect with the narrow waterway of the GIWW - MR-GO Reach 1 and the IHNC, without any structures to control excessive and prolonged water flow into the confined IHNC during hurricane storm surge conditions;

(b) to use the MR-GO channel as a "borrow pit" for construction material for the Congressionally mandated hurricane flood protection system, the Lake Pontchartrain and Vicinity (LPV) flood protection, and thus to construct the EBSBs in the vicinity and on alignment with the MR-GO navigation channel such that the EBSBs along the MR-GO channel to the south would foreseeably connect with the EBSBs along the GIWW and MR-GO Reach 1 to the north to confine and convey ("funnel") storm surge from Lake Borgne into the narrow IHNC, thus predictably exacerbating excessive and prolonged water flow into the confined GIWW - MR-GO Reach 1 and IHNC during hurricane storm surge conditions

("funnel effect") – again without any structures to control excessive and prolonged water flow during hurricane storm surge conditions;

(c) to construct, maintain, and operate the MR-GO channel in a manner that foreseeably allowed salt water intrusion which predictably led to the rapid destruction of tens of thousands of acres of protective, cypress forests, wetlands and swamps in the Lake Borgne Basin and the Central Wetlands Unit (area between EBSBs and 40 Arpent Canal) (Kemp 2007, Freudenberg et al 2007; see also Declarations of Kemp, Fitzgerald et al, Day, Morris); the erosion and degradation of these protective cypress forests, swamps, and wetlands predictably exacerbated storm surge levels and duration in the area; in addition, loss of these natural protective barriers – often described as "horizontal levees" that are highly effective in reducing hurricane surge, currents and waves—predictably resulted in exposing the MR-GO EBSBs directly to hurricane surge, current and wave effects from the Gulf of Mexico, and the geometry of the constructed features foreseeably magnified the forces and effects of the storm surge, currents, and waves in some sections.

(d) to maintain and operate the MR-GO channel in a manner that foreseeably allowed it to (i) erode its banks and widen Reach 2 several times its authorized width, thereby endangering the stability and elevations of the adjacent EBSBs and (ii) erode and degrade the protective vegetation buffer between the authorized channel alignment and the toe of the EBSBs that would have protected the EBSBs; maintenance dredging - required to keep the MR-GO in operation – and uninhibited wakes of ships traversing the channel foreseeable caused bank erosion

and significantly widened the channel in many areas beyond its authorized width (Team Louisiana 2007). The widening of the MR-GO had a further damaging effect in that the bank erosion exacerbated the settling of the soil constituting the EBSBs along Reach 2. Consequently, the settling of this soil ('creeping') reduced the height of the tops of the EBSB when measured against mean sea level.

(e) failed to use USACE guidelines for excavations near or within a federally constructed flood control project in connection with the EBIA site clearing activities at the Lower 9th Ward. Likewise, these activities did not conform with generally accepted engineering practice;

(f) to construct the LPV along Reach 2 and portions of Reach 1 (New Orleans 'Back Levee') with dredged spoil from the MR-GO channel which was not suitable for constructing a hurricane flood protection system for a coastal environment; a foreseeable consequence of which was that EBSBs, and not the Congressionally mandated hurricane flood protection system, were constructed;

(g) to construct the LPV hurricane flood protection structures along Reach 1 and Reach 2 without utilizing applicable USACE manuals, guidelines, criteria, standards, and polices in effect from 1965 to the present, and without utilizing the prevailing, generally-accepted engineering standards for coastal hurricane flood protection structures;

(h) Failure to expeditiously complete the hurricane flood protection system; 40 years after authorization by Congress to design and construct "200 to 300- year" hurricane flood protection for this area, it was still not completed. Time ran out

early the morning of 29 August 2005 as Hurricane Katrina crossed the delta of the Mississippi River.

2. Each of these factors, as well as in combination, were substantial in causing the failures and breaches of the man-made hurricane flood protection structures along Reach 1 and Reach 2 of the MR-GO. But for the increased and sustained surge and waves caused and abetted by the MR-GO during and after Hurricane Katrina, large portions of Greater New Orleans (particularly the Lower 9th Ward, New Orleans East, and St. Bernard Parish) would not have experienced catastrophic flooding of Biblical proportions. The MR-GO was a substantiated factor in causing the catastrophic flooding in these areas. The system in place would have been adequate to contain most of the surge but for the increased and sustained surge, currents, and waves exacerbated by the MR-GO.

3. The USACE failed to recognize the foreseeable and foreseen damaging effects of the design, construction, operation, and maintenance of the MR-GO on the natural environmental defenses and the adjacent, insufficient man-made hurricane flood protection structures. It was recognized that the MR-GO had important adverse impacts on the environment, such as the degradation and erosion of the vital protection vegetation between the outboard side of the EBSBs and the authorized channel alignment, but no effective action was ever taken to either remediate the effects or correct the deficiencies. In addition, the USACE recognized that the MR-GO channel itself could have deleterious effects on the crest elevations of man-hade hurricane flood protection structures that would be built upon its banks, but again no effective early action was ever taken to prevent the MR-GO channel from encroaching into the protective berm areas.

4. With regard to the MR-GO, there were feasible measures that the USACE could have undertaken to prevent or significantly mitigate its adverse effects (Bea and Arnold 2008). With respect to the design and construction aspects, the USACE did not design and construct hurricane flood protection Levees as specified in its own manuals, guidelines, criteria, standards, and polices in effect from 1965 to the present or in accordance with the prevailing, generally-accepted engineering standards for coastal hurricane flood protection Levees to adequately protect the significant population centers (Bea and Arnold 2008). In particular, the soil materials used by the USACE along Reach 2 and parts of Reach 1 of the MR-GO were not suitable for constructing a hurricane flood protection system in the direct proximity of a deep-draft navigational channel and an open water bodies (Lake Borgne, Gulf of Mexico).

5. Particular failures to meet accepted professional design and construction standards included the use of unsuitable uncompacted dredge spoil comprised largely of sandy, silty shell fill as foundations in major parts of this system; insufficient attention to transitions between components that comprised the system (this was a system in name only); the lack of sufficient provisions for protecting the soils to resist the effects of surge, waves, and currents (both exposed and protected sides); insufficient attention given to hydraulic effects including erosion, scour, hydrostatic pressure, and through- and under-levee seepage; and failure to meet maintenance requirements to address settlements and subsidence.

6. It is important to bear in mind that the EBSBs along the MR-GO were never intended to serve as hurricane flood protection Levees because (among other things) of the soil materials used and other features (such as lack of compaction, no armoring or surface cover, and no natural protective buffering). In a sense, therefore, the EBSBs along the two reaches performed as expected during and following Hurricane Katrina when they breached and severely

eroded as they were exposed to the storm surge, currents, and waves exacerbated by the MR-GO. To the extent that Congress mandated a hurricane flood protection system for Greater New Orleans in the wake of the catastrophic flooding during and after Hurricane Betsy in 1965, the USACE did not design and build such a system along vast stretches of the MR-GO. In Section 204 of the Flood Control Act of 1965 (Pub. L. No. 89-298, 79 Stat. 1073, October 27, 1965)—Congress directed the USACE to build "works of improvement for . . . the control of destructive floodwaters" and a "*project for hurricane-hurricane flood protection on Lake Pontchartrain, Louisiana.*" This project was supposed to protect the project area from "*the most severe combination of meteorological conditions that are considered reasonably characteristic of the region*." The evidence is overwhelming that the USACE did not design and construct such a project for either Reach 1 or Reach 2 of the MR-GO.

7. In addition to the fundamental conceptual decision not to build Levees, my forensic engineering analyses of the breaching and failure of the MR-GO Reach 1 and Reach 2 man-made features during Hurricane Katrina lead to the conclusion that the USACE made other engineering and design decisions that foreseeably contributed to the failure of the system during and after Hurricane Katrina. These include decisions developed during the concept development (e.g., failure to recognize I-wall soil tension gap on Levees and need for erosion–scour protection for exposed EBSBs), design (e.g., failure to properly evaluate soil conditions and characteristics used in construction of man-made features and abutments for navigation structures, failure to recognize and design for the important modes of failure), construction (e.g., use of obsolete vertical datum reference, extensive use of dredge spoil consisting of fine grained soils; EBSBs construction borrow pits located so as to exacerbate EBSBs settlements), operation and

maintenance (e.g., failure to respond to important reductions in the elevations of the protective man-made features due to settlements and subsidence).

8. A particular deficient design criterion included the use of the obsolete Standard Project Hurricane as the fundamental basis for the meteorologic – oceanographic design and configuration of the hurricane flood protection system.

9. Based on my experience, my observations and results from extensive analyses performed after conclusion of the ILIT (2006), IPET (2006), and Team Louisiana (2007) forensic engineering studies, it is my conclusion that a major contributor to the catastrophic flooding of the St. Bernard – Lower 9th Ward 'polder' was the premature breaching of the MR-GO Reach 2 EBSBs and breaches at the navigation structures at Bayou Dupre and Bayou Bienvenue, early the morning of August 29, 2005. The differential wave action attributable to the adverse effects of the MR-GO was the primary reason for this premature breaching. The design of a tidewater channel immediately adjacent to Lake Borgne and connecting the channel into the GIWW created a predicted and predictable "funnel effect" that locally increased the height and duration of the high water levels and current velocities. The analyses indicate breaching of the EBSBs developed early the morning of August 29, 2005 allowing water to flow into and fill the ponding area between the Reach 2 EBSBs and the 40 Arpent levees. Later, when the peak of the surge arrived, the breaches were further expanded and water was able to rapidly overtop the 40 Arpent levee and flood St Bernard Parish and the Lower 9th Ward polder.

10. The system in place—even though along the MR-GO it did not constitute Levees—would have been adequate to contain most of the surge but for the increased and sustained surge, currents, and waves exacerbated by the MR-GO. My review of the USACE

forensic engineering documentation regarding failures of the man-made structures along Reach 2, and the associated court Declarations and Depositions (e.g. Varuso 2006) indicates that the USACE thinks that the design, construction, operation, and maintenance of these man-made structures was not defective or deficient. The use of uncompacted coarse grained dredged spoil in construction, the lack of adequate defense against seepage and associated adverse hydraulic effects, and the lack of adequate armoring for current and wave attack is deemed by the USACE to be within their Congressional charge. The USACE contends that during Hurricane Katrina, these man-made structures did what they were supposed to do – they performed as intended. In my professional opinion, these assertions are demonstrably erroneous. These were not proper Hurricane flood protection structures – and they performed miserably. My analysis of the available documentation does not indicate that Congress instructed the USACE to construct such structures; rather Congress acted upon the recommendations provided by the USACE. Congress depended upon the USACE to do the work properly (meet the Standards of Care) and achieve the intended level of Hurricane flood protection approved by Congress (e.g. 200 – 300 year protection). The USACE's conscious decision after 1965 not to build Levees—and instead to construct EBSBs along parts of Reach 1 and virtually all of Reach 2 of the MR-GO—spelled the difference between the resulting catastrophe that claimed hundreds of lives and caused billions of dollars of property losses as opposed to some inconvenient but not cataclysmic flooding. These EBSBs combined with the destructive effects of the MR-GO provided the 'margin for failure.'

11. Results of analyses performed to determine the timing and causes of the Reach 2 EBSBs during Hurricane Katrina show that many breaches were initiated by wave side hydraulic attack (scour, erosion) when the waves reached about the mid-height of the EBSBs. Examination of aerial LiDAR survey elevation data gathered following Hurricane Katrina indicates

approximately 35 percent of the EBSBs along Reach 2 failed in this manner. Once the surge and waves reached the tops of the EBSBs, water rushing down the backside of the EBSBs were able to fully open and develop additional breaches. Approximately 47 percent of the EBSBs along Reach 2 failed in this manner. In areas of the man-made features composed of proper materials at proper elevations and sheltered from wave attack (approximately 18 percent of the man-made structures along Reach 2), the analyses show that breaching would not have occurred. Field observations made following Hurricane Katrina corroborate these observations. Absent the adverse effects of the MR-GO, the sheltering action of the wetlands and swamps could be expected to result in dramatic reductions in the wave scour and erosion intensities resulting in acceptable performance of properly designed, constructed, and maintained Levees. Even the EBSBs in place along Reach 2 during Hurricane Katrina would not have experienced breaches and overtopping as severe as actually occurred if the wetlands and swamps destroyed by the MR-GO had been in existence to buffer the storm surge and protect the EBSBs from wave scour and erosion. A primary reason for the catastrophic flooding of New Orleans East, Lower 9th Ward, and St Bernard Parish was the increased storm surge, waves, and currents caused by the presence and adverse effects of the MR-GO.

12. Results of analyses to determine the timing and causes of the breach at the Reach 2 Bayou Bienvenue navigation structure to EBSB tie-in (South side) show that hydraulic flow and pressures through the light weight shell fill used to help minimize settlements into the buried original bayou channel and hydraulic effects developed under the short sheet piling that did not cut off flow through the buried bayou channel were sufficient to develop seepage and stability failures at this location. This is clearly the result of the defective design of this part of this navigation structure and the enhanced surge, currents, and waves caused by the MR-GO.. The

analyses indicate this breach began development early the morning of August 29, 2005 allowing water to flow into and fill the ponding area between the Reach 2 EBSBs and the 40 Arpent levees. When the peak of the surge arrived, the breaches were further expanded and water was able to rapidly overtop the 40 Arpent levee and flood St Bernard Parish and the Lower 9th Ward polder.

13. Results of analyses to determine the timing and causes of the breach at the Reach 2 Bayou Dupre navigation structure to EBSB tie-in (North side) show that hydraulic flow and pressures were not sufficient to cause seepage or stability failures. Rather, this breach apparently developed as the result of wave attack and overtopping flow and erosion of the soils at this location which was exacerbated by the enhanced surge, currents, and waves caused by the MR-GO.

14. It is clear that in some cases the MR-GO channel banks were allowed by the USACE to encroach into the 'critical areas' adjacent to the EBSBs. These encroachments foreseeably endangered the elevations and stability of the EBSBs. The dangers associated with the erosion of the MR-GO channel banks were clearly recognized by the USACE at least as early as 1981: "*(h) Within 10 years the MR-GO bank will have eroded past the MR-GO R/W line (over 200 feet) and will threaten the stability of the hurricane levee*." (underline added for emphasis (USACE 1981).

15. The observations and analyses performed during this study show that lateral squeezing of the underlying marsh and clay layers into the adjacent MR-GO channel resulted in significant decreases in the crown elevations of the EBSBs. No documentation of precautions taken or analyses performed to assure that the integrity and stability of the EBSBs was not

endangered could be found during this study. Similar observations apply to the recent construction of soil borrow pits by the USACE adjacent to the protected sides of the MR-GO Reach 2 EBSBs.

16. In the case of the Reach 1 extension into IHNC, the MR-GO - GIWW exacerbated the hurricane surge experienced at this location. Surge peak elevations were increased by 2 to 3 feet and the durations of overtopping significantly extended. The increased surge contributed significantly to the failures of the floodwalls, Levees, and other man-hade hurricane flood protection structures on both east and west sides of the IHNC and along the GIWW. Water which came in through these breaches not only devastated the Lower 9th Ward, but as well contributed to the catastrophic flooding of the St. Bernard Parish – Lower 9th Ward 'polder', the New Orleans East polder, and the New Orleans Metropolitan area polder.

17. At the Lower 9th Ward, the USACE's industrial site clearing activities outside the floodwall and levee at the East Bank Industrial Area (EBIA), consisting of ground excavations to remove buried storage tanks and other debris, were also major contributors to the catastrophic breaches that developed on the IHNC at the Lower 9th Ward. These EBIA site clearing activities were associated with the USACE navigation lock expansion project funded out of the MR-GO budget of the USACE (completed early 2005). These EBIA site clearing activities were not conducted in accordance with USACE guidelines for excavations near or within a federally constructed flood control project (USACE 2005; Bea and Storesund 2008). Likewise, these activities did not conform with generally accepted engineering practice. The knowledge and technology existed but it was not used. Water entering through these breaches of the floodwalls along the IHNC not only devastated the Lower 9th Ward, but as well contributed to the

catastrophic flooding of the St. Bernard Parish – Lower 9th Ward 'polder' (area enclosed by contiguous flood protection structures, Figure 1).

18. Results of analyses performed to determine the timing and causes of the Reach 1 flood protection structures at the Lower 9th Ward, clearly demonstrate the adverse effects of excavations developed during the USACE IHNC Lock Expansion Project site clearing operations. These operations were completed just prior to hurricane Katrina (about May 2005). The locations of the breaches are directly correlated with the locations of these excavations. Two of the deepest excavations were in the immediate vicinity of the North Breach (Boland Marine Site) and the South Breach (Saucer Site). Both the sand backfilled, native soil backfilled and non-backfilled excavations provided ready and early access of the rising waters in the IHNC to communicate with the buried marsh and swamp layers that underlie this entire area. The hydraulic flow and pressure effects were sufficient to initiate very early movements of the supporting levee and floodwalls – well before overtopping, opening up the vertical water-stop joints, and eventually developing complete breaching as the floodwalls were overtopped. Each of these factors—enhanced surge, current, and waves caused by the MR-GO and the USACE EBIA excavation work—was a substantial factor in the failure of these structures and the ensuing catastrophic flooding. In addition, but for the contributions of the exacerbated hurricane surge, waves, and currents caused by the MR-GO and the USACE EBIA site clearing activities to the failures of the man-made structures at the Lower 9th Ward, there would have been greatly reduced flooding and much less catastrophic damage done to the areas within the St. Bernard-Lower 9th Ward polder during Hurricane Katrina.

19. The 'Neutral' MR-GO Hurricane Katrina Conditions assessments which are contained in Declaration No. 3 and which are summarized here are based on the assumption that

the Congressionally mandated and authorized MR-GO project should 'do no harm' to the environment and to the man-made flood protection structures that were intended to defend this region against hurricane flooding. It is further assumed that if there would be negative effects of the MR-GO that would have substantial deleterious effects on these elements, it was incumbent that the USACE properly address and mitigate these negative effects. Such negative effects—all of which were foreseeable, if not actually foreseen, before 1958, include:

(a) destruction and degradation of the natural hurricane flood protection features,

(b) salinity increases resulting in degradation of protective vegetation (marshes, swamps, wetlands, forests) both natural and associated with other constructed works (e.g. protective berms for flood protection levees and other man-made structures);

(c) water flow increases resulting in increases in surge elevations, currents, and waves;

(d) channel effects resulting in increases in the intensity of the hurricane waves and currents;

(e) erosion of both natural and man-made flood protection elements and the Reach 2 banks; and

(f) channel erosion which caused the MR-GO channel to encroach into the protective berm of the man-made hurricane flood protection structures of the LPV causing loss of crest elevation of these structures

No effective and early action was taken to prevent these various processes from continuing. These negative effects have been evaluated in development of the 'Neutral' MR-GO Hurricane Katrina Conditions summarized in Declaration No. 3.

20. Before construction and throughout its life cycle, the negative effects of the MR-GO could have and should have been addressed by feasible mitigating elements applied directly to the MR-GO channel itself and to the adjacent man-hade hurricane flood protection structures (Bea and Arnold 2008). It was incumbent on the USACE to address these potential environmental effects in the MR-GO environmental impact statement. The scientific and engineering technology, although not as well developed as today, did exist to properly address these effects over the past half century (Bea and Arnold 2008). In fact, the history of the development of the MR-GO project (*MR-GO -Chronology*, attached as Appendix B to Kemp Expert Report (July 2008) clearly shows that the USACE was aware of but never attempted to remediate these critical negative impacts. It is also clear that preoccupations with continued development of navigable waterways and other factors led to decisions not to mitigate these important impacts (Bea Declaration I). Today, some MR-GO channel mitigations are being developed and evaluated by the USACE as part of the *Mississippi River Gulf Outlet Deep-Draft De-Authorization Report* to Congress (USACE 2008a), the *Louisiana Coastal Protection and Restoration Project* (LCPRA, USACE 2008b), and the MR-GO Reach 2 man-hade hurricane flood protection structures mitigations included in the *Hurricane and Storm Damage Reduction System Design Guidelines* (USACE 2008c). These documents contain the very mitigation measures that have been recommended to the USACE since the at least the mid-1960s (*MR-GO Chronology*). These include placing barriers or gates at the entrance of the MR-GO at the Gulf of Mexico, at the intersection of the MR-GO with the GIWW in the vicinity of Paris Road, and at the IHNC at Seabrook, restoring natural protective features (barrier beaches, wetlands, marshes, swamps), providing armoring of channel banks, and provision of foreshore protection to protect the EBSBs and other similar levee alignments. Potential man-hade hurricane flood protection

structure mitigating measures include provision of protected and flood side armor for levees and embankments, wave berms, foreshore protection, EBSB and levee profiles that reduce surge – current – and wave effects, use of proper materials and construction methods, use of deeper sheet piling and other means to cut-off subterranean seepage paths, and construction and maintenance procedures to maintain levees and EBSBs to adequate elevations.

21. In summary, based on my experience, my observations and analyses, and the forensic engineering studies of the breaches of the man-made features of the MR-GO that resulted in the catastrophic flooding of St. Bernard Parish, the Lower 9th Ward, New Orleans East, and portions of the New Orleans Metro Bowl (Upper 9th Ward), it is my conclusion that given Hurricane Katrina Neutral MR-GO conditions as analyzed and determined by Wit, et al (2008) and Gautier, et al (2008):

(a) Reach 2 – There would have not been any significant breaching of the EBSBs along Reach 2 (Figure 1). Breaching of the Bayou Bienvenue (south) navigation structure wing-wall to EBSB interface would have developed following surge overtopping initiating between 8:00 am and 9:00 am (CDT) and completing approximately one hour later. The Bayou Dupre (north) navigation structure wing-wall to EBSB interface breach would not have developed. There would have not been any breaching or overtopping of the 40 Arpent Levees—and therefore no catastrophic flooding of the areas on the protected side of the 40 Arpent Levees. These times are referenced to the surge hydrographs developed by Wit, et al (2008) for Hurricane Katrina Neutral MR-GO conditions (characterized as Scenario 2C). Engineering analyses of the performance of these man-made flood

protection structures during Hurricane Katrina and during Hurricane Katrina Neutral MR-GO conditions are addressed in a separate Declaration (Bea 2008a).

(b) Reach 1 – With one exception, there would have not been any significant breaching of the New Orleans East Back Levee EBSBs, the Citrus Back Levee and the man-made flood protection structures along this alignment (Figure 1). The levee – floodwall sheet pile interface breach at the Air Products Plant would have developed due to a sheet pile interlock failure close to the time of overtopping – at approximately 8:00 am (CDT). With two exceptions, there would have been no significant breaching of floodwalls, levees, and man-made flood protection structures at the MR-GO – GIWW - IHNC intersection and north of this intersection. The first exception would be at the CSX railroad crossing where the temporary sandbag closure would have failed at approximately 7:00 am (CDT). The second exception would be behind the southern end of the Port of New Orleans where two large breaches would develop through an earthen levee – embankment fill (lightweight shell-sand) at the intersection of the levee, embankment and a concrete floodwall sections at approximately 9:00 am (CDT). South of the MR-GO – GIWW – IHNC intersection two breaches would have developed at the locations of the North Breach and South Breach at the Lower 9th Ward. The North Breach initiated at approximately 5:00 am and completed at 7:00 am (CDT). The South Breach initiated at approximately 6:00 am and completed at 8:00 am (CDT). These times are referenced to the surge hydrographs developed by Wit, et al (2008) for hurricane Katrina 'surge Neutral' MR-GO conditions (defined as Scenario 2c). Engineering analyses of the

performance of the man-made flood protection structures at the Lower 9th Ward during Hurricane Katrina and during Hurricane Katrina Neutral MR-GO are addressed in a separate Declaration (Bea 2008b).

22. Based on the evidence previously cited, in the case of the Reach 1 extension into IHNC, the MR-GO - GIWW foreseeably exacerbated the hurricane surge, currents, and waves experienced at this location. Surge peak elevations were increased by 2 to 3 feet and the durations of overtopping significantly extended. The increased surge contributed significantly to the failures of the floodwalls, Levees, and other man-hade hurricane flood protection structures on both east and west sides of the IHNC and along the GIWW. Water which came in through these breaches not only devastated the Lower 9th Ward, but as well contributed to the catastrophic flooding of the St. Bernard Parish – Lower 9th Ward 'polder', the New Orleans East polder, and the New Orleans Metropolitan area polder. Much of the catastrophic flooding, property damage, injuries, and loss of life could have been prevented if the USACE had properly designed, constructed, and maintained hurricane flood protection structures along the MR-GO Reach 1 and Reach 2 in conjunction with a properly located, designed, constructed, and maintained 'Hurricane Neutral' MR-GO.

23. Given these pervasive and multiple failures that developed and persisted over a long period of time (55 years), it is reasonable to ask: why did this happen? The answer to this simple question is not simple. A large number of organizational, political, social, scientific, and engineering 'causes' have been identified (ILIT 2006, Woolley and Shabman 2008, NAE / NRC 2006, ASCE 2007, Committee on Homeland Security 2006, Committee to Investigate the Preparation for and Response to Hurricane Katrina 2006, Towsend 2006, Farber et al 2007, Bea 2007b). A synthesis of these extensive in-depth investigations clearly indicates that the failures

of the man-made flood defense structures during Hurricane Katrina were not 'natural' – they were not the results of 'acts of God.' These failures were clearly man-made. The USACE was primarily responsible and accountable for these failures – and this responsibility and accountability has been acknowledged publicly (Baumy statements to representatives of Levees.org 2006, Strock statements to New York Times 2007). The USACE had the central responsibilities for design, construction, and maintenance of the MR-GO and the associated navigation structures (e.g. IHNC Lock). It is now obvious these navigation related activities degraded the capacities of the associated hurricane flood protection structures. Those effects became painfully evident during the morning of August 29, 2005.

24. The National Science Foundation sponsored Independent Levee Investigation Team identified eight categories of organizational failure that were attributed to the USACE's role in this un-natural disaster (ILIT 2006). These were failures of: 1) Foresight, 2) Organization, 3) Funding, 4) Diligence, 5) Trade-offs, 6) Management, 7) Synthesis, and 8) Risk Assessment and Management. This study concluded: "*The right things were traded-off for the wrong things at the wrong times and in the wrong ways.*" The USACE led and directed an organizational system that was fundamentally dysfunctional. The USACE values and beliefs that permeated this organization consistently trumped good science and engineering. Quality and reliability were surrendered to doing the work as cheaply as possible, to getting by and hoping for the best (Colten 2006). Problems were solved in a highly 'reactive' way – proactive 'preventative' measures were not well developed. There were constant and unrelenting pressures to save time and money (Government Accountability Office 1976, 1982, 1983, 1997, 2005a). These pressures were vividly illustrated in a USACE presentation to General Heiberg regarding changes from the Barrier Plan to the High Level Plan (USACE briefing notes March 21, 1983): *"It is significant*

that a large portion of the Barrier Plan costs is represented by the costs of the barrier complexes themselves, and it is these structures that have grown most disproportionately in estimated cost over the years. The disproportional growth is driven by these four factors: 1. Changes to accommodate escalation environmental concerns …; 2. Changes in design to meet operational needs to not fully appreciated in the original designs…; 3. Changes in size of the barrier navigation structures …..4. A disproportionate rise in the costs ….” “While the costs for the barrier plan were being driven upward by changes subsequent to authorization, the costs for the High Level Plan relative to the Barrier Plan were going down under the influence of the following:1. More cost-effective levee alignments….; 2. More cost-effective construction methods … .levee is now planned in the High Level Plan as an unconfined hydraulic fill, rather than the much more expensive hauled clay fill. The effect of this change is indeed dramatic: the hauled clay fill is about $100 million more costly than the unconfined hydraulic fill; 2. The Seabrook Complex was eliminated from the High Level Plan …. Eliminating the complex eliminates the satisfying of the MRGO mitigation requirements as well, and <u>these requirements remain to be otherwise satisfied.</u>”(underline added for emphasis) “The selection of unconfined hydraulic fill construction…lowers the cost of the High Level Plan by about $100 million as compared to the conventional hauled fill construction; and the deletion of the Seabrook Complex which lowers the cost of the High Level Plan by about $45 million.”

25. Many of the deficiencies introduced into the Greater New Orleans Flood Defense System (NOFDS) emanated from flawed decision making by the USACE regarding provision of adequate financial and human resources to do what was required. Active and rapid learning of the right lessons from mistakes and heeding the early warning signs of degradations was virtually non-existent. The decisions that flowed from these values, beliefs, and practices compounded in

a slow slide down the slippery slope to the avoidable, man-made disaster that unfolded early the morning of August 29, 2005.

26. For many years, the Corps of Engineers has been subjected to extreme pressures at the federal and state levels to do more with less (Government Accountability Office 1997; Office and Management and Budget 2006); do their projects better, faster, and cheaper; and improve project management (planning, organizing, leading, controlling). The organization's attempt to respond to all of these frequently conflicting pressures introduced organizational turbulence and diversion of attention and resources that continues the present time. The USACE developed a plan to re-engineer itself (USACE 2003) and did this again following Hurricane Katrina (Lt General Strock 2007) in the form of its "12 Actions for Change." Critically, USACE technical and engineering superiority and oversight was compromised in attempts to respond to all of these constraints and pressures.

27. During one of my 'one-on–one' meetings with a senior USACE engineer ('Jim' with 42 years of flood protection experience) who was helping direct Task Force Guardian operations in New Orleans to repair the Hurricane Katrina damage to the flood protection for the Greater New Orleans Area, remarked to me: "*Bob, today the Corps of Engineers is not like it was when you and your father were with us in the 1950s, we have taken engineering out of the Corps of Engineers.*" He went on to explain that the Corps of Engineers no longer did most of the engineering and construction work itself. It now relied on outside contractors – the paradigm of 'outsourcing'. The Corps former world leading engineering research efforts had been severely cut back and some parts eliminated. In place of these previous strengths, the Corps had directed most of its efforts to "project management" – the paradigm of' better, faster, cheaper.' But,

because the Corps no longer actually engineered and constructed what it engineered, it had lost vital ‘core competencies’ and could not provide adequate direction to the outside contractors.

28. In another field trip with a group of USACE employees leading and responsible for re-construction of the MR-GO Reach 2 EBSBs, after a day of observing the EBSB repair operations (it was very hot with lots of mosquitoes) and gathering soil samples from the repairs (no one asked me why I was gathering samples or what I intended to do with them), we (I was accompanied by my colleague Dr. Raymond Seed) were riding back in the ‘mules’ to Bayou Bienvenue - the entire discussion was focused on ‘hunting deer – with or without bait – with or without dogs.’ Even when we arrived at Bayou Bienvenue and I was moving the soil samples I had gathered (about 150 pounds) from the ‘mules’ to the boat to take us across the bayou and then from the boat to the trunk of our car, no one stopped me and asked what I was doing (the samples were subsequently sent to Dr. Jean-Louis Briaud at Texas A&M University for erosion testing). Even though these men had suffered through the aftermath of Hurricane Katrina, it was obvious that they were not seriously engaged with the challenges they faced in rebuilding these vital hurricane flood protection structures.

29. For me, these two experiences clearly answered the question posed earlier – why did this happen? It happened because of a long history of early warning signs of important degradations in the Reach 1 and Reach 2 MR-GO waterways and their associated effects on the natural environment and hurricane flood protection system that had not been properly recognized, analyzed, or ever corrected. This preventable catastrophe happened because of a long history of organizational hubris, arrogance, ignorance, and indolence—as well as a lack of leadership, a slavish desire to please its “customers” in the port, shipping, dredging, and pilot boat industries, and an inexplicable failure to recognize and act upon its duty to protect life and

property put in jeopardy by constructing and operating a dangerous waterway that connected the Gulf of Mexico directly with Greater New Orleans (Kemp 2008).

30. The investigation performed by Woolley and Shabman (2008) for the USACE attributed these failures to the "Tyranny of Incremental Decisions" (Figure 4). At the core of this tyranny were concerns for escalating costs and extended schedules (GAO 2005, 2006). The results were: 1) Loss of vision for an integrated system, 2) Lack of dynamic use of new information, 3) and Organizational decision making issues. While this report did not specifically address the sad history of the MR-GO and associated developments (e.g. the USACE IHNC Lock Replacement Project), information developed during this investigation clearly indicates that the same processes were responsible for the failures of the man-hade hurricane flood protection structures during Hurricane Katrina.

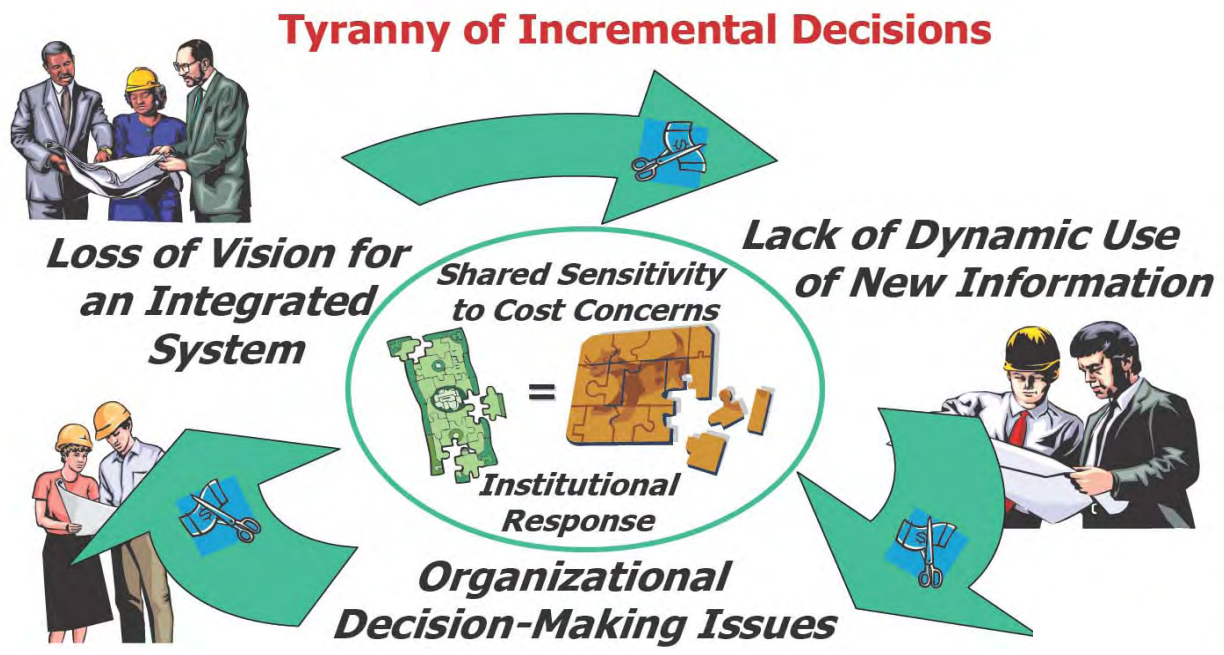


Figure 4: Hurricane flood protection Decision Chronology summary of findings (USACE 2006).