**DEPARTMENT OF THE ARMY**
**HEADQUARTERS, US ARMY CORPS OF ENGINEERS**
**441 G ST, NW**
**WASHINGTON, DC 20314-1000**

MAY 6 2009

CECW-CE

MEMORANDUM THRU Director Task Force Hope, U.S. Army Corps of Engineers, Mississippi Division, 7400 Leake Ave, New Orleans, LA 70118-3651

FOR Hurricane Protection Office, U.S. Army Corps of Engineers, P.O. Box 60267, New Orleans, LA 70118-3651

SUBJECT: Inner Harbor Navigation Canal, Lake Borgne Basin – Design Criteria Waiver for the Resiliency Design Checks

1. This is in reference to memorandum CEMVN-HPO, dated 23 Apr 2009, Subject as above.

2. Based on various discussions among HQUSACE, HPO, CEMVD, CEMVN, CEMVM, CEMVS, CEMVP, and the Geotechnical Criteria Assessment Team, the waiver request is approved subject to these two additional geotechnical design checks.

(a) Global slope stability of the structures in the Lake Borgne Basin will be evaluated using Spencer's Method and reported by the design team as a design check for resiliency with water retained on the outward side at the top of the wall, requiring a factor of safety of 1.1.

(b) Stability against failure by seepage and piping will be evaluated with a design check for resiliency at the maximum differential head that develops from surge levels to the top of structure, requiring a factor of safety of 1.3.

3. Criteria requests should be fully coordinated early in the process through the Vertical Team, including Mississippi Valley Division and the HQUSACE Regional Integration Team.

4. HQUSACE, POC for this action is Mr. Robert Bank, Robert.bank@usace.army.mil, 202-761-5532.

JAMES C. DALTON, P.E.
Chief, Engineering and Construction
Directorate of Civil Works

CF
CEMVD
CEMVN-ED
CEMVS-EC
CEMVP-EC
CEMVM-EC
CEMVP-EC
CEMVK-ED

DEPARTMENT OF THE ARMY
HURRICANE PROTECTION OFFICE, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

REPLY TO
ATTENTION OF

CEMVN-HPO

23 Apr 2009

CONCUR - [signature] 24 APR -

MEMORANDUM THRU Director Task Force Hope, U. S. Army Corps of Engineers, Mississippi Division, 7400 Leake Ave, New Orleans, LA 70118-3651 please respond by 4 MAY 2009 - thanks!

FOR Mr. James Dalton, Chief, Engineering and Construction, Headquarters, U. S. Army Corps of Engineers, 441 G Street N. W., Washington DC 20314-1000

SUBJECT: Inner Harbor Navigation Canal, Lake Borgne Basin – Design Criteria Waiver for the Resiliency Design Checks

1. Reference:

a. CECW-CE Memorandum dated 25 Apr 2008, Subject: Hurricane Protection System Slope Stability Design Criteria.

b. CECW-CE Memorandum dated 16 Jan 2009, Subject: Hurricane Protection System Seepage Design Criteria and Retention Slope Stability Design Criteria.

2. Request a design criteria waiver that permits a modification of the resiliency design checks outlined in reference 1.a. If approved, this waiver will still produce conservative designs consistent with the authorized level of protection and allow us to better achieve the required one hundred year level of risk reduction by June 2011.

3. Design Guidelines in reference 1.a (Tables 3.1, 5.1 and 5.2) include design checks for extreme events above the authorized design level of protection. These design checks were introduced to add resiliency to the overall system following lessons learned from Hurricane Katrina. However, these checks consider only hydrostatic loads due to water to the top of wall and do not include waves. Flood walls along the new hurricane system in the Lake Borgne Basin are designed to control the overtopping produced by wave action to a value that precludes the use of armoring on the protected side. This produces wall heights 10~12 feet higher than the static water elevation (design water elevation) corresponding to the 100-year level of protection. This extra height leads to a design check for a recurrence interval that is extremely high and far beyond authorized scope of design. The unintended consequence for the Lake Borgne Basin is that these design checks are controlling the design of the flood protection features and increasing construction costs significantly.

4. We recommend modifying the structural design check as follows: First, we propose to change the top of wall surge levels to the 0.2% surge levels in order to attach a reasonable return period to the design checks event (see enclosure). For structures, we also propose to include wave

loading into the design check. Second, for both surge and wave loadings, we propose to use 90% confidence levels which is consistent with the basic 1% design loadings. The allowable overstress and factors of safety for the pile loads are kept equivalent to the current design checks, i.e., water to the top of the flood protection system. This will result in the recommended structural design checks, i.e., replacing the three design checks based on water to top of wall (see enclosure).

5. Similarly, we recommend modifying the geotechnical design checks. We propose to change the top of wall surge levels to the 0.2% surge levels in order to attach a reasonable return period to the resiliency design checks event. We propose to use 90% confidence level which is consistent with the basic 1% design loadings. The recommended geotechnical design checks will obviate the current design checks based on water to the top of wall (see enclosure).

6. We have coordinated the proposed waiver with Anjana Chudgar (HQUSACE) and Neil Schwanz (MVD RTS), members of the IHNC Lake Borgne Barrier Senior Review Team, and they are in agreement with this request. The proposed modifications in the resiliency design checks make these checks more realistic and better align with the overarching risk-based approach for the Hurricane and Storm Damage Risk Reduction System. They also give consistency for a design methodology across the various disciplines for the resiliency design checks.

7. Our point of contact for this action is Dr. John Grieshaber, (504) 862-2979.

Encl

MICHAEL McCORMICK
COL, EN
Commanding

CF:
Mr. Jimmy Waddle, P.E.
Chief, RB-T, MVD
Mr. Walter Baumy, P.E.
Chief, Engineering Division, MVN
Mr. Michael Bart, P.E.
Chief, Engineering Division, MVP
Mr. Tom Miniard, P.E.
Chief, Engineering Division, MVM

CEMVN-HPO 22 April 2009

MEMORANDUM FOR RECORD

SUBJECT: Inner Harbor Navigation Canal, Lake Borgne Basin – Design Criteria Waiver for the Resiliency Design Checks

1. Background. Design Guidelines in the reference (Tables 3.1, 5.1 and 5.2) include design checks for extreme events above the authorized design level of protection. These design checks were introduced to add resiliency to the overall system following lessons learned from Hurricane Katrina. However, these checks consider only hydrostatic loads due to water to the top of wall and do not include waves. Moreover, flood walls along the new hurricane system in the Lake Borgne Basin are designed to control the overtopping produced by wave action to a value that precludes the use of armoring on the protected side. This produces wall heights 10~12 feet higher than the static water elevation (design water elevation) corresponding to the 100-year level of protection. This extra height leads to a design check for a recurrence interval that is extremely high and far beyond authorized scope of design. The unintended consequence for the Lake Borgne Basin is that these design checks are controlling the design of the flood protection features and increasing construction costs significantly.

2. Purpose. The objective of this MFR is to provide a basis for the recommended modifications to the Structural and Geotechnical Design Checks for the Lake Borgne area. The proposed changes in the resiliency design checks make these checks more realistic and it also fit better in the overarching risk-based approach for the Hurricane and Storm Damage Risk Reduction System. It also gives consistency for a design methodology across the various disciplines for the resiliency design checks.

3. Current Situation. The text hereafter provides detailed information about the project elevations in the Lake Borgne area, the background of the criteria, and the recommendations for modifications to the existing Design Checks from the HSDRSS Guidelines.

a. Project Elevations **-** The IHNC-Lake Borgne Barrier consists of three gate structures, and approximately 7,000 linear feet of barrier wall and T-wall crossing the Golden Triangle marsh east of the Michoud Canal. The top of wall of the gate structures and T-wall is EL +26.0. The top of the barrier wall is crenellated with top of merlon at EL +26.0 and top of crenel at EL +24.0. The IHNC Lake Borgne Barrier ties into the New Orleans East hurricane system at its north end and the St. Bernard hurricane system at its south end with transition T-walls (transition T-wall). These transition T-walls and the systems to which they tie have a top elevation of EL +32.0. All elevations are NAVD88 2004.65.

b. Criteria Background - The T-Wall and Slope Stability Design Criteria, as outlined in the New Orleans HSDRRS T-Wall Procedure and the HSDRRS Design Guidance, require Basic Design Loading conditions for the 1% percent hurricane event with waves. Design Checks have been introduced to add resiliency to the design of the overall risk reduction system following



**Enclosure**

lessons learned from Katrina and to prevent for catastrophic system failure. These two tracks in the HSDRSS design guidelines are schematically depicted in Fig 1.

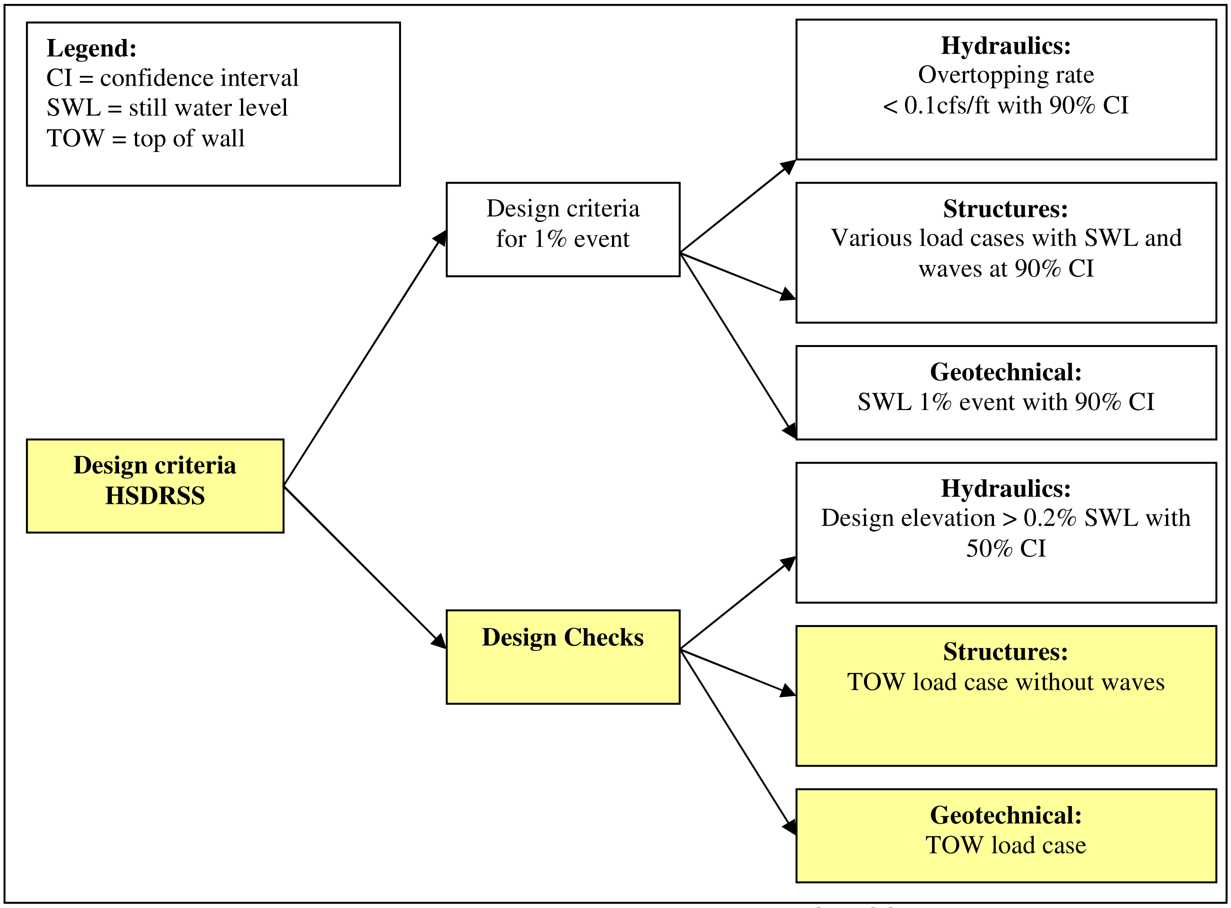



**Fig 1: Diagram with the schematically the design criteria for the HSDRSS. This note only considers the Structural and Geotechnical Design Checks from the HSDRSS guidelines (yellow boxes).**

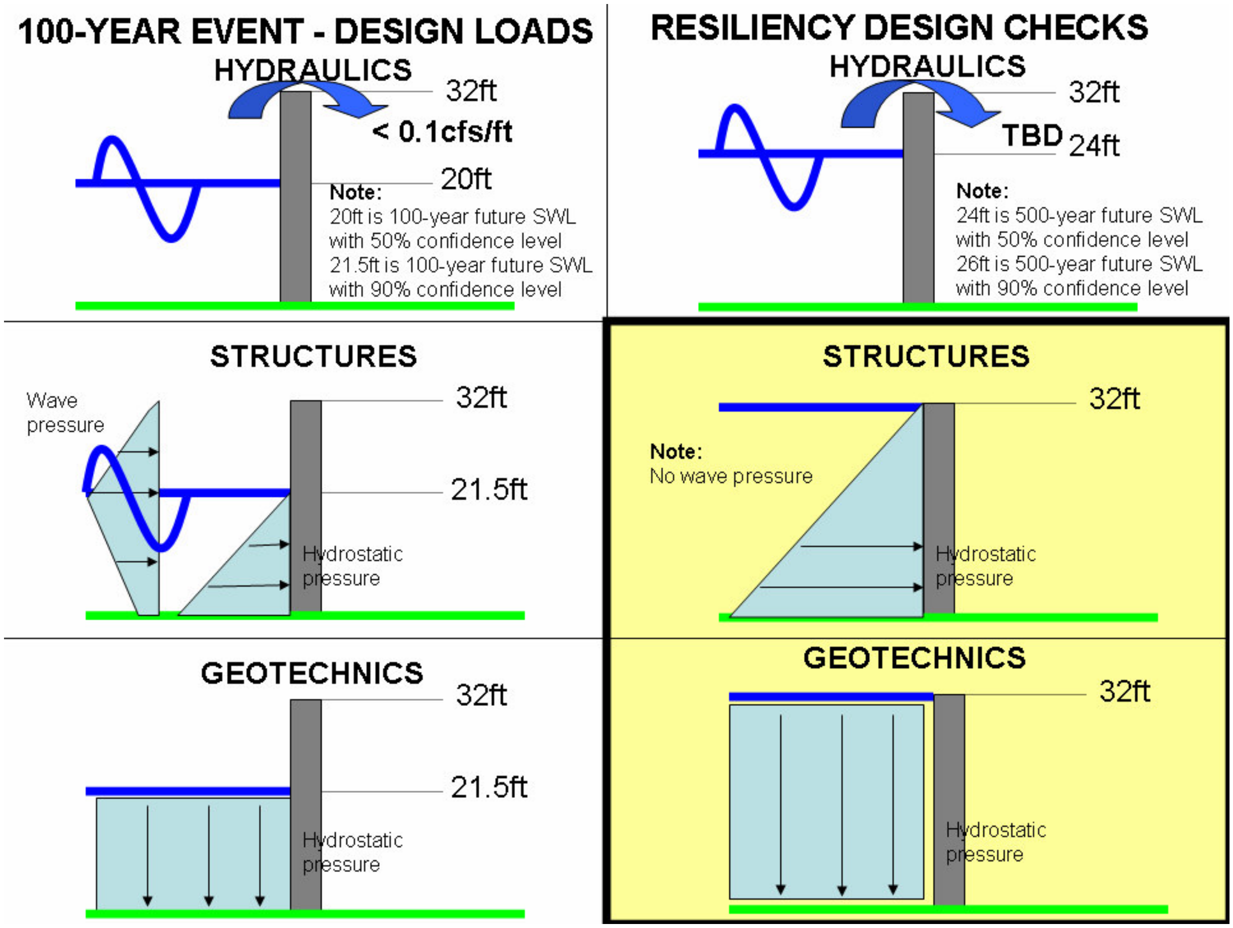



**Fig 2: Schematic diagram with the load cases for the HSDRSS for a straight wall. The 1% design load cases are at the left-hand side, the Design Checks at the right-hand side. This note only considers the Structural and Geotechnical Design Checks from the HSDRSS guidelines (i.e. the central and lower panels at the right-hand side)**

Fig 2 shows in more detail the basic design load cases for the 1% event (left-hand side) and Design Checks (right-hand side) from a Hydraulic, Structural and Geotechnical point of view. The depicted surge and top of wall design elevation numbers in Fig. 2 are realistic for the tie-in floodwalls near the IHNC barrier. In short, the following design checks are carried out:

- Hydraulics: The 1% floodwall/levee elevations are checked against the 0.2% still water level; the elevations are modified up to at least the 0.2% still water level to reduce overtopping in case of such an event. Furthermore, 0.2% overtopping rates are being computed and these values are probably be used to design inner slope armoring if necessary.

- Structures: The 1% design is checked against water to the top of the wall without waves. Higher overstress factors are being allowed for this design check compared with the 1% design load cases.

- Geotechnical: The 1% design is checked against water to the top of the wall without waves. Lower factors of safety are applied compared with the 1% design load cases.

This MFR only considers the Design Checks for Structures and Geotechnical.

The Design Checks for Structures and Geotechnical are summarized below. The load cases in Table 5.2 of the HSDRRS Design Guidance, dated 12 June 2008, are governing the Structural Design Checks. Table 1 below presents the geotechnical slope stability design criteria for Levees and Floodwalls. The grey marked conditions in Table 1 are related to the Design Checks for resiliency. Note that both the structural and the geotechnical load cases for resiliency include water to the top of the wall (TOW) and no wave loading.

**Table 5.2 (12 JUNE 2008) – EXISTING STRUCTURAL DESIGN CHECKS**

| HURRICANE PROTECTION - DESIGN CHECKS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| LOAD CASE | % ALLOWABLE OVERSTRESS | | PILE LOAD - FACTORS OF SAFETY (FOS) | | | | | |
| | WALL | FOUNDATION | STATIC LOAD TEST | | PDA LOAD TEST | | NO LOAD TEST | |
| | | | C | T | C | T | C | T |
| I. WATER TO TOP OF WALL, NO UNBALANCED LOAD + NO WAVE LOAD | 33⅓ | 33⅓ | 1.50 | 1.50 | 1.90 | 2.25 | 2.25 | 2.25 |
| II. WATER TO TOP OF WALL, UNBALANCED LOAD + NO WAVE LOAD | 50 | 50 | 1.33 | 1.33 | 1.67 | 2.00 | 2.00 | 2.00 |
| III. WATER TO TOP OF WALL, W/ OR W/O UNBALANCED LOAD + * BOAT IMPACT (BI) | 67 | 67 | 1.20 | 1.20 | 1.50 | 1.80 | 1.80 | 1.80 |

1. For SWL cases, apply (BI) 3-ft above SWL. For water to top of wall, apply impact at top of wall.

**Table 3.1 (12 JUNE 2008) EXISTING GEOTECHNICAL DESIGN CHECKS WITH WATER TO TOP OF LEVEE/WALL (IN GREY)**

| Analysis Condition | Required Minimum Factor of Safety | |
|---|---|---|
| | Spencer Method[1] | MOP[2] |
| End of Construction[3] | N/A | N/A |
| Design Hurricane[4] (SWL)* | 1.5 | 1.3 |
| Water at Project Grade (levees) [5] | 1.4 (1.5)[6] | 1.2 |
| Water at Construction Grade (levees) [5] | 1.2 | N/A |
| Extreme Hurricane (water @ top of I-Walls) [5] | 1.4 (1.5)[6] | 1.3 |
| Extreme Hurricane (water @ top of T-Walls) [5a] | 1.4 (1.5)[6] | 1.2 |
| Low Water (hurricane condition)[7] | 1.4 | 1.3 |
| Low Water(non-hurricane condition)[8] S-case | 1.4 | 1.3 |
| Water at Project Grade Utility Crossing[9] | 1.5(1.4) | 1.3 (1.2) |

* The 1% still water level with 90% confidence level is being applied in this load case.

4. Issue - The Top of Wall load case as defined in Table 5.2 (Structures) and Table 1 (Geotechnical) are not realistic cases to be applied for the IHNC / Lake Borgne area. The reason is twofold:

- The TOW load case has a return period that is extremely high (>> 1000 year)
- The TOW load case for Structures does not include waves (which is physically not realistic).

The basis for the first argument is shown in Figure 3 below. It can be observed the return period that is associated with the surge level to the top of the wall is much larger than 2000 years. Although the probabilistic method is not applicable for this range, a 10,000 year return period seems reasonable for surge levels equivalent to the top of wall based on extrapolation.

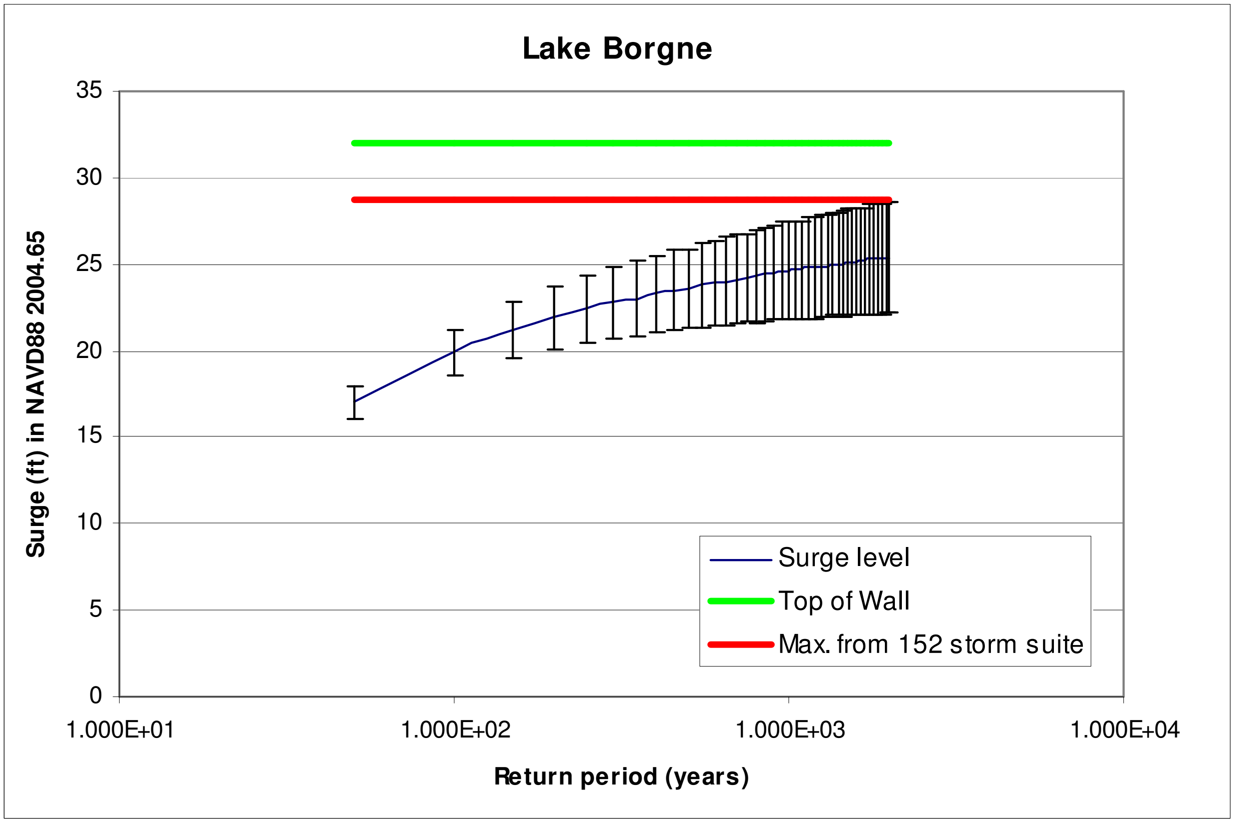



**Fig 3: Surge level frequency curve for future conditions (2060) for Lake Borgne area with 10% and 90% confidence levels.**

Secondly, the TOW load case only includes only the hydrostatic load. However, waves will be present in reality, and these waves induce an extra force and moment onto the structure. Although the magnitude of the wave force may be less than the hydrostatic force due to the surge, the wave force may be very dominant in the loading and structural behavior because of the large arm and resulting bending moment in the structure.

Based on this, the below changes to the present Design Criteria are recommended:

5. Recommendations - We recommend modifying the Structural Design Check as follows. We propose to change the top of wall surge levels to the 0.2% surge levels in order to attach a reasonable return period to the Design Checks event. For structures, we also propose to include wave loading into the Design Check. For both surge and wave loadings, we propose to use 90% confidence levels which is consistent with the basic 1% design loadings. The allowable overstress and factors of safety for the pile loads are kept equivalent to the existing Design Check Case III. This results in the following recommended structural design check (i.e. replacing the three design checks with top of wall):

**Table 5.2 (21 APRIL 2009) – REVISED STRUCTURAL DESIGN CHECK**

| Load Case Name | Loads Included | Allowable Overstress [2] | Pile Load - Factors of Safety [2] |
|---|---|---|---|
| Resiliency with Wave (SWL[1]+UNBL+Wave+Wind+BI) | Dead Load, SWL[1], Unbalanced Load[4], Wave Load[3], Wind Load[4], and Barge Impact Load[4] | 67% | 1.2 |

1 SWL is equal to the 0.2 % (500-yr) annual-chance-event - water level with 90% confidence.
2 The allowable overstresses are for both for the foundation and the wall. The pile load factor of safety assumes pile static load test is performed.
3 The wave load shall be based on 90% confidence values of the 0.2 percent-annual-chance-event wave forces.
4. If present

Along the same lines, we recommend modifying the Geotechnical Design Check as follows. We propose to change the top of wall surge levels to the 0.2% surge levels in order to attach a reasonable return period to the Design Checks event. We propose to use 90% confidence level which is consistent with the basic 1% design loadings. This results in the following recommended geotechnical design check (i.e. replacing the design checks with water to the top of wall):

**Table 3.1 (21 APRIL 2009) REVISED GEOTECHNICAL DESIGN CHECKS (IN GREY)**

| Analysis Condition | Required Minimum Factor of Safety | |
|---|---|---|
| | Spencer Method[1] | MOP[2] |
| End of Construction[3] | N/A | N/A |
| Design Hurricane[4] (SWL)* | 1.5 | 1.3 |
| Water at Project Grade (levees) [5] | 1.4 (1.5)[6] | 1.2 |
| Water at Construction Grade (levees) [5] | 1.2 | N/A |
| Extreme Hurricane (SWL**) [5] | 1.3 (1.4)[6] | 1.1 |
| Extreme Hurricane (SWL**) [5a] | 1.3 (1.4)[6] | 1.1 |
| Low Water (hurricane condition)[7] | 1.4 | 1.3 |
| Low Water (non-hurricane condition)[8] S-case | 1.4 | 1.3 |
| Water at Project Grade Utility Crossing[9] | 1.5(1.4) | 1.3 (1.2) |

* The 1% still water level with 90% confidence level is being applied in this load case.
** The 0.2% still water level with 90% confidence level is proposed to be applied in this load case.

Figure 4 shows the proposed changes to the existing Design Checks schematically.

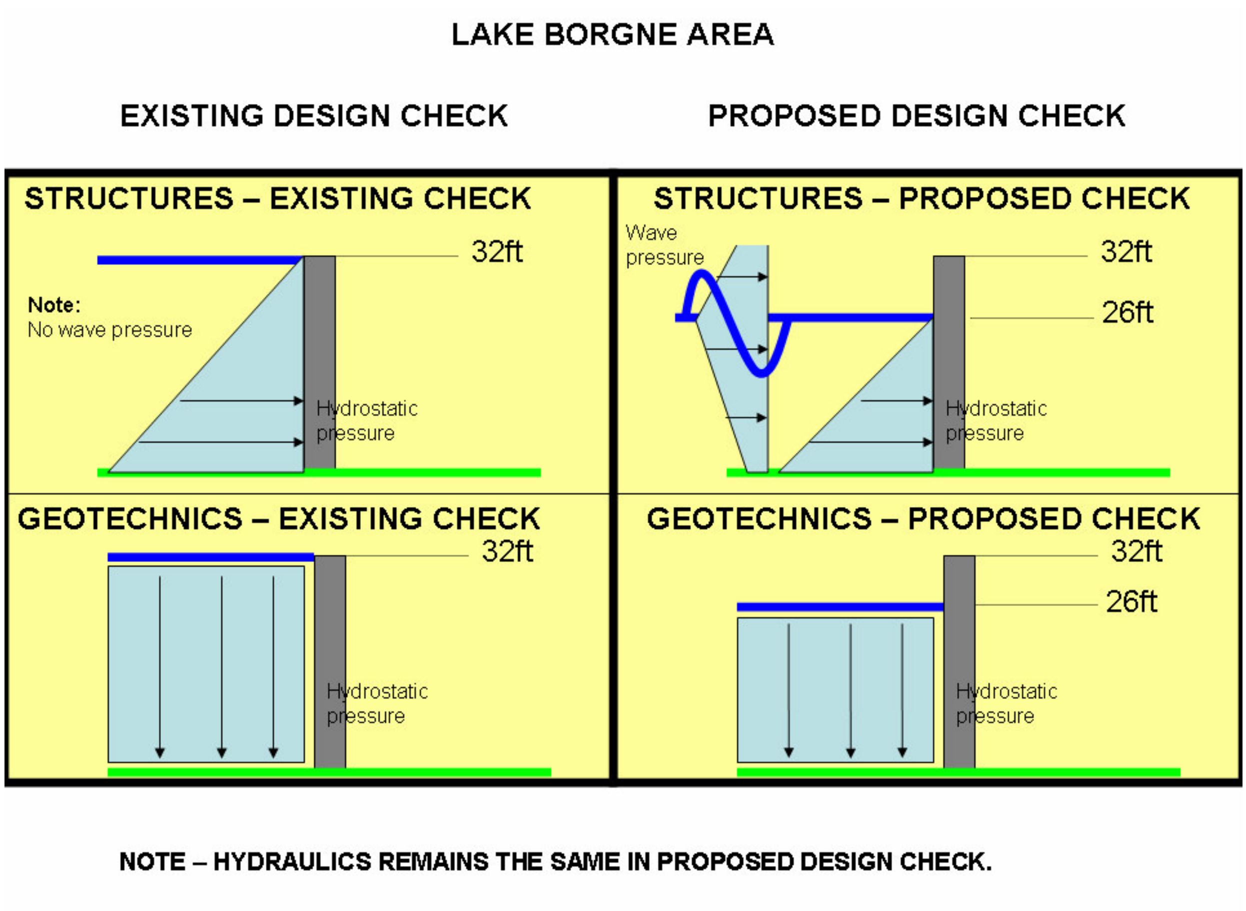



**Fig 4: Schematic diagram with the existing checks (left) and proposed checks (right) in the Structural and Geotechnical Design Checks load cases for Lake Borgne area.**

The proposed change in the Design Checks make the resiliency check more realistic and it also fits better in the overarching risk based approach than the existing ones. It also gives consistency throughout the various disciplines for the Design Checks, see table next page. Although the current Design Checks change is proposed for the Lake Borgne region, the proposed changes should also be considered in view of the entire Hurricane Storm and Damage Risk Reduction System. It will depend on the magnitude of surge and waves if these new Design Checks will lower or increase the design loading conditions compared to the existing design guidelines.

6. Coordination. These proposed changes to the current resiliency design checks were discussed during a a telephone conference on 21 April 2009 that included Anjana Chudgar, HQUSACE, Neil Schwanz, MVP, and the following from HPO: COL Michael McCormick, John Grieshaber, Luis Ruiz, Tom Hassenboehler, Pete Cali, Jennifer Kline, Louis Danflous, Angela DeSoto Duncan and Mathijs van Ledden. The proposed Design Checks criteria waiver as outline above was discussed following the powerpoint slides included at the end of this memorandum. The attendees all agreed on the proposed criteria modification from using a Top of Wall Design Check into a Design Check using a 500-year event as a basis, as summarized below:

| Lead discipline | Failure mechanism | Usual design case: 1% event in any given year | Extreme design check: 0.2% event in any given year (resiliency) |
|---|---|---|---|
| Hydraulics | Design height too low | Design height > 1% SWL via erosion of inner slope mechanism | Design height > 0.2% SWL (50% confidence interval) |
| | Erosion inner slope | 1% overtopping rate less than 0.1 cfs/ft at 90% confidence level | 0.2% overtopping rate (armoring to be considered) |
| | Erosion at outer slope | TBD | TBD |
| Geotechnical | Slope stability inner or outer slope | 1% still water level with 90% confidence level using Spencer with FOS = 1.5 | Still water to top of levee/wall using Spencer with FOS = 1.4<br><br>***Proposed direction: 0.2% still water level with 90% confidence using Spencer with same FOS*** |
| | Seepage/piping | 1% still water level with 90% confidence level with specific FOS for levee toe/berm | Still water to top of levee/wall (or design grade) with lowered FOS for levee toe/berm<br><br>***Proposed direction: 0.2% event still water level with 90% confidence with same FOS as above*** |
| Structures | Structural integrity pile foundation and structure | 1% wave/hydrostatic forces at 90% confidence levels with allowable overstress factors and FOS | Still water to top of levee/wall with higher allowable overstress factors<br><br>***Proposed direction: 0.2% event forces with 90% confidence levels with higher overstress factors/lower FOS*** |

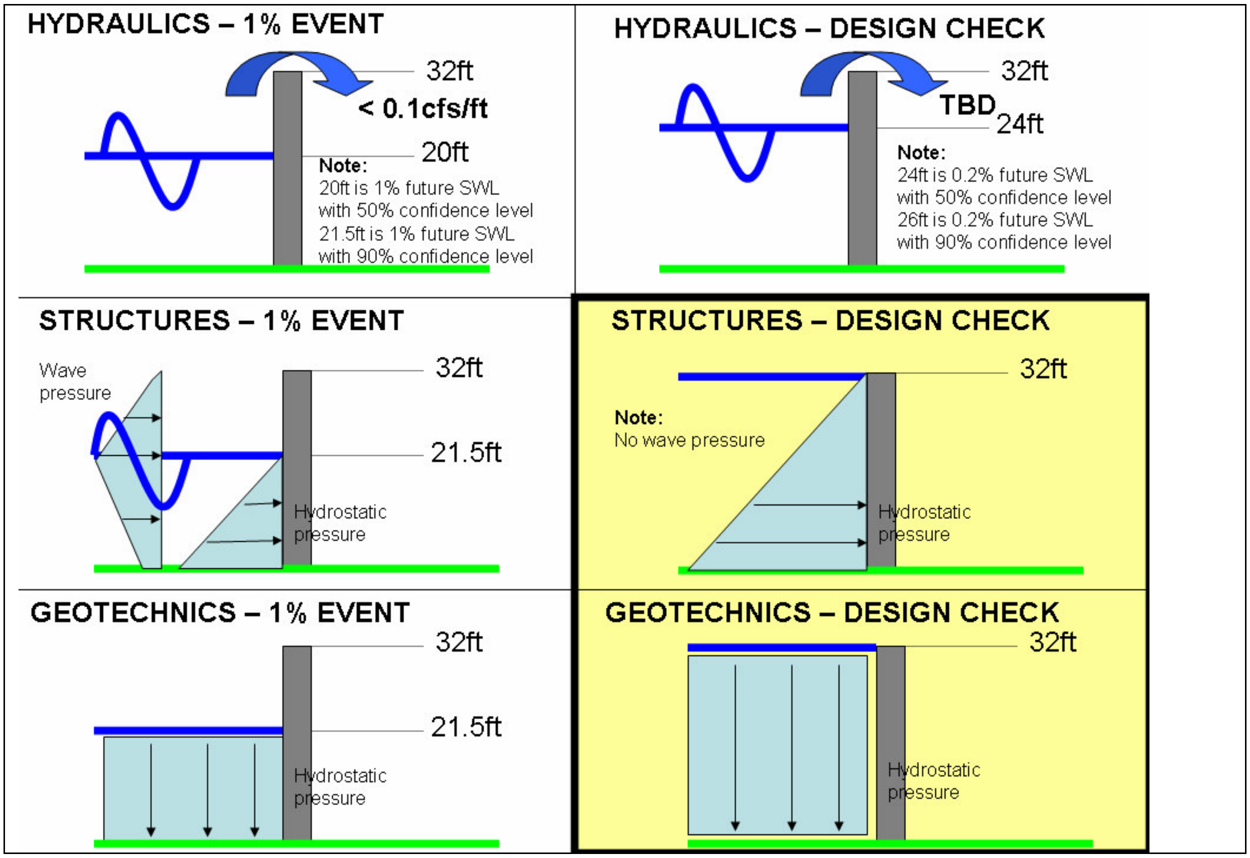
**Enclosure — Slides used on Teleconference April 21, 2009**

# Discussion

## HSDRSS Structures and Geotech Design Checks at Top of Wall (TOW)

Hurricane Protection Office

Luis Ruiz, Tom Hassenboehler, Pete Cali, Mathijs van Ledden, Jennifer Kline, Angela Desoto-Duncan, Louis Danflous, John Grieshaber, COL McCormick


HYDRAULICS – 1% EVENT
32ft
< 0.1cfs/ft
20ft
Note:
20ft is 1% future SWL with 50% confidence level
21.5ft is 1% future SWL with 90% confidence level
HYDRAULICS – DESIGN CHECK
32ft
TBD
24ft
Note:
24ft is 0.2% future SWL with 50% confidence level
26ft is 0.2% future SWL with 90% confidence level
STRUCTURES – 1% EVENT
Wave pressure
32ft
21.5ft
Hydrostatic pressure
STRUCTURES – DESIGN CHECK
32ft
Note:
No wave pressure
Hydrostatic pressure
GEOTECHNICS – 1% EVENT
32ft
21.5ft
Hydrostatic pressure
GEOTECHNICS – DESIGN CHECK
32ft
Hydrostatic pressure

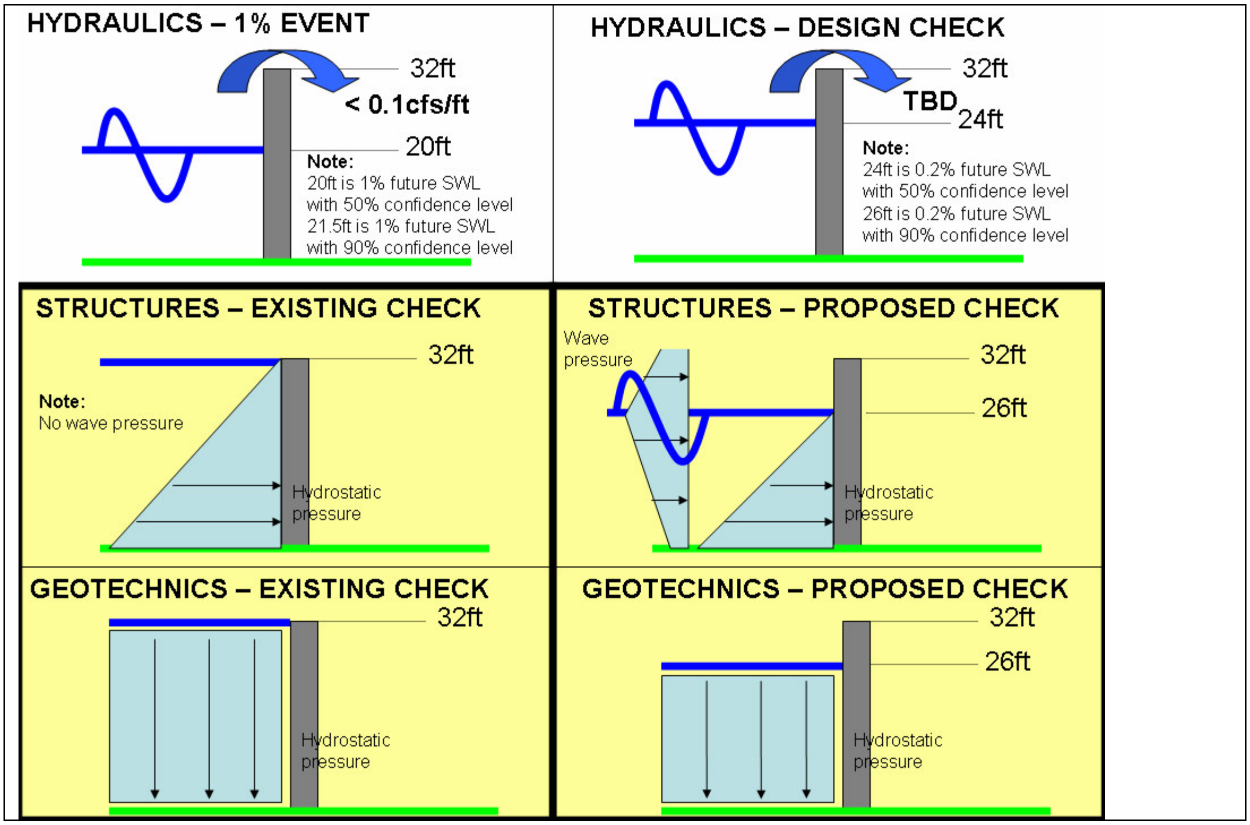
# TOW Design Checks

- TOW height is governed by surge and waves from ***hydraulic*** point of view to limit overtopping rates and minimize risk of inner slope failure

- **Structural and geotechnical** Design Checks with still water at TOW are not realistic:
  - Return period is extremely low (<< 1,000 year)
  - Load case will physically not exist (no waves included)

## Proposed direction

- **Hydraulic** resiliency check is carried out at 500-year event for design elevation and overtopping rates
- **Make structural and geotechnical** Design Checks consistent with hydraulic check and include wave loading for Structures


HYDRAULICS – 1% EVENT
32ft
< 0.1cfs/ft
20ft
Note:
20ft is 1% future SWL
with 50% confidence level
21.5ft is 1% future SWL
with 90% confidence level
HYDRAULICS – DESIGN CHECK
32ft
TBD
24ft
Note:
24ft is 0.2% future SWL
with 50% confidence level
26ft is 0.2% future SWL
with 90% confidence level
STRUCTURES – EXISTING CHECK
32ft
Note:
No wave pressure
Hydrostatic
pressure
STRUCTURES – PROPOSED CHECK
Wave
pressure
32ft
26ft
Hydrostatic
pressure
GEOTECHNICS – EXISTING CHECK
32ft
Hydrostatic
pressure
GEOTECHNICS – PROPOSED CHECK
32ft
26ft
Hydrostatic
pressure