UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO   SANTA BARBARA • SANTA CRUZ

TELEPHONE: (510) 643-8678
TELEFAX: (510) 643-8919
E-MAIL: bea@ce.berkeley.edu
HTTP://www.ce.berkeley.edu/

CENTER FOR CATASTROPHIC RISK MANAGEMENT
DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINI
212 McLAUGHLIN HALL
BERKELEY, CALIFORNIA 94720-1710

October 25, 2006

Subject: Gentilly Landfill Potential Influences on Reliability of Adjacent ICWW/MRGO Flood Protection Levee

The Louisiana Department of Environmental Quality, Office of Environmental Services (LDEQ), has prepared a decisional document that provides justification for the continued operation and utilization of the Gentilly Landfill. LDEQ's justification document includes a slope stability study conducted by Soil Testing Engineering, Inc. (STE), which examines the potential impact of the completed landfill upon the performance of the adjacent Inter Coastal Water Way (ICWW) – Mississippi River Gulf Outlet (MRGO) flood protection levee, in place to protect New Orleans East. This review examines the slope stability study and provides preliminary conclusions regarding both the reliability of its conclusions and the risk implications of the proposed landfill on the adjacent ICWW - MRGO flood protection levee.

In addition to the STE report, entitled "Geotechnical Investigation, Gentilly Landfill, Slope Stability Analyses" (STE, 25 July 2006), and this author's knowledge and experience gained from examining the failure of the New Orleans flood protection system in the aftermath of Katrina, this review is based on information previously provided by LDEQ. It is also based on information contained in the NISTAC report prepared for the Federal Emergency Management Agency, entitled "Potential Impact by the Old Gentilly Landfill on the Environment Due to the Placement of the New Type IIII C&D Landfill" (NISTAC, a joint venture of Dewberry & Davis and URS Group, Inc, 14 February 2006).

STE's slope stability analyses focuses on the final projected condition of the proposed landfill and addresses the likelihood that the proposed landfill will significantly degrade the ability of the adjacent ICWW/MRGO flood protection levee to perform its intended functions. STE concludes that the landfill, completed to its permitted height, shows minimum factors of safety (FS) in the range of 1.2 to 1.35. Factor of safety analyses are based on engineering assessments of the expected weight of the fill, the expected strengths of the underlying soils, and the expected failure mode (slope stability).

Two important ideas are inherent in the slope stability study. First, the term "factors of safety" refers to levels of acceptable risk. The nearer to 1 the factors of safety are, the more likely a failure is to occur. If a system has a factor of safety below one, the capacity of the system is already overwhelmed by the demand being placed upon it. At this point, it is said to be in a state of failure. When the capacity of the system exceeds the demand placed upon it, the factors of safety rise, and the probability of failure diminishes.

The New Orleans flood protection system was previously designed to a factor of safety of 1.3 (referred to as, but in reality not quite, Category Three protection), slightly higher than the 1.2 found here. That provided a one in fifty chance per year of failure. As noted in the Independent Levee Investigation Team's report to Congress, of which your writer was a member, that level of acceptable risk was developed in the 1950's to defend sparsely developed agricultural lands. Factors of 2 to 3 or greater are appropriate for important facilities and densely populated areas. Of note, offshore structures and the Dutch flood protection system are built to a much higher factor of safety, a one in ten thousand chance of failure, known as Category Five protection. In any event, permitting the construction of this landfill is inconsistent with the stated goal of a Category Five flood protection system for the City of New Orleans, which includes New Orleans East.

The second important concept is the reliability of the underlying assumptions imbedded in the Gentilly slope stability model. The more assumptions that are contained in a safety analysis, the more likely some assumptions are incorrect, and the more probable a consequent failure becomes. Again, New Orleans has just recently experienced the devastating effect of erroneous assumptions and natural variability in the soil properties and other properties in the failure of the flood protection system. A reliability analysis attempts to quantify the risk inherent in uncertain assumptions that constitute part of the model.

In this case, the reliability analyses would explicitly address the uncertainties that are associated with the engineering assessments and the effects of these uncertainties on the reliability of this important flood protection levee. Based on the information contained in the referenced reports, there have been no analyses performed to determine the potential effects of these uncertainties on the justification for continued operation and utilization of the Gentilly Landfill.

Based on the available information, this author has performed preliminary analyses to characterize and quantify the primary uncertainties (natural, model) associated with the projected landfill 'demands' (loads, stresses imposed on the supporting soils), and the 'capacities' of the underlying soil layers to support the projected demands without excessive displacements, and with the associated analytical models. These analyses have not addressed uncertainties associated with human, organizational, and information developments (Bea, 2006).

Given the range of factors of safety cited, the preliminary analyses indicate total uncertainties (expressed as the logarithm of the standard deviation of the slope stability demand and capacity) of 60% to 70%. These values are based on demand uncertainties (primarily dependent on the long-term effective compacted unit weight of landfill) in the range of 40% to 50%, capacity uncertainties (primarily dependent on effective shear strengths of the affected soils) in the range of 30% to 40%, and analytical model (circular arc slope stability) in the range of 20% to 30%. The analyses have assumed that the analyses that have been performed have been based on 'best estimate' values and that there are no systematic 'biases' that have been introduced into the computed factors of safety.

The resulting probabilities of failure (likelihood that the slopes are 'unstable', deform excessively) are in the range of 25% to 37% (Figure 1). These results can be interpreted as about one chance in three (1/3) that the adjacent flood protection levee will be seriously impaired (slope stability failure) when the proposed landfill is completed (2012).

As noted, these results have been based on the premise that the analyses have been based on 'best estimates'. A primary concern identified in these analyses is that of the effective compacted long-term unit weight of landfill (65 pounds per cubic foot, pcf) and the shear strength attributed to the landfill. Consultation with a landfill stability analysis expert (Dr. Raymond Seed, University of California Berkeley) indicated a value of 90 pcf could be more appropriate; such values have been used previously for similar landfills in California. Additional concerns were expressed for the effects of severe rainfall and moisture accumulation in the landfill in further increases in the unit weight. If such an effective unit weight was appropriate for these analyses, this would indicate a significant reduction in the previously cited factors of safety.

Another major element for concern is that of the condition of the adjacent flood protection levee when subjected to the effects developed by intense hurricane surge and waves. The ICWW flood protection levee at this very location overtopped and was subject to severe pressure during Katrina. The lateral force of another hurricane surge, pushing against the levee above ground, coupled with the lateral force associated with the weight of the landfill, pushing in the opposite direction below ground, raise very serious concerns about a shearing effect upon the levee itself. A sheer plane could develop could concentrate in the low strength soil layers that underlie the landfill and the levee (e.g. the very soft clay layer found approximately 20 ft. below the surface). These effects have not been included in the analyses performed to date nor in these results.

Given the potential ramifications of significant degradation in the ability of the adjacent flood control levees to withstand storm surges without breaching combined with the potential damaging and life-threatening effects of significant flooding from such breaches in such conditions, it is clear that probabilities of failure in the range of 25% to 37% are excessive and should not be accepted. We at least should give the people of New Orleans the same level of safety we give our oil infrastructure.

This review of the analyses that have been performed indicates that there are additional conditions (e.g. water saturated fill, storm surge conditions acting on flood protection levee), parameters (e.g. soil displacements), and states (e.g. soils affected by fill leachate) that should be further analyzed using the best available proven technology.

Initial considerations and estimates indicate that such analyses will provide additional information that will indicate the probabilities of failure cited above have been underestimated and that these probabilities of failure are even more unacceptable than indicated above.

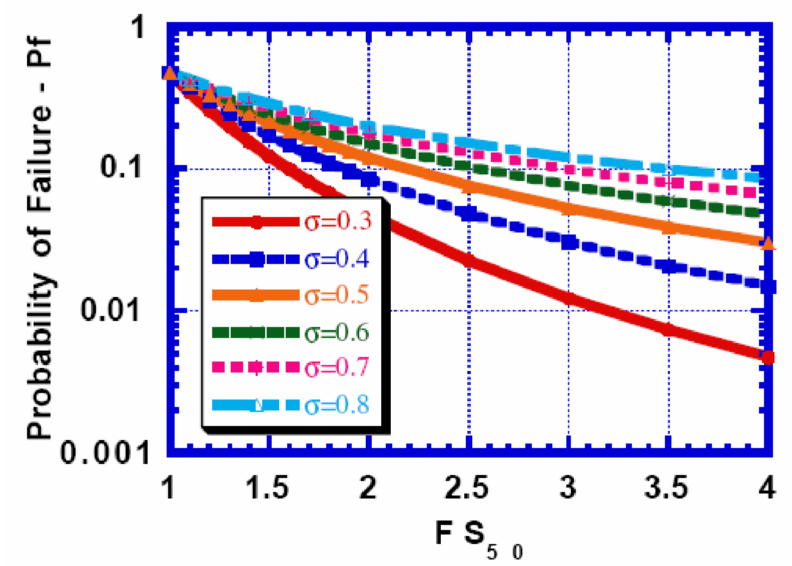

Figure 1: Probabilities of failure as functions of the Factor of Safety (FS50) and total uncertainties (σ)

Explanation of Figure 1. The probability of failure (Pf) is the probability or likelihood that the demand (loads, stresses) imposed by the proposed landfill (final condition) will equal or exceed the capacity of the landfill, underlying and adjacent soils to resist the demand without failing (excessive displacements). Failure is determined as the condition when the imposed demand exceeds the available capacity. The distributions of the slope stability demand and capacity have been evaluated to be well characterized with Lognormal distributions. The factor of safety (FS50) is expressed as the ratio of the median (50-th percentile) demand to the median capacity (this presumes that there are no systematic 'biases' present in the referenced analyses. The factor of safety has been determined from the geotechnical stability analyses. The total uncertainty in demand and capacity (σ) is determined from the standard deviations of the logarithms of the demand (σD) and capacity (σC, σ2 = σD 2+σC 2). The uncertainties in demand and capacity have been determined from the available data on soil strengths, unit weights of the fill, and accuracy of the analytical model employed to determine the factor of safety.

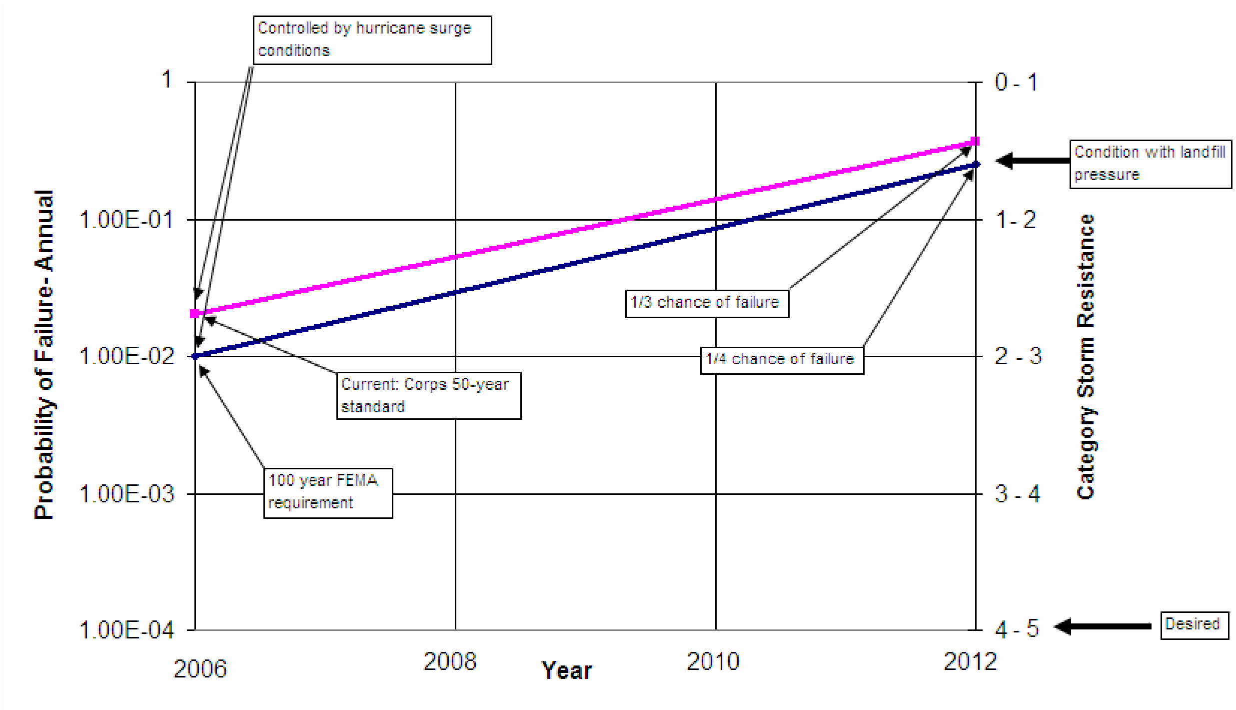

Figure 2: Probabilities of failure and Category Storm Resistance as functions of time

Reference (copy attached)

Bea, R. G. (2006). "Reliability and Human Factors in Geotechnical Engineering," Journal of Geotechnical and Geoenviromental Engineering, American Society of Civil Engineers, Vol. 32, No. 5, pp 631-643.

Professor Robert Bea, PhD
Professional Engineer (Ret), Civil Engineering, State of Louisiana, Registration No. 8139