ATTACHMENT B

GLOBAL STABILITY ANALYSIS

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Mr. John McAuliffe, Program Director
Honeywell
5000 Brittonfield Parkway, Suite 700
East Syracuse, NY 103057

Re: Global Stability Analysis
ROD Remedy Bulkhead Alignment and Dredge Depth
Offshore of Causeway and SMU 1
Willis/Semet Site, Syracuse, New York
MRCE File 9801

Dear Mr. McAuliffe:

At your request, we document herein global stability analysis cases, assumptions, and results. This review examined global stability along the hydraulic barrier sheet pile alignment immediately outboard and south of the Causeway structure. The analysis is based on the hydraulic barrier terminating in the silt and clay layer designated as Stratum M2. The barrier alignment assumed for this analysis is 20 feet outboard of the causeway and immediately along the shoreline south of the causeway, as shown in Figure 1. The stability analysis assumes a dredge depth as required by the Onondaga Lake Record of Decision (ROD) to remove deep soils underlying lake sediments which are contaminated with non-aqueous phase liquid (NAPL), as well as for shallower depths to remove in-lake waste deposits offshore of the causeway in Sediment Management Unit 2 (SMU-2) and in SMU-1. The dredge depths used in this analysis, 7.5 m (25 ft) in SMU-2 offshore of the causeway, and 6.7 m (22 ft) in the adjacent SMU-1 are based on the pre-design investigation work performed by Parsons in 2005 and 2006.

SOIL PROFILE DEVELOPMENT

The two soil profiles analyzed, Cross Sections A and B, are located on Figures 1 and 2 and shown in Figures 3 and 4. Cross Section A is representative of the causeway area in SMU-2. Cross Section B represents the geologic profile in SMU-1 south of the causeway structure. Soil profiles A and B were prepared by Parsons using data obtained in the 2005-2006 offshore boring program, as well as previous investigations.

Although discontinuous layers of sandy soils were occasionally observed between the Marl (Stratum M1) and the silt and clay layer (Stratum M2), these sandy soils were not included in the design soil profiles. It is typical for Stratum M1 to directly overlie Stratum M2. The analysis profile therefore represents the more general as well as severe stability case. Stratum S2 underlies the marl and is a compact sand. Analyses show that the underlying sand is not involved in potential failure planes.

SOIL PROPERTIES

Soil properties used in the stability analysis were selected by MRCE based on a review of the soil properties compiled from historical data; from information such as laboratory strength data and Cone Penetrometer Test (CPT) data collected as part of the pre-design investigations in 2005 and 2006; and by calculation using overburden pressures. The undrained shear strengths used for the Marl (Stratum M1) and for the underlying silt and clay (Stratum M2) are in agreement with the CPT-derived strengths and/or strengths estimated by the ratio of shear strength (C), to existing vertical effective overburden (Po). The C/Po ratio is a means to estimate the strength of normally consolidated clays based on the prevailing vertical effective overburden pressure. In all cases, the design shear strengths selected for this analysis equaled or exceeded the shear strength derived from the C/Po calculation. Strengths were not increased to account for consolidation to the proposed new fill loads. Soil properties used for both profiles are summarized on the output of each analysis case and are also listed below:

STRATUM	UNIT WEIGHT (PCF)	SHEAR STRENGTH (PSF)	FRICTION ANGLE (degrees)
New sand fill	105	0	29
F1- fill	105	200	20
F2 – Solvay Waste	110	100	25
M1- Marl	105	450	0
M2- Silt and Clay	117	400	0
S2 - Sand	120	0	34
In-lake Silt	105	200	20

SLOPE STABILITY ANALYSIS

The stability analysis was performed using the Bishop analysis method by the program Slope/W 2004 published by Geo-Slope, International. The stability analysis is based on two-dimensional conditions, which is appropriate for the removal scenarios evaluated for both design soil profiles.

Soil Profile A - SMU-2 Causeway Alignment

Cases A1 through A5 were evaluated for Soil Profile A (SMU-2) which places the hydraulic barrier sheet pile alignment 20 ft outboard of the causeway. Analysis output is attached as Appendix A. The graphic (contours) above each section represent the model calculated factors of safety. The cases evaluated and resulting factors of safety are provided in Table 1.

Table 1 – Soil Profile A Causeway - Analysis Cases and Computed Factors of Safety

	CASE	DREDGE DEPTH	FACTOR OF SAFETY
A1	Existing Condition	None	1.54
A2	Barrier 20 ft outboard of causeway, Fill upland to Elev. +371	None	1.53
A3	Barrier 20 ft. outboard of causeway, Fill upland to Elev. +371	2 meters	1.31
A4	Barrier 20 ft. outboard of causeway, Fill upland to Elev. +371	3 meters	1.27
A5	Barrier 20 ft. outboard of causeway, Fill upland to Elev. +371, width of dredging 30 ft.	7.5 meters	1.05

Soil Profile B – SMU-1 Area

Cases B1 through B3 were evaluated for Soil Profile B in SMU-1, south of the causeway structure. Analysis output is attached. The cases evaluated and resulting factors of safety are provided in Table 2.

Table 2 – Soil Profile B SMU-1 - Analysis Cases and Computed Factors of Safety

	CASE	DREDGE DEPTH	FACTOR OF SAFETY
B1	Existing Condition	None	1.64
B2	Barrier at shoreline, Fill upland to Elev. +371	None	1.66
B3	Barrier at shoreline, Fill upland to Elev. +371, width of dredging 120 ft.	6.7 meters	1.06

DISCUSSION OF RESULTS

Under existing conditions, for soil Profile A (SMU-2), the critical failure surface has a factor of safety of about 1.5. For the prevailing (existing) conditions for Soil Profile B (SMU-1) the factor of safety for the critical failure surface is about FS=1.6. The difference is attributed to the slightly different case geometry (ground surface and subsurface profiles, material thickness and depth, mudline profile and elevation, etc).

For reference, the minimum allowable FS for stability acceptable to the Federal Highway Administration, as published in their technical literature, is 1.3 for the temporary case and 1.5 for the permanent case. These criteria are directly applicable given the proximity of Interstate Highway I-690, and are reasonable and widely used. The temporary condition applies in this case because the mudline would be rebuilt with imported granular fill as part of the cap construction after dredging is complete.

Figure 5 summarizes the results of the analyses presented in Tables 1 and 2 above, and illustrates the change in factor of safety with dredging depth. Dredging removes weight from the toe of the critical slip circles, reducing a substantial resisting force and increasing the force imbalance. The causeway Profile A can sustain about 2 meters of dredging, and Profile B can sustain about 4 meters of dredging before the global stability factor of safety drops below FS=1.3.

Neither the causeway Profile A, nor Profile B can support the ROD-specified dredge depth. For both soil profiles, the factor of safety for global stability drops below the allowable criterion (FS=1.3) before reaching a dredge depth sufficient to remove NAPL.

We note from inspection of the critical slip circles determined for Profile A (comparing the initial conditions Case A1 to the 20 foot offset Case A2), that although the critical slip surface moves towards the lake when the hydraulic barrier is placed 20 feet outboard of the causeway, the critical slip surfaces will still intersect I-690. The analysis indicates offset distances more than 20 feet will be required to move the inboard edge of the potential slip surfaces outboard of the highway and utilities, even for shallow dredging.

The critical slip circles extend through the clay aquitard of Stratum M2 Clay. Therefore, a structure which would support the shoreline to permit the ROD-specified dredging would have to penetrate through the bottom of the aquitard Clay into the underlying sand, till and bedrock in order to increase the factor of safety to an acceptable level. Those penetrations are undesirable, as they may compromise the hydraulic impermeability of Stratum M2. As the forces driving the instability are large, we estimate that a structure capable of providing sufficient resistance to raise global safety would be large in scale and would require numerous penetrations of the aquitard clay immediately underlying the NAPL.

SUMMARY AND CONCLUSIONS

The ROD remedy includes construction of a hydraulic barrier closing with the aquitard Clay, and dredging outboard of the hydraulic barrier to remove NAPL. Based on the collection of data during the pre-design investigation and geotechnical evaluations conducted after issuance of the ROD, it was determined that the hydraulic barrier wall at the shoreline in the vicinity of the causeway (SMU-2) and a small portion of SMU-1, as described in the ROD, or even 20 feet out from the causeway in SMU-2, would not be feasible for the following reasons:

- Global stability analysis has determined that the ROD-specified dredging to depths sufficient to remove NAPL will cause the lake shoreline to become unstable.

- The instability as it pertains to the SMU 2 causeway area covers a large enough area so as to likely incorporate highway I-690 and the numerous utilities between the highway and the causeway.

A structure of sufficient capacity to support the shoreline so that ROD-specified dredging can be performed, however, it would need to penetrate through the confining aquitard clay which immediately underlies the NAPL, which is undesirable.

Please do not hesitate to contact us if you have any questions regarding the content of this report.

Very truly yours,

MUESER RUTLEDGE CONSULTING ENGINEERS

By: ______________________________
David R. Good, P.E.

Attachments
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