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MEMORANDUM

To: Marie-France Duthilleul, P.Eng
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Date: March 17, 2023

JLR No.: 31500-000

CC: Brent Whaley, P.Eng
Jason Olinski, P.Eng

From: Liam Irwin, EIT

Re: 31500-000 – HONI Orleans – Fire Water Tank Hold-Down Slab R3

Background

J.L. Richards & Associates Limited (JLR) is currently providing architectural and engineering consultant services to Hydro One Networks Inc (HONI) for the design of a new Operations Centre in the Orleans suburb of Ottawa, ON. Included in the new site development are multiple 68500-litre fire water storage tanks, which are proposed to be located below grade between Frank Kenney Road and the new asphalt parking lot on the site. As these tanks will occupy a large volume below grade and have the potential to be empty following a fire event on site, it is necessary to evaluate the buoyancy potential of the empty tanks to ensure the tanks will not “float”.

The purpose of this memorandum is to outline the results of our assessment of the buoyancy potential and communicate our recommendations.

Available Information

The following available information has been used in our assessment:

1. Geotechnical Investigation Report – prepared by Golder Associates, dated January 2012, revised December 2022
2. Hydrogeological Assessment Letter – Final Groundwater Level Monitoring – prepared by GHD Limited, dated November 2022
3. Civil site plan (drawings C-002 to C-010) – prepared by J.L. Richards and Associates Ltd., dated March 17, 2023
4. 68500-Litre Tank drawings – prepared by Power Precast Solutions, dated April 2022

Assumptions

The following assumptions have been made for the buoyancy evaluation of the fire water storage tanks:

1. Design groundwater table elevation is at 86.0 mAMSL in accordance with the recommendations provided in the Hydrogeological Assessment Letter by GHD. (Monitoring activities observed groundwater levels between 84.22 and 85.62 mAMSL).
2. Elevations of the underside of tanks and the finished new grade are located at 84.0 and 87.65 mAMSL, respectively, in accordance with JLR drawing C-009.
3. Proposed cover above top of tanks consists of 100mm topsoil (weight neglected), minimum 350mm engineered fill (bulk weight included) and 150mm rigid insulation (weight neglected).
4. A factor of safety of 1.25 is applied to the buoyancy forces for global stability in accordance with reference design standards.
5. Tanks are empty, except for permanent tank components (i.e., no stored water within the tank).
6. Rated 12 kPa vehicle surcharge load is occasional and therefore, does not contribute to buoyancy resistance.

7. The following material unit weights have been assumed in our calculations:
    a. Backfill materials: 20 kN/m^3 bulk weight for soils above measured groundwater table.
    b. Weight of 68500 L precast concrete tank is provided by precast Manufacturer.
8. Buoyancy-inducing forces include:
    a. Buoyancy of the 68500 L tanks due to groundwater level at measured elevation.
9. Buoyancy-resisting loads include:
    a. Nominal dry weight of the tank sections as indicated on the manufacturer drawings,
    b. Weight of 350mm thick engineered fill above the tank.
10. The geometry of the tanks is 9145mm x 3660mm x 3050mm high.

<u>Procedure</u>

The full buoyancy calculations are provided in Appendix A. The calculations are summarized as follows:

Nominal dry weight of tank = 644 kN
Weight of engineered fill above tank = 228 kN
Combined weight of tank and fill above = 644 kN + 228 kN = 872 kN

Factored tank buoyancy force = 821 kN

Required hold-down force = 821 kN – 872 kN = -51 kN < 0 kN

Therefore, the proposed tanks are stable against buoyancy and a concrete hold-down slab is not required.

<u>Discussion</u>

Based on the assumptions and calculations summarized above, a concrete hold-down slab is not required to resist buoyancy uplift of the proposed tanks. As the size of the proposed water storage tanks has been reduced from the previous design and the elevation of the tanks raised, the factored buoyancy force on the tanks is now less than the self-weight of the concrete tanks plus the weight of the soil cover above.

This buoyancy analysis has been completed in accordance with applicable engineering standards for consideration of buoyancy uplift, including ACI PCR 350.4-04 – *Design Considerations for Environmental Structures* and CSA S900.2:21 - *Structural Design of Wastewater Treatment Plants*. The design ground water table used for the analysis (as recommended by GHD) is elevated above the highest measured GWT level for the site. A factor of safety of 1.25 has further been applied to the calculated buoyancy forces.

If you have any questions or concerns, please do not hesitate to contact the undersigned.

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J.L. RICHARDS & ASSOCIATES LIMITED

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Reviewed by:

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Associate
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LSI/JMO:xx

Attachment: Appendix A – Buried Reservoir Buoyancy Calculations

J.L.Richards
ENGINEERS · ARCHITECTS · PLANNERS

BURIED RESERVOIR BUOYANCY

Designer: **Liam Irwin, EIT**

Date:_____________

Engineer of Record: **Jason Olinski, P.Eng., M.Eng**

Date:_____________

Peer Reviewer: **Brent Whaley, P.Eng**

Date:_____________

ITEMS HIGHLIGHTED IN YELLOW ARE REQUIRED USER INPUTS
ITEMS HIGHLIGHTED IN PINK ARE CRITICAL USER CHECKS
ITEMS HIGHLIGHTED IN BLUE ARE INTERIM RESULTS
ITEMS HIGHLIGHTED IN GREEN ARE FINAL RESULTS

Objective: To check buoyancy requirements for proposed water storage tanks.

Notes:
- Design Calculation per the NBCC 2015 or OBC 2012
- See end of sheet for results.

1.0 - Tank Buoyancy

(Assumes GWT at 86.0 mAMSL)

68500L tanks, 9145mm x 3660mm x 3050mm high.
Top half = 28645 kg, Bottom half = 37025 kg

$D_{tank} := (28645\ kg + 37025\ kg) \cdot 9.81\ \frac{m}{s^2} = 644.223\ kN$ — Dry weight of water storage tank

$l_{tank} := 9145\ mm$ $w_{tank} := 3660\ mm$ $h_{tank} := 3050\ mm$

$EL_{Grade} := 87.65\ m$ $EL_{GWT} := 86\ m$

$t_{topsoil} := 100\ mm$ $t_{engFill} := 350\ mm$ $t_{topInsulation} := 150\ mm$

$EL_{USTank} := EL_{Grade} - t_{topsoil} - t_{engFill} - t_{topInsulation} - h_{tank} = 84\ m$

$\gamma_{water} := 9.81\ \frac{kN}{m^3}$ — Unit weight of water

$\gamma_{sat} := 20\ \frac{kN}{m^3}$ — Bulk unit weight of earth fill (per geotech report)

$A_{tank} := l_{tank} \cdot w_{tank} = 33.471\ m^2$ — Footprint area of tank

$V_{tank} := A_{tank} \cdot h_{tank} = 102.086\ m^3$ — Volume of tank

$B_{tank} := 1.25 \cdot (A_{tank} \cdot (EL_{GWT} - EL_{USTank})) \cdot \gamma_{water} = 820.869\ kN$ — Buoyancy force on tank

$A_{riser} := \frac{\pi \cdot (24\ in)^2}{4} = 0.292\ m^2$ — Area of tank risers (reduction in soil cover volume)

$V_{fill} := (A_{tank} - 3 \cdot A_{riser}) \cdot t_{engFill} = 11.408\ m^3$ — Volume of soil fill above tank

$D_{fill} := V_{fill} \cdot \gamma_{sat} = 228.166\ kN$ — Weight of soil fill above tank (GWT is below top of tank)

$D_{withFill} := D_{tank} + D_{fill} = 872.388\ kN$ — Weight of tank with fill above assuming buoyant soil density

$D_{reqWithFill} := B_{tank} - D_{withFill} = -51.52\ kN$ — Required hold-down weight for tank with fill above assuming buoyant soil density

Therefore the tanks are stable against buoyancy and a hold-down slab is not required