# **APPENDIX J**

## SUMP AND RISER CALCULATIONS FOR SCA DESIGN

# **GEOSYNTEC CONSULTANTS**

## COMPUTATION COVER SHEET

Client: <u>Honeywell</u> Project: <u>C</u>	nondaga Lake	SCA Design	_ Project/Proposal #:	GJ4299 Task #: _18	8
TITLE OF COMPUTATIONS	SUMP	AND RISER (	CALCULATIONS FO	R SCA DESIGN	
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#### SUMP AND RISER CALCULATIONS FOR SCA DESIGN

#### **INTRODUCTION**

This package was prepared in support of the design of the Sediment Consolidation Area (SCA) for the Onondaga Lake Bottom Site, which will be constructed on Wastebed 13 (WB-13) to contain dredged material from the Lake. This package presents analysis of the proposed liquid management system (LMS) sump and riser of the SCA, which will utilize geotextile tubes (geo-tubes) for dewatering. The purpose of the analyses presented in this package is to:

- 1. Evaluate the hydraulic requirements for riser pipe perforations to handle the design inflow during post-closure conditions.
- 2. Evaluate the requirements for structural stability of the riser pipe, including: (i) ring compressive strain; (ii) ring bending strain; (iii) ring buckling; (iv) longitudinal (axial) strain and buckling; and (v) flotation.
- 3. Calculate the liquid storage volume and typical pump off and on times for the sumps during post-closure conditions.

The pumps, risers, and sumps analyzed herein are designed for the post-closure conditions. Interim liquid removal measures (e.g., temporary pumps) will be used during the operational period, as needed. These measures are not addressed in this package and will be addressed in the Sediment Management Intermediate and/or Final Design.

#### METHODOLOGY

The sump and riser calculations in this package include three steps: (i) sizing the riser pipe perforations to achieve the target inflow rates; (ii) calculating the dimensions and structural stability of the riser pipe; and (iii) calculating the volume of the sump.

#### **<u>Pipe Perforation Sizing:</u>**

The riser pipe perforations were sized to accommodate the target design inflow, following the general procedure of Bernoulli's Equation [Qian et al., 2002]. Initially, the area of each perforation  $A_b$  (ft<sup>2</sup>) was calculated with an assumed diameter *d* (ft) as follows:

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		$A_b = \frac{\pi}{4} * d^2$		(1)		

Bernoulli's Equation was then used to calculate the inflow capacity of a single perforation of diameter d as follows:

$$Q_b = C * A_b * v_{ent} \tag{2}$$

where:

 $Q_b$  = Inflow per orifice (ft<sup>3</sup>/s) C = Discharge coefficient, assumed to be 0.62 [Qian et al., 2002]  $v_{ent}$  = Entry velocity (ft/s), assumed to be 0.1 ft/s [Qian et al., 2002]

The calculated maximum inflow capacity for a selected perforated pipe length L was then computed using Equation 3.

$$Q_{in} = Q_b * N_{row} * R * L \tag{3}$$

where:

$$Q_{in} = Calculated maximum inflow capacity for the perforated length (ft3/s)
$$N_{row} = Number of perforations per row = \frac{360^{\circ}}{\theta}$$

$$\theta = Angle between perforations within a row (^{\circ})$$

$$R = Number of rows per foot = \frac{12}{\delta}$$

$$\delta = Offset between rows of perforations (in)$$

$$L = Perforated pipe length (ft)$$$$

The perforated pipe length L only takes into account the length between the automatic "off" elevation of the pump and the top of the sump excavation (i.e., the "on" elevation of the pump). It is noted that the perforations may extend to the bottom of the riser, however water may pond below the automatic "off" elevation of the pump. Therefore, the perforations below the

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automatic "off" elevation have been conservatively ignored for purposes of this calculation. The number of perforations per row and offset between rows for the proposed riser pipe was varied to analyze various possible pipe perforation options.

#### **<u>Pipe Structural Stability:</u>**

Calculations were performed to verify that the proposed high density polyethylene (HDPE) manhole riser pipes are able to withstand the loads applied on them with adequate factors of safety. Failure mechanisms that were checked include: (i) ring compressive strain; (ii) ring bending strain; (iii) ring buckling; (iv) longitudinal (axial) strain and buckling; and (iv) flotation. It is noted that the pipe structural stability is dependent on the standard dimension ratio (SDR) which is only available in specific values.

The radial pressure applied on the manhole riser may be approximated using the active earth pressure, computed by Equation 4 [Chevron Phillips, 2004]. It is noted that the coefficient of 1.21 in the equation is intended to account for the variability of active earth pressure around the riser. It is further noted that this equation has been modified to take into account strength reduction due to the perforations, which are assumed to extend the entire length of the riser [Qian et al., 2002]:

$$P_{R} = \frac{1.21 * K_{A} * \gamma * H}{1 - \frac{n * d}{12}}$$
(4)

where:

$$P_R$$
 = Radial pressure (psf);

 $\gamma$  = Soil unit weight (pcf);

- H = Height of fill (ft);
- $K_A$  = Active earth pressure coefficient =  $\tan^2(45 \phi/2)$ ;

 $\Phi$  = Soil friction angle (deg);

n = Number of perforations per lineal foot of pipe; and

d = Diameter of a single perforation (in).

The downdrag load applied to the manhole due to soil settlement is calculated assuming that the radially-directed pressure varies linearly with depth. Equation 5 can be used to calculate the average shear stress  $T_A$  applied to a manhole riser [Chevron Phillips, 2004]. The average shear stress may then be used in Equation 6 to calculate the downdrag load [Chevron Phillips, 2004].

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		$T_A = \mu^*$	$\frac{(P_{R1} + P_{R2})}{2}$			(5)	

where:

=	Average shear stress (psf);
=	Radial pressure at top of riser (psf);
=	Radial pressure at base of riser (psf); and
=	Friction coefficient between riser and soil.
	= = =

$$P_{D} = T_{A} * \pi \frac{(D_{O})}{12} * H \tag{6}$$

where:

 $P_D$  = Downdrag load (lb);  $D_O$  = Outside diameter of riser (in);  $T_A$  = Average shear stress (psf); and

H = Height of manhole fill (ft).

It is noted that  $\mu$  of 0.4 is recommended for the coefficient of friction between HDPE manholes and granular or granular-cohesive backfills [Chevron Phillips, 2004]. It is further noted that the effect of water will reduce the downdrag load due to the buoyancy effect. However, the water level will fluctuate due to seasonal variations and the effect of pumping operations. Therefore, water has been conservatively ignored in calculation of the radial pressure, average shear stress, and downdrag load.

**Ring Compressive Strain**: Radially-directed earth loads cause ring compressive strain and bending strains in the riser. It is noted that ring compressive strain should be limited to 3.5% at 73°F [Chevron Phillips, 2004]. Equations 7 and 8 may be used to determine ring compressive thrust and ring compressive strain, respectively [Chevron Phillips, 2004].

$$N_T = \frac{P_R}{144} * (R_M)$$
 (7)

where:

 $N_T$  = Ring compressive thrust (lb/in);

 $P_R$  = Radial pressure (psf);

 $R_M$  = Mean riser radius (in) =  $\frac{ID+t}{2}$ ;

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	ID	=	Inside ma	anhole	diameter (ii	n); and					
	t	=	Minimum	n wall t	hickness (in	n).					
					$\varepsilon_T = \frac{N_T}{E^* t}$	-			(8)		

where:

$\boldsymbol{\varepsilon}_T$	=	Ring compressive strain (in/in);
$N_T$	=	Ring compressive thrust (lb/in);
Ε	=	Modulus of elasticity (psi); and
t	=	Minimum wall thickness (in).

**Ring Bending**: Ring deflection often occurs during installation, causing a bending moment within the riser. It is noted that ring bending strain can be added to ring compressive strain to calculate the combined strain, which should be limited to 5% at 73°F [Chevron Phillips, 2004]. Equations 9 and 10 may be used to determine ring bending moment and ring bending strain, respectively, assuming 2% deflection during installation [Chevron Phillips, 2004].

$$M_E = 0.25 * C_O * D_M * N_T \tag{9}$$

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where:

 $M_E$  = Ring bending moment (lb-in/in);  $C_O$  = Correction for 2% deflection = 0.02;  $D_M$  = Mean riser diameter (in); and  $N_T$  = Ring compressive thrust (lb/in).

$$\varepsilon_B = \frac{6*M_E}{E*t^2} \tag{10}$$

where:

 $\varepsilon_B$  = Ring bending strain (in/in);

 $M_E$  = Ring bending moment (lb-in/in);

E = Modulus of elasticity (psi); and

t = Minimum wall thickness (in).

**Ring Buckling**: If ring compressive thrust exceeds a critical buckling value, the manhole riser may buckle. Ring buckling is calculated differently depending on whether the riser is above or

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below the water level. It is noted that the water level for this project will vary seasonally and based on operational conditions, therefore both calculations were performed and the more critical result was used in analysis. For a manhole riser completely above the water level, the critical ring compressive thrust may be calculated using Equation 11 [Chevron Phillips, 2004].

$$N_{CR} = 0.3 * R_H * t * E^{1/3} * E_S^{2/3}$$
(11)

where:

$N_{CR}$	=	Critical ring compressive thrust, no water (lb/in);
$R_H$	=	Geometry factor = $1.0$ if relative stiffness (RS) is less than $0.005$ ;
t	=	Minimum riser wall thickness (in);
Ε	=	Modulus of elasticity of soil (psi);
$E_S$	=	Young's Modulus of soil (psi);
RS	=	Relative stiffness = $\frac{0.22 * E * t^3}{E_s * R_M^3}$ ; and
$R_M$	=	Mean radius of riser (in).

If the manhole riser or a portion of the riser is below the water level, the critical compressive thrust may be calculated with Equation 12 [Chevron Phillips, 2004].

$$N_{CRW} = 0.82 * \sqrt{\frac{R * B' * E' * E * t^3}{D_M}}$$
(12)

where:

$$N_{CRW} = Critical ring compressive thrust with water (lb/in);$$
  

$$D_M = Mean diameter (in);$$
  

$$R = Buoyancy reduction = 1 - 0.33 * \frac{H'}{H};$$
  

$$H' = Height of water from invert (ft);$$
  

$$H = Height of manhole fill (ft);$$
  

$$E = Modulus of elasticity of soil (psi);$$
  

$$E' = Modulus of soil reaction (psi);$$
  

$$t = Minimum riser wall thickness (in); and$$

$$B' = \frac{1}{1+4*e^{(-0.065*H)}}$$

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It is noted that the ring compressive thrust  $N_T$  should not exceed 50% of the critical ring compressive thrust  $N_{CR}$  or  $N_{CRW}$  [Chevron Phillips, 2004]. It is further noted that while the manhole top and bottom may increase the stiffness and lower the amount of buckling observed, this is conservatively ignored for purposes of this calculation.

**Longitudinal (Axial) Strain and Buckling**: Longitudinal compressive strain may be caused by downdrag loads, dead loads (i.e., manhole weight), and any live loads (i.e., equipment and personnel on top of the manhole). Longitudinal compressive strains can be calculated using Equation 13 [Chevron Phillips, 2004].

$$\varepsilon_A = \frac{P_D + P_L + P_W}{E * \pi * D_M * t} \tag{13}$$

where:

 $\boldsymbol{\varepsilon}_A$ = Longitudinal compressive strain (in/in);  $P_D$ Downdrag force (lb); =  $P_L$ Live load (lb); = Dead load (lb);  $P_W$ = Modulus of elasticity of soil (psi); Ε =  $D_M$ Mean riser diameter (in); and = Minimum riser wall thickness (in). t =

Local wall buckling can occur if the longitudinal strain exceeds the critical longitudinal strain, calculated by Equation 14 [Chevron Phillips, 2004].

$$\varepsilon_{CR} = \frac{2*t}{D_M * \sqrt{3*(1-\mu^2)}}$$
(14)

where:

 $\varepsilon_{CR}$  = Critical longitudinal compressive strain (in/in);

 $D_M$  = Mean riser diameter (in);

 $\mu$  = Poisson's ratio for HDPE; and

t = Minimum riser wall thickness (in).

It is noted that the use of granular soil or granular-cohesive soil surrounding the manhole will provide an additional safety factor not considered in this calculation; therefore the use of an

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additional safety factor is not required [Chevron Phillips, 2004]. Therefore,  $\varepsilon_A$  must be less than  $\varepsilon_{CR}$ . Additionally,  $\varepsilon_A$  must be less than 3.5%. It is noted that if the calculated strain  $\varepsilon_A$  fails to meet either condition, a thicker riser (i.e., smaller SDR) should be selected.

**Flotation**: When a manhole riser is surrounded by water, the buoyancy force may cause flotation if the downward forces (i.e., manhole weight, friction, etc.) are not sufficient to resist the buoyancy force due to the water. It is noted that flotation will only occur if water is between the riser bottom and the liner. Based on current designs, the riser will be placed directly on top of the liner, so flotation is not expected to be an issue. However, to be conservative, the effect of flotation has been calculated. The net downward (resisting) force can be calculated using Equation 15 [Chevron Phillips, 2004]. It is noted that a factor of safety of 1.5 is selected for both the weight of the anti-flotation slab and the soil weight.

$$F_{DOWN} = W_{MH} + W_{CC} + \frac{W_{AF}}{FS_{AF}} + \frac{W_{AFS}}{FS_{AFS}}$$
(15)

where:

 $F_{DOWN}$ Total downward force (lb); $W_{MH}$ Manhole weight (lb); $W_{CC}$ Weight of manhole cover (lb); $W_{AF}$ Weight of anti-flotation slab (lb); $FS_{AF}$ Factor of safety for anti-flotation slab weight; $W_{AFS}$ Weight of soil above anti-flotation slab (lb); and $FS_{AFS}$ Factor of safety for soil weight above anti-flotation slab.

Manhole weight and the weight of manhole cover can be obtained from the manufacturer of the riser and/or calculated from design drawings. It is noted that because the manhole cover will be installed after construction of the manhole, its weight has been conservatively neglected (i.e., assumed to be zero) for purposes of the analyses herein. It is additionally noted that for purposes of flotation calculations, the manhole weight has been conservatively neglected (i.e., assumed to be zero). The weight of the anti-flotation slab can be computed using Equation 16 [Chevron Phillips, 2004].

$$W_{AF} = (L_{AF} * w_{AF} * \frac{t_{AF}}{12} * (\gamma_C - \gamma_W))$$
(16)

where:

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$W_{AF}$ =	Weight of anti-flotation slab (lb);							
$L_{AF}$ =	Length of anti-flotation slab (ft);							
w <sub>AF</sub> =	Width of anti-flotation slab (ft);							
$t_{\sf AF}$ =	Thickness of anti-flotation slab (in);							
$\gamma_c =$	Unit weight of concrete (pcf); and							
$\gamma_W =$	Unit weight of water (pcf).							

Equation 17 is used to calculate the weight of the soil above the anti-flotation slab [Chevron Phillips, 2004]. It is noted that for the soil weight calculation, there will not be soil directly above the riser; therefore, the plan area of the riser has been subtracted from the total area.

$$W_{AFS} = (L_{AF} * w_{AF} - A_{OVER}) * (\gamma * (H_{AF} - H_{W}) + H_{W} * (\gamma - \gamma_{W}))$$
(17)

where:

$W_{AFS} =$	Weight of soil above slab (lb);
$L_{AF}$ =	Length of slab (ft);
$w_{AF}$ =	Width of slab (ft);
$A_{OVER} =$	Plan area of riser directly on top of slab (ft <sup>2</sup> );
γ =	Soil unit weight (pcf);
<i>γ</i> <sub>W</sub> =	Unit weight of water (pcf);
$H_{AF}$ =	Height of soil above slab (ft); and
$H_W =$	Height of water above slab (ft).

The upward forces lifting the manhole off the ground include the buoyant force acting on the manhole, as shown in Equation 18 [Chevron Phillips, 2004].

$$F_{UP} = \pi * \frac{D_O^2}{576} * \gamma_W * H_W$$
(18)

where:

 $F_{UP}$  = Uplift force (lb);  $D_O$  = Outside diameter of riser (in);  $\gamma_W$  = Unit weight of water; and  $H_W$  = Height of water (ft).

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The overall factor of safety against flotation can be calculated using Equation 19 [Chevron Phillips, 2004]. It is noted that for purposes of this calculation, FS values have been applied to the downward (i.e., resisting) forces individually, therefore, an overall safety factor of 1.0 is be considered acceptable [Chevron Phillips, 2004].

$$FS = \frac{F_{DOWN}}{F_{UP}} \tag{19}$$

where:

FS = Factor of safety against flotation;  $F_{DOWN}$  = Total downward force (lb); and  $F_{UP}$  = Total upward force (lb).

It is noted that the ability of the manhole cover to carry personnel loads and equipment without excessive deformations (i.e., flexural strength) is an important safety consideration. It is recommended that certification be obtained from the manhole riser manufacturer for a minimum allowable live load of about 750 lbs for the manhole cover. Clear signs should be posted at the cover to indicate allowable live loads.

#### Sump Volume and Pump Sizing:

The storage volume of the sump is calculated as the volume between the pump off level and the top of the low permeability soil liner outside the sump area. This volume is a combination of open area inside the riser pipes and pore volume of areas outside the risers that are filled with gravel.

Pump on time is calculated by dividing the storage volume by the selected pumping rate minus the design inflow rate. Pump off time is calculated by dividing the storage volume by the inflow rate to the sump.

#### **INPUT PROPERTIES**

The calculated liquid inflow rate for the entire SCA was 0.4 gal/min, as presented in Appendix I, "Evaluation of Hydraulic Performance for SCA Design". It is noted that this inflow rate has been computed for post-closure conditions (i.e., after placement of the final cover system). However, it is noted that placement of the geomembrane in the final cover system may not occur immediately after construction. Therefore, a target inflow rate of 15 gal/min has been

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selected to represent conditions following the fourth year of construction. This inflow rate was computed in Appendix I of the SCA Initial Design Submittal [Parsons and Geosyntec, 2009] for conditions following the fourth year of construction including the placement of a 3-inch thick leveling layer.

As presented in Figure 1, the liner grading plan indicates that the total water infiltration will be split between the western sump area and the eastern sump area. Based on the relative areas, it appears that approximately 67% of the infiltration will drain to the western sump and approximately 33% to the eastern sump area. Therefore, the assumed target liquid inflow rate for the individual sump areas is 10 gal/min. The perforation sizing and pipe structural analyses performed in this package assume that both the western and eastern sump areas will be designed identically to be able to handle the target inflow of 10 gal/min. The volume and pump on and off time calculations use a target liquid inflow rate of 10 gal/min for the western sump area and 5 gal/min for the eastern sump area. It is noted that for the post-closure condition, the total inflow rate of 0.4 gal/min is expected to follow the same 67%/33% split. Therefore, the volume and pump off and on time calculations use a target liquid inflow rate of 0.27 gal/min for the western sump area and 0.13 gal/min for the eastern sump area.

It is further assumed that each sump area will consist of two separate riser pipes, a main and a backup, with a pump in the main riser and a 10 ft offset between each riser pipe. As presented in Figure 2, the pump was assumed to require a 1 ft working pad above the liner, have an automatic off elevation 3 ft above the bottom of the pump, and have an automatic on elevation L ft above the automatic off elevation. The walls of the excavated sump area were assumed to be sloped at a 2.5 horizontal:1 vertical (H:V) slope. Each riser pipe was assumed to be approximately 5 ft in diameter. In addition, a 10 ft offset between the edge of the riser pipe and the start of the sump side slopes was provided. The area of the pumps is small relative to the total sump area and has been neglected with respect to the sump volume calculation.

It is assumed that the riser pipes will be SDR 26, with an inside diameter of 57.85 inches and a nominal outside diameter of 63 inches, as shown in Table 1. The riser pipes are assumed to be HDPE with a long-term modulus of elasticity at 73°F of 28,200 psi, as shown in Table 2 [Chevron Phillips, 2004]. A reduction factor of 0.76 has been conservatively applied to account for stress concentrations [August et al., 1997]. The Poisson's ratio of HDPE is assumed to be 0.45 for long-term and 0.35 for short-term [Chevron Phillips, 2004]. It is assumed that there will not be any riser stubouts. The manhole weight is assumed to be approximately 8000 lb for purposes of downdrag calculations, based on the estimated weight per lineal foot shown in Table 1 and a 40 ft riser. It is noted that for purposes of anti-flotation calculations, the manhole weight is neglected, as discussed previously. A square anti-flotation slab with length and width of 7.25

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ft and a thickness of 6.0 inches will be constructed from concrete ( $\gamma_c=150$  pcf). It is assumed that the riser will be bolted to the anti-flotation slab.

The design live load for purposes of downdrag calculations is considered to be 1000 lb. It is noted that the weight of two people (assumed to be 250 lb per person), the pump (assumed 100 lb), and other cap equipment such as bolts and flanges (assumed 100 lb) is less than 1000 lb, therefore this assumption is considered reasonable. However, it is noted that the allowable live load on the cap may be less than 1000 lb due to flexural stability of the cap itself. Therefore, the allowable live load should be selected based on manufacturer recommendations.

It is assumed that the riser pipes are surrounded by a layer of gravel throughout their entire height. The maximum riser height is considered to be 40 ft. It is noted that after the dredged material in the geo-tube undergoes settlement, the total thickness of geo-tubes is expected to be less than 30 ft, therefore the use of a 40 ft riser is considered to be conservative. The water is considered to rise to a maximum of 18.5 ft above the base. This corresponds to an elevation of 434 ft, the same height as the lowest berm elevation near the sumps. It is noted that this condition is not expected to occur, however this represents the worst-case scenario of the SCA flooding with water during operations and is therefore expected to be conservative.

Based on discussions with Parsons, two types of gravel, #2 and #3A, are available from nearby quarry sites for use in the SCA drainage layer, including the sump areas. The sieve analysis test results for these two types of gravel are presented in Table 3, and the associated grain size distribution curves are in Figure 3. Gravel type #3A has a larger  $D_{85}$  value ( $D_{85}$ =1.4 in) than type #2 ( $D_{85}$ =0.9 in), therefore it has been assumed that #3A will be selected for the drainage layer to provide more drainage capacity. The unit weight and drained friction angle of the gravel are considered to be 120 pcf and 38 degrees, respectively, following recommendations from Appendix G, "Slope Stability Analyses for SCA Design". A typical value of 0.4 is chosen for the porosity of the gravel. The elastic modulus for coarse grained soils is assumed to be 250 tsf, as shown in Table 4 [USACE, 1990].

#### CALCULATIONS

A sample calculation spreadsheet for the pipe perforation sizing is included in Attachment 1, following the methodology described above. The calculation worksheets for the pipe structural stability and sump volume are also provided in Attachment 1.

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#### **RESULTS OF ANALYSIS**

The results of the pipe perforation sizing are summarized in Table 5. Multiple combinations of perforation angle and row offset resulted in acceptable calculated FS values. Choosing a pipe perforation length of 4 ft (i.e., a total excavation depth of 8 ft), pipe perforation angle of 45 degrees and row offset of 3 inches results in a calculated inflow capacity of 19.4 gal/min. A conceptual diagram of the proposed design is presented in Figure 4.

Based on the pipe perforation dimensions chosen, the structural stability appears to be acceptable, as summarized in Table 6. Specifically, the calculated ring compressive strain, combined ring strain, and ring buckling satisfy the target criteria of less than 3.5%, less than 5.0%, and less than 50%, respectively. In addition, the calculated longitudinal strain is less than the critical longitudinal strain (i.e., 5.2%) and less than the set limit of 3.5%. The calculated FS value against flotation with the anti-flotation slab satisfies the chosen target FS.

The results of the sump volume calculations are summarized in Table 7. Based on the results presented previously, a sump depth of 8 ft was selected, with the two sumps separated by 10 ft. This configuration resulted in a total storage volume of 47,000 gallons for each of the sump areas and a filling time of approximately 78 hours for the western sump area and 156 hours for the eastern sump area under the design condition (i.e., inflow of 10 gal/min to the western sump and 5 gal/min to the eastern sump). For a selected pumping rate of 30 gal/min, the western sump will have a pump on time of approximately 39 hours under the design condition (i.e., inflow of 10 gal/min). For a selected pumping rate of 20 gal/min, the eastern sump will have a pump on time of approximately 52 hours under the design condition (i.e., 5 gal/min).

For the post-closure conditions (i.e., inflow of 0.27 gal/min to the western sump and 0.13 gal/min to the eastern sump), the configuration resulted in a fill time of approximately 2900 hours for the western sump and 6000 hours for the eastern sump. For a selected pumping rate of 30 gal/min, the western sump will have a pump on time of approximately 26 hours under post-closure conditions (i.e., inflow of 0.27 gal/min). For a selected pumping rate of 20 gal/min, the eastern sump will have a pump on time of approximately 39 hours under the design condition (i.e., 0.13 gal/min).

#### SUMMARY AND CONCLUSIONS

This package presents calculations to support the design of the sump areas of the proposed SCA within WB-13. Three types of calculations were performed: (i) evaluation of the hydraulic requirements for pipe perforations to handle the required inflow during post-closure conditions; (ii) evaluation of the requirements for structural stability of the riser pipe, including ring

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compressive strain, ring bending strain, ring buckling, longitudinal (axial) strain and buckling, and flotation; and (iii) calculation of liquid storage volume and filling time for the sump area during post-closure conditions.

Based on the calculations, it is recommended that a SDR 26 riser pipe with an inside diameter of 57.85 inches and a nominal outside diameter of 63 inches, with a perforation angle of 45 degrees, perforation row offset of 3 inches, and a total SOLW excavation depth of 8 ft be selected. This resulted in a calculated inflow capacity of 19.4 gal/min, exceeding the target design inflow of 10 gal/min for design conditions and 0.27 gal/min for post-closure conditions. It is noted that the calculated strains did not exceed the target strains. In addition, the calculated FS of the riser pipe satisfied the target FS with regards to flotation with the inclusion of a 7.25 ft x 7.25 ft x 6.0 inches square concrete anti-flotation slab beneath the riser.

For the western sump area, the calculated sump storage volume of 47,000 gallons resulted in a pump off time of 78 hours and pump on time of 39 hours using the design inflow rate of 10 gal/min and a pumping rate of 30 gal/min. Additionally, the calculated sump storage volume of 47,000 gallons resulted in a pump off time of 2900 hours (approximately 120 days) and pump on time of 26 hours using the design post-closure inflow rate of 0.27 gal/min and a pumping rate of 30 gal/min.

The eastern sump area with a calculated sump storage volume of 47,000 gallons, a design inflow rate of 5 gal/min, and a pumping rate of 20 gal/min, resulted in a calculated pump off time of 156 hours and pump on time of 52 hours. Additionally, the calculated sump storage volume of 47,000 gallons resulted in a pump off time of 6000 hours (approximately 250 days) and pump on time of 39 hours using the design post-closure inflow rate of 0.13 gal/min and a pumping rate of 20 gal/min.

Different pump capacities and on/off times may be used as appropriate based on actual field conditions, as long as performance requirements are met. It is further noted that a smaller SDR ratio is expected to reduce the strains and increase the calculated FS values and therefore pipes with a smaller SDR ratio than SDR of 26 used in this calculation may be used as appropriate.

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#### REFERENCES

August, H., Holzöhner, U., and Meggyes., "Advanced Landfill Liner Systems", Thomas Telford Publishing, London, 1997.

Chevron Phillips, "Manhole Reference Guide", First Edition. Chevron Phillips Chemical Company LP, 2004.

IscoIndustries, "*High Density Polyethylene Pipe Typical Physical Properties*", Manufacturers' Literature, 2009.

Parsons and Geosyntec, "Draft Onondaga Lake Sediment Consolidation Area (SCA) Civil and Geotechnical Initial Design Submittal", Prepared for Honeywell, August 2009.

Qian, X., Koerner, R.M., and Gray, D.H., "Geotechnical Aspects of Landfill Design and Construction", Prentice Hall Inc., Upper Saddle River, NJ, 2002.

United States Army Corps of Engineers (USACE)., "Engineering and Design: Settlement Analysis", EM 1110-1-1904, September 1990.

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Tables

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Table 1: Typical Pipe Properties [IscoIndustries, 2009]

### PE 3608/3408 IPS HDPE PIPE SIZES

Pressu	Pressure Rating DR 17 ( 100ps		osi)	DR 19 ( 89psi )			D	R 21 ( 80p	si)	D	DR 26 ( 65psi )			DR 32.5 ( 50psi )		
Nominal Size	Actual O.D.	Min. wall	Average I.D.	Weight Ib/lf	Min. wall	Average I.D.	Weight Ib/If	Min. wall	Average I.D.	Weight Ib/If	Min. wall	Average I.D.	Weight Ib/If	Min. wall	Average I.D.	Weight Ib/If
3/4"	1.050"															
1"	1.315"													:		
1 1/4"	1.660"															
1 1/2"	1.900"															
2"	2.375"	0.140"	2.079"	0.429		-				-			1	:		
3"	3.500"	0.206"	3.064"	0.932												
4"	4.500"	0.265"	3.939"	1.540	0.237"	3.998"	1.387	0.214"	4.046"	1.262	0.173"	4.133"	1.030	0.138"	4.206"	0.831
5"	5.375"	0.316"	4.705"	2.197	0.283"	4.775"	1.980	0.256"	4.832"	1.801	0.207"	4.937"	1.470	0.165"	5.024"	1.186
5"	5.563"	0.327"	4.869"	2.353	0.293"	4.942"	2.120	0.265"	5.001"	1.929	0.214"	5.109"	1.574	0.171"	5.200"	1.270
6"	6.625"	0.390"	5.799"	3.338	0.349"	5.886"	3.007	0.315"	5.956"	2.736	0.255"	6.085"	2.233	0.204"	6.193"	1.801
7"	7.125"	0.419"	6.236"	3.860	0.375"	6.330"	3.478	0.339"	6.406"	3.165	0.274"	6.544"	2.582	0.219"	6.660"	2.083
8"	8.625"	0.507"	7.549"	5.657	0.454"	7.663"	5.097	0.411"	7.754"	4.637	0.332"	7.922"	3.784	0.265"	8.062"	3.053
10"	10.750"	0.632"	9.409"	8.788	0.566"	9.551"	7.918	0.512"	9.665"	7.204	0.413"	9.873"	5.878	0.331"	10.049"	4.742
12"	12.750"	0.750"	11.160"	12.362	0.671"	11.327"	11.138	0.607"	11.463"	10.134	0.490"	11.710"	8.269	0.392"	11.918"	6.671
14"	14.000"	0.824"	12.254"	14.905	0.737"	12.438"	13.429	0.667"	12.587"	12.218	0.538"	12.858"	9.970	0.431"	13.087"	8.044
16"	16.00"	0.941"	14.005"	19.467	0.842"	14.215"	17.540	0.762"	14.385"	15.959	0.615"	14.695"	13.022	0.492"	14.956"	10.506
18"	18.00"	1.059"	15.755"	24.638	0.947"	15.992"	22.199	0.857"	16.183"	20.198	0.692"	16.532"	16.480	0.554"	16.826"	13.296
20"	20.00"	1.176"	17.506"	30.418	1.053"	17.768"	27.406	0.952"	17.981"	24.936	0.769"	18.369"	20.346	0.615"	18.695"	16.415
22"	22.00"	1.294"	19.256"	36.805	1.158"	19.545"	33.162	1.048"	19.779"	30.172	0.846"	20.206"	24.619	0.677"	20.565"	19.863
24"	24.00"	1.412"	21.007"	43.801	1.263"	21.322"	39.465	1.143"	21.577"	35.907	0.923"	22.043"	29.299	0.738"	22.434"	23.638
26"	26.00"	1.529"	22.758"	51.406	1.368"	23.099"	46.316	1.238"	23.375"	42.141	1.000"	23.880"	34.385	0.800"	24.304"	27.742
28"	28.00"	1.647"	24.508"	59.618	1.474"	24.876"	53.716	1.333"	25.173"	48.874	1.077"	25.717"	39.879	0.862"	26.174"	32.174
30"	30.00"	1.765"	26.259"	68.439	1.579"	26.653"	61.664	1.429"	26.971"	56.105	1.154"	27.554"	45.779	0.923"	28.043"	36.934
32"	32.00"	1.882"	28.009"	77.869	1.684"	28.429"	70.160	1.524"	28.770"	63.835	1.231"	29.391"	52.086	0.985"	29.913"	42.023
34"	34.00"	2.000"	29.760"	87.907	1.789"	30.206"	79.204	1.619"	30.568"	72.064	1.308"	31.228"	58.814	1.046"	31.782"	47.440
36"	36.00"	2.118"	31.511"	98.553	1.895"	31.983"	88.796	1.714"	32.366"	80.791	1.385"	33.065"	65.922	1.108"	33.652"	53.186
42"	42.00"	2.471"	36.762"	134.141	2.211"	37.314"	120.861	2.000"	37.760"	109.966	1.615"	38.575"	89.727	1.292"	39.260"	72.392
48"	48.00"	2.824"	42.014"	175.205	2.526"	42.644"	157.857	2.286"	43.154"	143.629	1.846"	44.086"	117.194	1.477"	44.869"	94.552
54"	54.00"	3.176"	47.266"	222.547	2.842"	47.975"	199.791	2.571"	48.549"	182.298	2.077"	49.597"	148.324	1.662"	50.478"	119.668
63"	62.99"							3.000"	56.631"	247.800	2.423"	57.854"	202.010	1.938"	58.881"	162.980
NOTE:													1			

- Items highlighted in Blue indicates standard stocking items that are more readily available.

Pressures are based on using water at 23°C (73°F).
 Average inside diameter calculated using nominal OD and minimum wall plus 6% for use in estimating fluid flows. Actual ID will vary.
 Service factors should be utilized to compensate for the effect of liquids other than water, and for other temperatures.
 Other piping sizes or DR's may be available upon request.

- Standard Lengths: 40' for 2"-24" / 50' for 26" and larger / Coils available for 3/4"-6"(8" by special order)

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Selected Pipe

#### Notes:

These are typical commercially available HDPE pipe sizes. 1.

The pipe chosen has an outside diameter of 63 in, based on the nominal outside diameter of 2. 5 ft as discussed in the package.

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Table 2: Modulus of Elasticity Values for HDPE [Chevron Phillips, 2004]

LOAD	TEMPERATURE						
DURATION	0° F	73° F	120° F	140°F			
Short-term	260,000	110,000	65,000	50,000			
1 hour	148,000	69,600	36,900	28,400			
10 hours	122,000	57,500	30,500	23,500			
1000 hours	92,800	43,700	23,200	17,800			
10 years	67,100	31,600	16,800	12,900			
50 years	59,900	28,200	15,000	11,500			

Table 2-2 Modulus of Elasticity for HDPE, psi

Notes:

- 1. The Modulus of Elasticity chosen is for 50 years (long-term) at 73°F.
- 2. A reduction factor of 0.76 has been applied to the chosen reduction factor [August et. al, 1997]

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Table 3: Sieve Analysis Test Results for Potential Gravel Sources

Sieve		
Size	#3A's	#2
3"	100.0%	100.0%
2"	100.0%	100.0%
1 1/2"	95.1%	100.0%
1"	14.5%	91.5%
3/4"	5.8%	65.2%
1/2"	3.4%	13.3%
3/8"	2.4%	0.8%
1/4"	1.8%	0.4%
#4		
1/8"		
#8		
#10		
#16		
#20		
#30		
#40		
#50		
#80		
#100		
#200		

Note:

1. These results were provided to Geosyntec by Parsons.

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Table 4: Typical Elastic Modulus Values for soils [USACE, 1990]

soil	E, tsf
Clay	
Very soft clay	5 - 50
Soft clay	50 - 200
Medium clay	200 - 500
Stiff clay, silty clay	500 - 1000
Sandy clay	250 - 2000
Clay shale	1000 - 2000
Sand	
Loose sand	100 - 250
Dense sand	250 - 1000
Dense sand and gravel	1000 - 2000
Silty sand	250 - 2000

#### Typical Elastic Moduli

Notes:

1. It is assumed that the riser pipes will be surrounded by gravel, which may or may not be heavily compacted. Therefore, a value of 250 tsf has been assumed to represent the worst expected scenario.

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Table 5: Pipe Perforation Summary

Assumed Hole Diameter <i>d</i> (in)	Perforated Pipe Length <i>L</i> (ft)	Perforation Angle θ (°)	Row Offset δ (in)	Computed Inflow Capacity (gal/min)
1.00	3	45	2	21.9
1.00	3	45	3	14.6
1.00	4	45	3	19.4
1.00	4	60	2	21.9
1.00	4	60	3	14.6

Note:

1. This table summarizes acceptable combinations of perforated pipe length L, perforation angle  $\theta$ , and row offset  $\delta$ .

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Table 6: Mechanical Stability Summary

Calculation	Target	Calculated	OK?
Ring Compressive Strain (%)	< 3.5%	0.84%	Yes
Combined Ring Strain (%)	< 5.0%	1.46%	Yes
Ring Buckling (%)	< 50%	15.64%	Yes
Longitudinal Strain (%)	< 3.5%	2 9 7 9/	Voc
	< 5.2%	2.0770	Tes
Flotation with slab (FS)	> 1.0	3.05	Yes

Note:

1. These values are calculated following the methodology of Chevron Phillips [2004], as described in the package.

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Table 7A: Sump Volume Summary – Design 15 gal/min flow rate

	Q <sub>DESIGN</sub> (gal/min)	Pump Off Time <sup>[2]</sup> (hr)	Pump Rate (gal/min)	Pump Time (hr)
Sump 1	10	77.9	30	38.9
Sump 2	5	155.7	20	51.9

Table 7B: Sump Volume Summary – Post-Closure

	Q <sub>DESIGN</sub> (gal/min)	Pump Off Time <sup>[2]</sup> (hr)	Pump Rate (gal/min)	Pump Time (hr)
Sump 1	0.27	2883.9	30	26.2
Sump 2	0.13	5989.7	20	39.2

Notes:

- 1. These values are calculated assuming an excavation depth of 8 ft, pipe perforation angle of 45 degrees, and perforation row offset of 3 inches, as described in the package.
- 2. This is the time taken for the liquid level to go from the minimum to maximum level within the sump area.
- 3. Different pump capacities and on/off times may be used as appropriate based on actual field conditions, as long as performance requirements are met.

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# Figures



Figure 1: Grading Plan of Top of Low Permeability Soil Layer

Note:

- 1. Approximately 67% of the SCA area will drain to the western sump area, and approximately 33% of the SCA area will drain to the eastern sump area.
- 2. This figure does not include settlement.



Figure 2: Conceptual View of Sump Area

Notes:

- 1. The backup riser is conservatively assumed to be filled with gravel, therefore no extra sump volume capacity is considered.
- 2. The total SOLW excavation depth is the sum of L (perforated pipe length), the 3 ft minimum liquid height and the 1 ft base. The 3 ft minimum liquid height is sufficient for several commercially available electrical pumps.
- 3. The side slopes are 2.5 horizontal:1 vertical.
- 4. The width of the sump bottom is considered to be 5 ft for the riser and 10 ft offset from the side slopes, for a total of 25 ft. The length of the sump bottom is 40 ft, as shown on this figure.
- 5. The low permeability soil liner has a minimum thickness of 1.5 ft near the sump area.



Figure 3: Grain Size Distribution Curves

Note:

1. These grain size distribution curves are based on sieve analysis results for potential gravel sources provided to Geosyntec by Parsons.

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Figure 4a: Conceptual View of Proposed Perforated Pipe Section Design (Plan View)



Figure 4b: Conceptual View of Proposed Perforated Riser Pipe Section Design (Side View)

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# **Attachment 1: Calculation Spreadsheets**

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### Bernoulli's Equation to calculate pipe perforations

Finding Area of Each Perforation	$A_b = \pi/4^* d^2$	
Diameter of Perforation [d] =	1.00 in =	8.33E-02 ft
Area of Perforation $[A_b]$ =	5.45E-03 ft^2	
<u>Bernoulii Equation <sup>[1]</sup></u>	$Q_b = C^* A_b^* v_{ent}$	
Entry Velocity [v <sub>ent</sub> ] =	0.1 ft/s	
Discharge Coefficient [C] =	0.62	
Inflow per Orifice [Q <sub>b</sub> ] =	3.38E-04 ft^3/s =	2.03E-02 ft^3/min
Pipe Design		
Perforation offset angle $[\theta]$ =	45 degrees	
#Perforations in each row [N <sub>row</sub> ] =	8	
Offset between rows $[\delta]$ =	3.00 in	
Number of Rows [R] =	4	
Pipe Length [L] =	4 ft	
Maximum Flow 0	Dia = Oh * Nrau * R *L	
Maximum inflow Rate [Q <sub>in</sub> ] =	2.60 ft^3/min	= <b>19.43</b> gal/min

Note:

1. Qian et al. [2002]

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Client: Honeywell Project:	Onond	aga Lake SCA	Final Design	Pr	oject/ Pr	oposal No.:	GJ4299	Task No.:	18
	PRO	OPOSED MA Onondaga	NHOLE RIS Lake - SCA	ER DE Design	SIGN				
Pipe Type:									
Name: Nominal Inside Diamet Minimum wall thickness Reference Outside Diamete Mean Diameter (in) Inside-Diameter Dimension Manhole Weight (lb) Height of GW above bass Modulus of elasticity (p Diameter of stubouts (i Number of stubouts Number of perforation Diameter of perforation	Perform       ter     ID       (in)     t =       er (in) $D_0$ $D_M$ IDR $h$ Ratio     IDR $h$ e (ff) $H_w$ $h$ (si) $E$ = $n$ ) $D_S$ $N_S$ = $n$ ons (in) $a$	rmance Pipe         =       57.854         :       2.423         =       62.99         =       60.42         =       23.9         =       8080.4       Obt         =       18.5         =       21,432         =       0.0         =       0         n       4         i       1.0	tained from manufactu 50 year duration at ' applied reduction fa	Quick Chec Irer IscoPipe 73°F [Chevrc Ctor=0.76 Ai	<b>k: Are requi</b> Yes on Phillips, 2 ugust et al., 1	irements met? 004], 1997]			
Stresses and Loads	uii (iii) u	. 1.0							
Pr.	$P_R = ($	$[1.21 * K_A * y * H)/(1 - P_R = Radially direcK_A = Active earth p\varphi = Soil angle of in\gamma = Soil unit weighH = Height of fill an = Number of perd = Diameter of pe$	n*d/12) ted pressure (psf) oressure coefficient = ternal friction (°) t (pcf) bove base (ft) forations per ft = rforations (in) =	[Chevron Ph tan <sup>2</sup> (45-φ/2) 4 1	illips, 2004]	and [Qian et.al, 20	02]		
La 1 (Gravel above 2 (Gravel below	yer No. γ (p c GWT) 120 γ GWT) 120 3 4 5 6	H (ft)         q           0         21.5         3           0         18.5         3	b (°)         K <sub>A</sub> 88.0         0.238           98.0         0.238	P <sub>R1</sub> (psf) <b>0.00</b> 1113.94	P <sub>R2</sub> (psf) 1113.94 2072.44	T <sub>A</sub> (psf) 222.79 637.28			
	Ma	ax. Radially Directed E Dry soil weight (v	arth Pressure P <sub>R</sub> = weighted average) =	2072.44 120.00	psf psf				
Downdrag Load	$T_A = \mu$ Samp $T_A$ $T_A$	$\mu_{F} * (P_{R1} + P_{R2}) / 2$ $T_{A} = \text{Average shear}$ $P_{R1} = \text{Radial pressu}$ $P_{R2} = \text{Radial pressu}$ $\mu_{F} = \text{Friction coeffit}$ $\mu_{F} = 0.4 \text{ for HDPE}$ le Calculation for Laye $I_{1} = 0.4 * (0 + 1113.94)$ $I_{2} = 222.79 \text{ psf}$	[Chevron Phill r stress (psf) re at top of riser (psf) re at base of riser (ps cient between riser an risers with granular o r 1: ) / 2	ips, 2004] f) d soil = r granular-co	0.4 shesive soils	[Chevron Phillips,	2004]		
	Avera T	age shear stress of riser $_A = 414.49$ psf	$=(T_{A1}*H_1+T_{A2}*H_2-$	+)/H					
Compressive Stress caused	by Downdrag $P_D = 7$	$\frac{\text{g Load}}{\Gamma_{\text{A}} * \pi * (D_{\text{O}}/12) * \text{H}}$	[Chevron Phill	ips, 2004]					

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Client: Honeywell	Project:	Onondaga	Lake SCA	Final Design	Project	/ Proposal No.:	GJ4299	Task No.:	18
<u>Ring St</u>	<u>rains</u>								
Ring Com	pressive Thrust								
King Com	pressive rinuse	$N_T = P_R * R_P$	<sub>4</sub> / 144	[Chevron Philli	os, 2004]				
		N <sub>T</sub>	= Ring compress = Radial pressure	ive thrust (lb/in)					
		R <sub>M</sub>	= Mean radius o	f riser (in) = (ID + t) /	2 = (57.854 + 2	2.423)/2 = 30.1385			
		$N_{T} = 20^{\circ}$	72.44 * 30.1385 /	144					
		N <sub>T</sub> =	433.75 lb/in						
Ring Com	pressive Strain								
		$\epsilon_{\rm T} = N_{\rm T} / (E$	* t) – Ping comprossi	[Chevron Philli	os, 2004]				
		N <sub>T</sub>	<ul> <li>Ring compress</li> <li>Ring compress</li> </ul>	ive thrust (lb/in)					
		E = t =	<ul> <li>Modulus of elas Minimum wall th</li> </ul>	ticity (psi) iickness (in)					
		$\varepsilon_{\rm T} = 432$	3.75 / (21432 * 2.	423) Should be less t	han 3.5% at 73°F [	Chevron Phillips, 2004]			
		$\epsilon_{\rm T} =$	0.84%	<	.5%, OK!				
Ring Bend	ing								
		$M_E = 0.25 *$ $M_F$	$C_0 * D_M * N_T$ = Ring bending	[Chevron Philli] moment (in-lb/in)	os, 2004]				
		Co	= 0.02 (correctio	n for 2% deflection),	Chevron Phillips,	2004]			
		D <sub>M</sub> N <sub>m</sub>	= Mean riser dia = Ring compress	meter (in)					
		$M_{\rm E} = 0.2$	5 * 0.02 * 60.422	2 * 433.75					
		$M_E =$	131.04 in-lb	/in					
Ring Bend	ing Strain								
		$\epsilon_{\rm B} = 6 * M_{\rm E}$	/ (E * t <sup>2</sup> )	[Chevron Philli	os, 2004]				
		ε <sub>B</sub> M <sub>F</sub>	= Ring bending s = Ring bending :	moment (in-lb/in)					
		E =	Modulus of elas	ticity (psi)					
		$\epsilon_{\rm B} = 6 *$	131.04 / (21432	* 2.423^2)					
		$\epsilon_{\rm B} =$	0.62%						
Combined	Ring Strain								
		$\varepsilon_T + \varepsilon_B$ shou $\varepsilon_T + c_T =$	Id be less than 5%	6 [Chevron Phillips, 2	004] 5%, OK!				
		C1 . CB	2						

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Written	by: Jose	eph Sura		Date:	12/1/2009	Reviewed by:	Fan Zhu/I	R. Kulasingam	Date:	12/4/2	2009
Client:	Honeywe	ell	Project:	Ononda	aga Lake SCA	Final Design	Project/ Proj	posal No.: (	GJ4299	Task No.:	18
		<u>Ring B</u> i	uckling								
		Ring Buck	ting (manhole a	bove GWT)							
				N <sub>CR</sub> = Calcu RS = RS =	= 0.3 * R <sub>H</sub> * t * E <sup>1/3</sup> * $N_{CR}$ = Critical rin $R_{H}$ = Geometry fi t = Minimum wal E = Modulus of e $E_{S}$ = Elastic Mod late Relative Stiffness: (0.22*E*t <sup>3</sup> ) / (E <sub>S</sub> * R <sub>t</sub> (0.22*E*t <sup>3</sup> ) / (E <sub>S</sub> * R <sub>t</sub> )	Es <sup>2/3</sup> [Chu g compressive thrust (lb/in) actor l thickness (in) lasticity (psi) ulus of soil (tsf) = s RS; if RS<0.005, R <sub>H</sub> =1.0   $a_{1}^{3}$ $a_{3}^{3}$ (3472 22 * 30 1385^3)	evron Phillips, 2004] 250 = [Chevron Phillips, 200	3472.22 (psi) 14]			
				RS =	0.0007	Geometry Factor=	1.0				
				N <sub>C</sub> N <sub>C</sub>	$_{R} = 0.3 * 1.0 * 2.423$ $_{R} = 4629.85$	* 21432^1/3 * 3472.22 ^2/	3				
		Ring Buck	ling (manhole b	elow GWT)							
				N <sub>CRW</sub>	$= 0.82 * ((R * B' * E N_{CRW} = Critical r R = Buoyancy redB' = 1/(1+4*e^{(-0.0t)} t = Minimum walE = Modulus of e E_s = Elastic Mod$	$_{\rm S} * E * t^3/D_{\rm M}$ <sup>0.5</sup> [Chu ing compressive thrust for m fuction = 1 - 0.33 * H <sub>w</sub> /H = $^{(5H)}$ = 1 / (1+4*exp(-0.06 1 thickness (in) lasticity (psi) ulus of soil (psi) = 32	evron Phillips, 2004] nanhole below GWT (1 = 0.847 55*40))= 0.771	lb/in)			
				N <sub>CR</sub> , N <sub>CR</sub> ,	$W_W = 0.82 * (0.771*0.8)$ $W_W = 2773.64 \text{ lb}$	47*3472.22*21432*(2.423 //in	)^3)/(60.422)				
				N <sub>T</sub> sh N N <sub>C</sub> N <sub>CR</sub> N <sub>T</sub> /N <sub>C</sub>	ould not be greater th $T_{T} =$ 433.75 lb $R =$ 4629.85 lb $W =$ 2773.64 lb $R =$ <b>15.64%</b>	an 50% of the more critical /in /in /in more critical Less that	of N <sub>CR</sub> and N <sub>CRW</sub> [Che <b>1 50%, OK!</b>	evron Phillips, 2004]			
		Longitudir	nal Compressive	Strain	ι.						
		Longiudii	<u>eonpresive</u>	ε <sub>A</sub> = ( ε <sub>A</sub> = ( ε ε	$\begin{array}{l} P_{\rm D} + P_{\rm L} + P_{\rm W}) / (E *) \\ \varepsilon_{\rm A} = {\rm Longitudinal} \\ P_{\rm D} = {\rm Downdrag \ l} \\ P_{\rm L} = {\rm Live \ load} ({\rm I} \\ P_{\rm W} = {\rm Dead \ load}, \\ E = {\rm Modulu \ os} \ dead \\ D_{\rm M} = {\rm Mean \ riser} \\ t = {\rm Minimum \ wal} \\ A_{\rm A} = (273409.9 + 1000) \\ A_{\rm B} = 2.87\% \end{array}$	$\begin{aligned} \pi * D_{M} * t) & [Che \\ compressive strain (in/in) \\ oad (lbs) \\ ps) &= 1000 \\ including riser weight (lbs) \\ lasticity (psi) \\ diameter (in) \\ l thickness (in) \\ 0 + 8080.4) / (21432 * Pi * e) \end{aligned}$	evron Phillips, 2004] 60.422 * 2.423)				
				$\epsilon_{CR} = \epsilon_{CR}$	$\begin{array}{l} (2 * t) / (D_{M} * (3*(1-\mu \\ \epsilon_{CR} = Critical lon \\ D_{M} = Mean riser \\ \mu = Poisson's ratit \\ t = Minimum wal \\ R = (2 * 2.423) / (60. \\ R = 5.19\% \end{array}$	<sup>21</sup> ) <sup>0.5</sup> ) [Ch gitudinal compressive strain diameter (in) o for HDPE = 0.45 for long l thickness (in) $422* (3*(1 - 0.45^2))^{0.5})$	evron Phillips, 2004] 1 (in/in) -term [Chevron Phillip	us, 2004]			
				$\epsilon_A m t$ $\epsilon_A =$	ist be $\leq \epsilon_{CR}$ AND $\epsilon$ 2.87%	A must be $< 3.5\%$ [Che	evron Phillips, 2004] DK!				

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Client:	Honeywell	Project:	Onondaga	a Lake SCA 1	Final Design		Project/ Proposal No.:	GJ4299	Task No.:	18
	<u>Flotatio</u>	on (anti-flotai	tion slab)							
			FS = F <sub>DOW</sub> F F F	$F_{\rm UP} / F_{\rm UP}$ $F_{\rm S} = Factor of safety$ $F_{\rm DOWN} = Downward =$ $F_{\rm UP} = Uplift forces (calculated)$	[Chevron Phillip forces (resisting flotat ausing flotation)	os, 2004 tion)	]			
			F <sub>DOWN</sub> = V	$V_{MH} + W_{CC} + (W_{AF})/W_{MH} = Manhole weights W_{CC} = \text{Concrete cap} W_{AF} = \text{Anti-flotation} W_{AFS} = \text{Soil weight a}$	$FS_{AF} + (W_{AFS})/FS_{AFS}$ ght (lb)= weight (lb) = slab weight (lb) bove slab (lb)	0.0 0	[Chevron Phillips, 2004]			
	Collar Din	nensions and Safe	tv Factors							
	Weight of Weight of	Pl <u>Slab</u> <u>Soil</u>	an area of riser di Unit Height of soil ab Safe Safe $W_{AF} = L_{AF}$ $W_{AF} = 7$ $W_{AF} =$ $W_{AFS} = (L_{AFS})$	Width of slat Length of slat Thickness of slab rectly on top of slab weight of concrete ( ght of soil above slal ove slab below GW ty Factor for slab we ty Factor for soil we * $w_{AF} * (t_{AF} / 12) *$ .25 * 7.25 * (6/12) .2302.2 It $AF * w_{AF} - A_{OVER}$ * (4 AF = Soil weight (weight for the source of	$\begin{aligned} & (f) \qquad w_{AF} = \\ & (f) \qquad L_{AF} = \\ & (f) \qquad L_{AF} = \\ & (f) \qquad L_{AF} = \\ & (f^2) \qquad A_{OVER} = \\ & pcf) \qquad \gamma_C = \\ & pcf) \qquad \gamma_C = \\ & b(f) \qquad H_{AF} = \\ & f(f) \qquad H_{WAF} = \\ & f(f) \qquad H_{F} = $	7.25 7.25 6.0 21.6 150 39.5 18.0 1.5 1.5	[Chevron Phillips, 2004] ·γ <sub>w</sub> )) [Chevron Phillips,	2004]		
	<u>Total Dow</u>	nward Force	Y W <sub>AFS</sub> = (	$v = \text{Soft unit weight (} \\ v_w = \text{Unit weight of w} \\ 7.25 * 7.25 - 21.6) * \\ 111985.2  \text{lb} \\ v_w = \text{Unit weight of w} \\ v_w = Unit $	pcf) vater = $62.4 \text{ pcf}$ (120*(39.5 - 18) + 1	8*(120	- 62.4))			
			$F_{DOWN} = V$	V <sub>MH</sub> + W <sub>CC</sub> + (W <sub>AF</sub> )/ <b>76191.6</b> lb	$FS_{AF} + (W_{AFS})/FS_{AFS}$		[Chevron Phillips, 2004]			
	<u>Total Upw</u>	ard Force	$F_{UP} = \pi * ($ $F_{UP} = \pi$ $F_{UP} =$	$(D_0^2/576) * \gamma_w * H_w$ t * (62.99^2 / 576) * <b>24982</b> lb	62.4 * 18.5		[Chevron Phillips,	2004]		
	Factor of S	<u>Safety</u>	Note that S FS = $F_{DOW}$ FS = 7	Safety Factors have a <sub>N </sub> / F <sub>UP</sub> 76191.6 / 24982	lready been applied i	ndividu	ally to resisting factors, target FS=1	.0		
			FS =	3.05	>	1.0, OK	<u>[</u>			

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Client: Honeywell	Project:	Onond	aga Lake SCA	A Final Design	Project/ Proposal No.:	G <b>J4299</b>	Task No.:	18

#### Sump Volume Calculations: Design Flow Rate (15 gal/min)

Design Parameters <sup>[1]</sup>		
	Sump 1	Sump 2
Gravel Porosity $n =$	0.4	0.4
Perforated Length $L$ (ft) =	4	4
Target Inflow Rate Q <sub>IN</sub> (gal/min) =	10	5
Pumping rate Q <sub>PUMP</sub> (gal/min) =	30	20
Riser Nominal Diameter D <sub>R</sub> (ft)=	5	5
Length at Maximum Liquid Level $a$ (ft) =	80	80
Length at Minimum Liquid Level b (ft) =	60	60
Width at Maximum Liquid Level $c$ (ft) =	65	65
Width at Minimum Liquid Level $d$ (ft) =	45	45

Volume Calculations <sup>[2]</sup>		
Vol. of Sump from $W_{MIN}$ to $W_{MAX}$ (gal) = V	PYRAMID	
V <sub>PYRAMID</sub> (gal) = (	L /6)*(ad +b	c +2ac +2bd )/0.134
V <sub>PYRAMID</sub> (gal) =	115920.4	115920.4
Storage Vol. inside Riser V <sub>RISER</sub> (gal) = (a	π/4*D <sub>R</sub> <sup>2</sup> *L)/	.134
V <sub>RISER</sub> (gal)=	586.1	586.1
Total Storage Vol. (gal) = (	V <sub>PYRAMID</sub> -V <sub>RISE</sub>	<sub>ER</sub> )*n+V <sub>RISER</sub>
Total Storage Vol. (gal) =	46719.8	46719.8
Pump On and Pump Off Time Calcul	ations <sup>[3]</sup>	

Pump On and Pump Off Time Calculations <sup>[3]</sup>				
Pump off time (hr)= V <sub>STORAGE</sub> /Q <sub>IN</sub>				
Pump off time (hr)=	77.9	155.7		
Pump on time (hr)= V <sub>s</sub>	Pump on time (hr)= V <sub>STORAGE</sub> /(Q <sub>PUMP</sub> -Q <sub>IN</sub> )			
Pump on time (hr)=	38.9	51.9		

Notes:

- 1. The lengths and widths at minimum and maximum liquid levels are calculated assuming a 2.5 H:1 V side slope and geometry as shown in Figure 2.
- 2. The sump volume is calculated based on a truncated rectangular pyramid. The riser pipe volume is calculated based on a cylindrical pipe. The volume occupied by the riser pipe wall thickness is small relative to the overall storage volume and is ignored.
- 3. Pump off time represents the amount of time necessary for the sump area to fill from the minimum water level to the maximum water level. The pump on time represents the amount of time that the pump runs to remove the liquid.
- 4. The backup riser is conservatively assumed to be filled with gravel in this calculation.

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#### Sump Volume Calculations: Post-Closure Condition

Design Parameters <sup>[1]</sup>				
	Sump 1	Sump 2		
Gravel Porosity $n =$	0.4	0.4		
Perforated Length L (ft) =	4	4		
Target Inflow Rate Q <sub>IN</sub> (gal/min) =	0.27	0.13		
Pumping rate Q <sub>PUMP</sub> (gal/min) =	30	20		
Riser Nominal Diameter D <sub>R</sub> (ft)=	5	5		
Length at Maximum Liquid Level $a$ (ft) =	80	80		
Length at Minimum Liquid Level b (ft) =	60	60		
Width at Maximum Liquid Level c (ft) =	65	65		
Width at Minimum Liquid Level $d$ (ft) =	45	45		

Volume Calculations <sup>[2]</sup>				
Vol. of Sump from $W_{MIN}$ to $W_{MAX}$ (gal) = V	/ <sub>PYRAMID</sub>			
V <sub>PYRAMID</sub> (gal) = (	L /6)*(ad +bc	c+2ac+2bd )/0.134		
V <sub>PYRAMID</sub> (gal) =	115920.4	115920.4		
Storage Vol. inside Riser $V_{RISER}$ (gal) = $(\pi/4*D_R^2*L)/.134$				
V <sub>RISER</sub> (gal)=	586.1	586.1		
Total Storage Vol. (gal) = $(V_{PYRAMID} - V_{RISER})^* n + V_{RISER}$				
Total Storage Vol. (gal) =	46719.8	46719.8		

Pump On and Pump Off Time Calculations <sup>[3]</sup>				
Pump off time (hr)= V <sub>STORAGE</sub> /Q <sub>IN</sub>				
Pump off time (hr)	= 2883.9	5989.7		
Pump off time (days)	= 120.2	249.6		
Pump on time (hr)= V <sub>STORAGE</sub> /(Q <sub>PUMP</sub> -Q <sub>IN</sub> )				
Pump on time (hr)	= 26.2	39.2		

Notes:

- 1. The lengths and widths at minimum and maximum liquid levels are calculated assuming a 2.5 H:1 V side slope and geometry as shown in Figure 2.
- 2. The sump volume is calculated based on a truncated rectangular pyramid. The riser pipe volume is calculated based on a cylindrical pipe. The volume occupied by the riser pipe wall thickness is small relative to the overall storage volume and is ignored.
- 3. Pump off time represents the amount of time necessary for the sump area to fill from the minimum water level to the maximum water level. The pump on time represents the amount of time that the pump runs to remove the liquid.
- 4. The backup riser is conservatively assumed to be filled with gravel in this calculation.