Map Document: (F:\GIS\Nextera\GISSpatial\MXDs\ReportMXDs\D_G_ConstructionReport\JerichoREA_September2013\09172013_Jericho_ProjectLocation_NHFeatures.mxd)

Lake Huron
Kettle Point 44
Lambton Shores
North Middlesex
Warwick
Adelaide Metcalfe
Middlesex Centre
Refer to Parkhill Interconnect Project Appendix from Original REA Submission
Legend
Wind Energy Centre Study Area
Transmission Line Study Area
Parcel Boundary
120m Area of Investigation
Municipal Division
Setback Distances
60 m Road/Rail Buffer
80 m Property Boundary Buffer
500 m Substation Footprint Buffer
550 m Noise Receptor Buffer
75 m Petroleum Resources Buffer
2 km Boundary from Project Location
Other Resources
Petroleum Well
Authorized Aggregate Site
Closed Landfill
Roads
Freeway
Expressway / Highway
Major Road
Local Road
Ramp
Railway
Existing 500kV Transmission Line
Receptor
Participating Receptor
Non-participating Receptor
Vacant Lot Participating Receptor
Vacant Lot Non-participating Receptor
Project Location
GE Turbine
Permanent Meterological Tower
Access Road
Collection Line
Crane Path
Transmission Line
Substation & Laydown Area
Disturbance Areas
Natural Feature
Watercourse (ABCA, SCRCA)
Watercourse (MNR)
Waterbody
Cartographic Wetland
Woodlots
Produced by AECOM under licence from Ontario Ministry of Natural Resources, Copyright © Queens Printer 2012
N
W
E
S
Metres
0 200 400 800 1,200 1,600
1:50,000
UTM Zone 17N, NAD 83
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Jericho Wind Energy Centre
Construction Report
Project Location and Socio-Economic Features
September 2013
Project 60155032
AECOM
Figure 2-3

Appendix D

Revised Hydrogeological Calculations for Dewatering Activities

Appendix D-1 Hydrogeological Calculations for Dewatering Activities for Turbine

1. Introduction

As described in the *Technical Guide to Renewable Energy Approvals (MOE, 2011)*, an important environmental effect to consider in the Construction Plan report is the potential for the Project to interfere with existing uses of a water resource.

Section 3.3.3 (Geology and Groundwater) of the Construction Plan Report determines that the extraction of groundwater for construction dewatering purposes will be less than 50,000 litres per day (L/day) for all turbines with the exception of turbines 8, 25, and 32 – 34, where dewatering has the potential to be greater than 50,000 L/day. At these turbines available geotechnical and geological information indicate permeable sediments (i.e. sand) within 4 mbgs. Daily groundwater inflow rates and resulting radii of influence are attributable to the following:

- A short duration of dewatering activities (3-4 days per turbine base);
- The number of turbine foundations / collection line trenches installed at one time;
- The amount of precipitation that occurs directly before or during construction; and
- The surficial material being excavated.

2. Calculation of Water Takings

Conservative estimates of groundwater inflow rates for a turbine foundation were calculated based on an assumed excavation of 21 x 21 m and a required excavation depth of 4 mbgs. The required water table drawdown varies for each turbine and is dependent on results of the geotechnical investigation and the depth and/or thickness of permeable sediments at the turbine location. The hydraulic conductivity assumed for turbines 8, 25, 32, 33 and 34 ranges between 1.0×10^{-4} 5.0×10^{-4} m/s and is estimated based on available geotechnical borehole information and geological mapping.

In addition, the calculated radii of influence for the construction dewatering were calculated to range between 131 and 278 m.

The analytical calculations used to determine the predicted groundwater inflow and radii of influence were based upon Powers *et al.* (2007)[1] and Sichart *et al.* (1930)[2].

Table 1 summarizes the predicted groundwater inflow, radii of influence and applied hydraulic conductivity.

Table 2 shows an example calculation used to determine the radius of influence and groundwater inflow for a sand and gravel unit.

1. *Powers, J.P, Corwin, A.B., Schmall, P.C., Kaeck, W.E., and Herridge, C.J., 2007. Construction Dewatering and Groundwater Control: New Methods and Applications, 3rd Ed. John Wiley and Sons Inc.*
2. *Sichart, W. and Kyrieleis, W., 1930. Grundwasser Absekungen bei Fundierungsarbeiten. Berlin, Germany.*

Table 1. Summary of Predicted Groundwater Inflow and Radii of Influence

Turbine ID:	8	25	32	33	34
Area:	Excavation for base of single turbine				
Initial Head:	4 m	4 m	4 m	4 m	4 m
Final Head:	0 m				
Excavation Length:	21 m				
Side Slope Wall Ratio:	Varies, but assume 1H : 1V for calculation				
Trench Width:	21 m				
Number of Sides:	4				
Hydraulic Conductivity (m/s):	$5.0e^{-4}$	$5.0e^{-4}$	$5.0e^{-4}$	$5.0e^{-4}$	$1.0e^{-4}$
Q (L/day):	214,350	214,350	214,350	214,350	95,860
ROI (m):	278	278	278	278	131

Notes: Q – Flow rate (L/day)
ROI –Radius of Influence (m)

Radius of Influence and Groundwater Inflow Rate Calculations - Turbine Foundation

Spreadsheet Instructions
Edit
Results

TURBINE No: 8

After: Powers et al, 2007 & Sichart and Kryieleis, 1930.
USE FOR BOX SHAPED EXCAVATIONS, WHERE x/a IS SMALL (I.E. <1.5)

x/a 1

Radius of Influence

Ro = 3000(H-h)K^1/2

Sichardt's empirical relationship

Raduis of Influence	Ro =	872.07	ft
Saturated Thickness before Dewatering	H =	13	ft
Saturated Thickness after Dewatering	h =	0	ft
Hydrualic Conductivity	K =	5.00E-04	m/s
Number of Sides	n =	4	

Equivalent Radius of Influence for Square or rectangular shaped areas

r_e = (ax/Pi)^1/2

Width of Trench	a =	21	m
Length of Trench	x =	21	m
Pi	3.141593		
Equiv Radius of Infleunce	r_e =	11.85	m

Therefore, the Total Radius of Influence equals **R_T = Ro + r_e**

R_T = 277.65 m

Groundwater Seepage Rate

Jacob's modified non-equilibrium equation**

Q= [(xK(H^2-h^2)/2L]*n

Radius of Influence	Ro =	265.81	m
Equiv Radius of Infleunce	r_e =	11.8	m
Saturated Thickness before Dewatering	H =	3.9624	m
Saturated Thickness after Dewatering	h =	0	m
Hydrualic Conductivity	K =	5.00E-04	m/s
Length of Trench	x =	21	m
Line Source Distance*	L =	132.9029363	m
Pi	3.141593		
Groundwater Inflow Rate	Q =	2.48E-03	m3/s
	Q =	**214,346**	L/day
Sheet Pile % reduction	%	0	%
Revised Total Groundwater Inflow Rate	**Q' =**	**214,346**	L/day

Notes:

*** Only good for horizontal flow, need to use darcy for vertical flow*

***First Term is for Gravity Flow*

***Second Term is for artesian flow (confined aquifer)*

**Line source distance is the distance where the confined aqufier is drained (i.e., under gravity flow conditions), but the confining unit is still flowing under pressure*

References:

Powers, J.P, Corwin, A.B., Schmall, P.C., Kaeck, W.E., and Herridge, C.J., 2007. Construction Dewatering and Groundwater Control: New Methods and Applications, 3rd Ed. John Wiley and Sons Inc

Sichart, W. and Kyrieleis, W., 1930. Grundwasser Absekungen bei Fundierungsarbeiten. Berlin, Germany.

References:

Appendix B-2 Hydrogeological Calculations for Dewatering Activities for Collection Line

3. Introduction

As described in the *Technical Guide to Renewable Energy Approvals (MOE, 2011)*, an important environmental effect to consider in the Construction Plan report is the potential for the Project to interfere with existing uses of a water resource.

Section 3.3.3 (Geology and Groundwater) of the Construction Plan Report determines that the extraction of groundwater for construction dewatering purposes will be less than 50,000 litres per day (L/day) for all collection lines installed in surficial material with relatively impermeable aquifer properties (i.e. St. Joseph till). Where collection lines are installed in permeable surficial materials, such as sand and gravel, dewatering has the potential to be greater than 50,000 L/day. Daily groundwater inflow rates and resulting radii of influence are attributable to the following:

- A short duration of dewatering activities (1 day per 50 m length of collection line);
- The number of turbine foundations / collection line trenches installed at one time;
- The amount of precipitation that occurs directly before or during construction; and
- The surficial material being excavated.

4. Calculation of Water Takings

Conservative estimates of groundwater inflow rates for a collection line were calculated based on an assumed excavation of 1 m wide by 50 m long, a required excavation depth of 2 mbgs with a required water table drawdown of 1 m. The hydraulic conductivity assumed for all collection lines encountering permeable surficial sediments is estimated to 5.0 x 10^{-4} m/s. Based on the same excavation dimensions, conservative estimates for groundwater inflow rate to excavations within sand and gravel deposits were calculated to be 174,300 L/day.

In addition, the calculated radii of influence for the construction dewatering were calculated to be 77 m.

The analytical calculations used to determine the predicted groundwater inflow and radii of influence were based upon Powers *et al.* (2007)[3] and Sichart *et al.* (1930)[4] equation for long thin trenches.

Table 1 summarizes the predicted groundwater inflow, radii of influence and applied hydraulic conductivity.

Table 2 shows an example calculation used to determine the radius of influence and groundwater inflow for a sand and gravel unit.

3. *Powers, J.P, Corwin, A.B., Schmall, P.C., Kaeck, W.E., and Herridge, C.J., 2007. Construction Dewatering and Groundwater Control: New Methods and Applications, 3rd Ed. John Wiley and Sons Inc.*
4. *Sichart, W. and Kyrieleis, W., 1930. Grundwasser Absekungen bei Fundierungsarbeiten. Berlin, Germany.*

Table 2. Summary of Predicted Groundwater Inflow and Radii of Influence

Area	Excavation for collection line
Initial Head:	1
Final Head:	0
Excavation Length:	50
Side Slope Wall Ratio:	Varies, assume 1H :1V for calculation
Trench Width:	1 m
Number of Sides:	4
Hydraulic Conductivity (m/s):	$5.0e^{-4}$ m/s
Q (L/day):	174,300
ROI (m):	77

Notes: Q – Flow rate (L/day)
ROI –Radius of Influence (m)

Radius of Influence Calculation - Collection Line Trench
Powers et al. 1992 - Dewatering Design using Analytical Methods
USE FOR LONG THIN TRENCHES WHERE x/a IS LARGE

Radius of Influence

Ro = 3000(H-h)K^1/2 (Ro, H, h all in feet and K in m/s)
Sichardt's empirical relationship

Radius of Influence	Ro =	199.23	ft
Saturated Thickness before Dewatering	H =	3.30	ft
Saturated Thickness after Dewatering	h =	0.33	ft
Hydrualic Conductivity	K =	5.00E-04	m/s

Equivalent Radius of Influence for Square or rectangular shaped areas

r_e = (ax/Pi)^1/2

Width of Trench	a =	1	m
Length of Trench	x =	50	m
Pi	3.14159		
Equiv Radius of Infleunce	r_e =	16.23	m

Therefore, the Total Radius of Influence equals **$R_T = Ro + r_e$**

R_T = 76.96 m

Groundwater Seepage Rate

Jacob's modified non-equilibrium equation**

Q= [(πK(H^2-h^2))/ln(Ro/$r_{e)}$]+ 2[(xK(H^2-h^2))/2L]

Radius of Influence	Ro =	60.73	m
Equiv Radius of Infleunce	r_e =	16.2	m
Saturated Thickness before Dewatering	H =	1.01	m
Saturated Thickness after Dewatering	h =	0.10	m
Hydrualic Conductivity	K =	5.00E-04	m/s
Length of Trench	x =	50	m
Line Source Distance	L =	30.36	m
Pi	3.14159		
Groundwater Inflow Rate	Q =	2.02E-03	m3/s
	Q =	**174,288**	L/day
Sheet Pile % reduction	%	0	%
Revised Total Groundwater Inflow Rate	**Q' =**	**174,288**	L/day

Notes:

*** Only good for horizontal flow, need to use darcy for vertical flow*

***First Term is for Gravity Flow*

***Second Term is for artesian flow (confined aquifer)*

**Line source distance is the distance where the confined aqufier is drained (i.e., under gravity flow conditions), but the confining unit is still flowing under pressure*

References:

Powers, J.P, Corwin, A.B., Schmall, P.C., Kaeck, W.E., and Herridge, C.J., 2007. Construction Dewatering and Groundwater Control: New Methods and Applications, 3rd Ed. John Wiley and Sons Inc

Sichart, W. and Kyrieleis, W., 1930. Grundwasser Absekungen bei Fundierungsarbeiten. Berlin, Germany.