MEMO

TO: Gary Tomlinson, Senior Environmental Officer
Ministry of the Environment and Climate Change (MOECC)

FROM: Darin Burr, Dillon Consulting Limited

DATE: July 21, 2014

SUBJECT: Dufferin Wind Farm
Transmission Pole Foundations Identified for Mitigation Measures

OUR FILE: 13-8287

CC: Robb Phiri, Construction Manager, Longyuan Power
David Restivo, Environmental Monitoring Project Manager, Dillon Consulting Limited
Don McKinnon, Project Manager, Dillon Consulting Limited
Jeff Hammond, Longyuan Power
Rebecca Crump, Longyuan Power

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1. INTRODUCTION

The Ontario Ministry of the Environment and Climate Change (MOECC) has asked Dufferin Wind Power (DWP) to identify pole foundations at the Dufferin Wind Farm (DWF) 230kV transmission line that will incorporate mitigation measures into their design and construction. The purpose of these mitigation measures is to reduce the risk of the pole foundations acting as preferential pathways for surface water movement into aquifers. Design and construction details of the proposed mitigation measures were provided in our July 4, 2014, technical memorandum to the Ministry of Environment (MOE). Information on which pole locations are to undergo mitigation is presented herein.

2. INSTALLATION OF LOW-PERMEABILITY SURFACE SEALS

DWP has agreed to construct low permeability surface seals at select pole locations. The proposed seal will be made of bentonite clay that is placed within and/or outside of the steel casing. The casing will be covered with native soil and mounded around the pole. The proposed mitigation measure that will be used depends upon pole location as outlined below:

North of Highway #89

a) Installation of surface seals around the exterior of the steel casing for all poles;
b) Installation of surface seals within the interior of the steel casing (between the casing and the pole) for all poles not constructed using concrete filled caissons.

South of Highway #89

c) Same as measures a) and b) for poles located in wetland areas or locations susceptible to flooding, and areas where the base of the pole foundation is within 2.5 m of a utilized overburden or bedrock aquifer.

3. SELECTION METHODS FOR POLE LOCATIONS TO UNDERGO MITIGATION

All pole foundations north of Highway #89 will be sealed at surface. Selection of pole locations south of Highway #89 that would require sealing was based on identifying those locations where the base of the pole foundation (conservatively assumed to be 9 m) was <2.5 m from a utilized aquifer and identifying those locations that are prone to flooding. Identification of areas prone to flooding was based on wetland and surface water mapping, confirmed by field surveys. To assess the separation distance between the base of the pole foundation and the aquifer utilized in the area, the following methodology was followed:

1) Water well locations within 500 m of the transmission alignment, as identified in the MOE Water Well Record (WWR) database, were mapped using GIS. Information from these wells was used to assess the characteristics of the local aquifers and estimate the depth of the bedrock under the transmission line poles. Most weight was given to wells closest to and generally within 150 m of the transmission line. Where close wells did not exist, information from wells up to 500 m away from the transmission line was used in the analysis. A summary of the database information used in this assessment is provided as **Attachment 1** to this memorandum.
2) The thicknesses of lower permeability material between 9 m depth and the top of the next utilized aquifer below this depth was calculated based on the lithological information provided in the WWR database. The lithological horizon used as an aquifer was based on the depth that was either identified as open hole construction or screened. For this analysis, it was assumed that material described in the WWR that contained one or more of the words clay, silt or till was not an aquifer and the permeability would be relatively low. Material described as limestone or rock was considered the bedrock aquifer and material described as sand and/or gravel was considered overburden aquifer material. All of these units were considered to have a relatively high permeability.
3) Depth to water and reported water found information was not used in the analysis and the encountered lithological units were conservatively assumed to be fully saturated. Geotechnical information from borehole drilling along the alignment was not used, as the depths of the boreholes were generally too shallow to assess lithological materials below the pole foundation depth (~9m).
4) The overburden was considered to be a utilized aquifer if a well record plotted within 150 m of the transmission line and the well was identified to produce water from the overburden. Note that the use of the overburden aquifer appears very limited in the project area south of Highway #89 and only two of the 80 reviewed water well records along the alignment were identified as pumping from an overburden aquifer.
5) In cases where permeable overburden material (e.g., sand, gravel, boulders etc.,) was reported to be overlying the bedrock aquifer, the top of utilized aquifer was defined as the top of the permeable overburden material. This approach conservatively assumes that there would be a hydraulic connection between the bedrock and the overlying overburden aquifer.

Following this approach, the separation distance between the base of the pole and the utilized aquifer was mapped and is presented in **Map 1** for wells within 500 m of the transmission line. The type of aquifer utilized (bedrock or overburden) is identified: blue dots are bedrock wells and purple dots are overburden wells. Based on this analysis, the majority of the wells south of Highway #89 are mapped as pumping from an aquifer that is hydraulically separated from the base of the pole foundation by more than 2.5 m. Wells that do not meet this condition and are within or near 150 m of a transmission line pole, include wells BH IDs 10061258, 10061103, 10062289 and Well ID 7185586. Pole locations identified for surface sealing are presented in **Table 1**.

Table 1: Pole Locations (New and Existing Installations) Requiring Surface Sealing

North of Highway #89	South of Highway #89	
all poles (1 to 216)	225, 226	235 to 243, 246
	249 to 254	258 to 262
	270 to 273	284 to 305
	309 to 318	325 to 330, 334
	351 to 355	357 to 366
	376 to 381	385 to 387

In total, 216 pole foundations north of Highway #89 and Highway #90 pole foundations south of Highway #89 are identified for surface sealing.

Respectively submitted,

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PRACTISING MEMBER
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07/21/14
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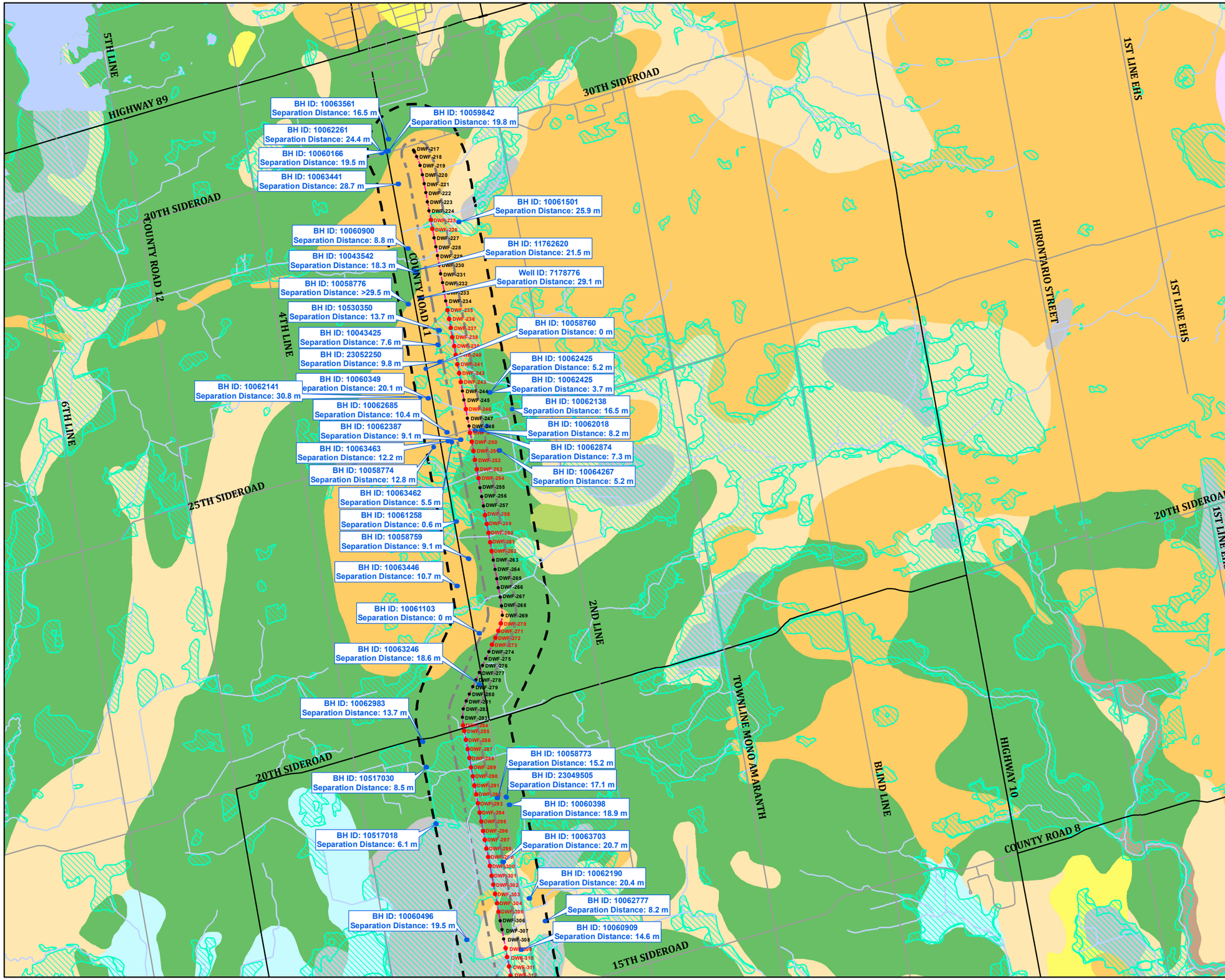
Dufferin Wind Power Project
Map 1
Inset A: Pole Foundations Incorporating Surface Sealing

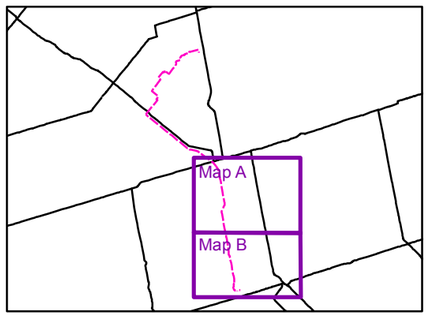


MOE Water Well Records - Bedrock Well
MOE Water Well Records - Overburden Well
Pole Locations
Pole Location Identified for Surface Sealing
230 kV Line
Major Roads
Local Roads
Watercourse
500 m Pole Location Setback
150 m Pole Location Setback
Waterbody
Wetland

Surficial Geology

Paleozoic bedrock
Stone-poor, carbonate-derived silty to sandy till
Glaciolacustrine-derived silty to clayey till
Ice-contact stratified deposits
Sandy deposits
Massive-well laminated
Foreshore-basinal deposits
Modern alluvial deposits
Organic deposits

Separation Distance (m) between base on Pole and top of Utilized Aquifer



Data Provided By:
Surficial Geology: Ontario Geological Survey
Water Well Records: MOE Water Well Records Database

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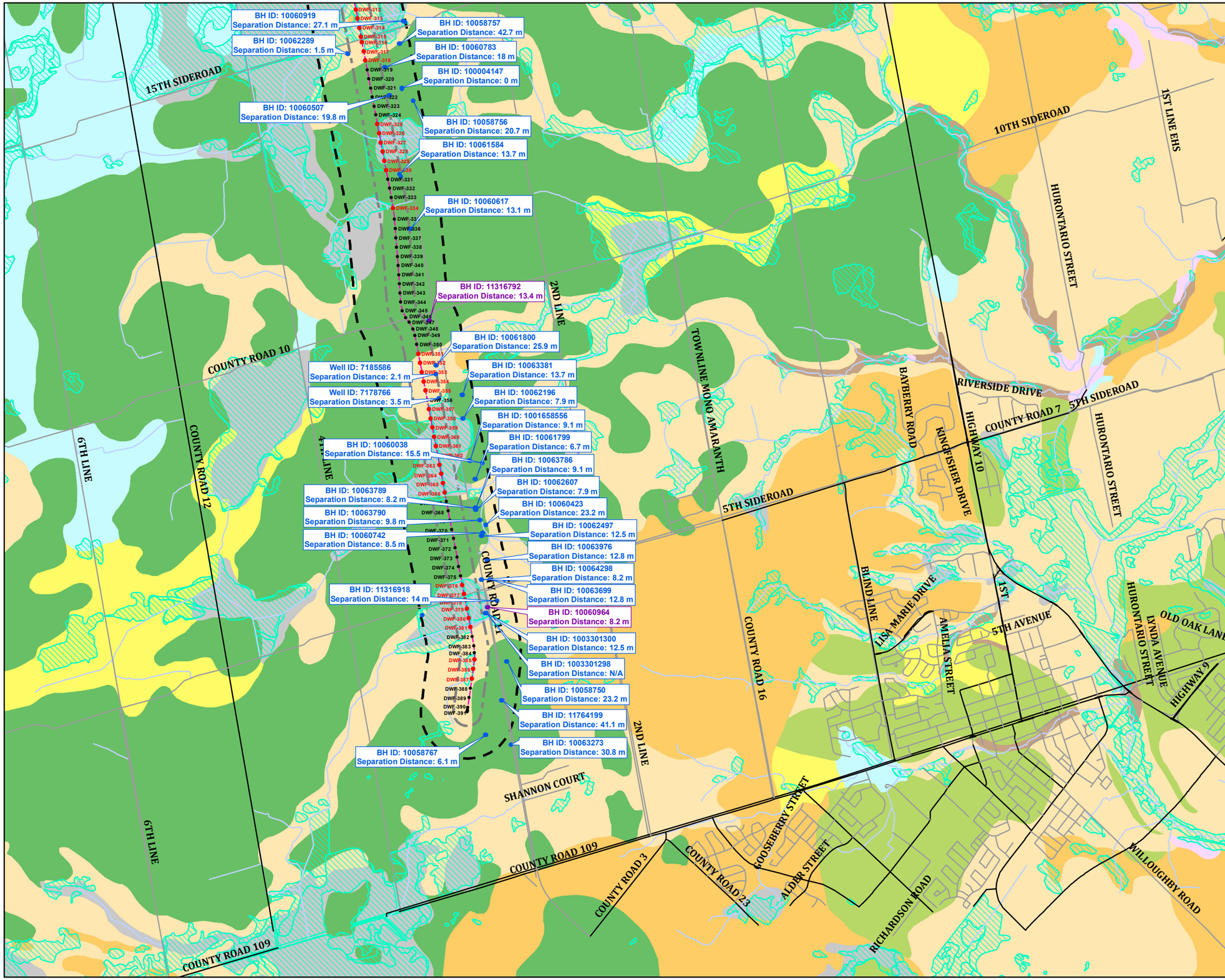
Dufferin Wind Power Project
Map 1
Inset B: Pole Foundations Incorporating Surface Sealing



MOE Water Well Records - Bedrock Well
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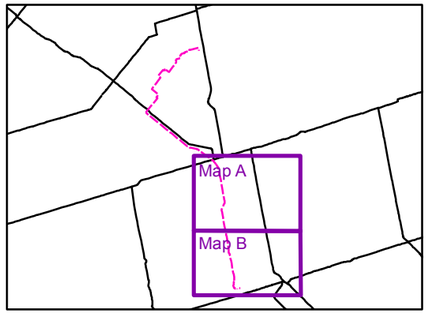
Separation Distance (m) between base on Pole and top of Utilized Aquifer



Data Provided By:
Surficial Geology: Ontario Geological Survey
Water Well Records: MOE Water Well Records Database

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ATTACHMENT 1: WATER WELL RECORD INFORMATION

Location	BH/Well ID	Latitude	Longitude	Depth of well (m)	pumped aquifer	depth to bedrock (m)	Depth to top of Overburden aquifer type material (m)	Overburden aquifer material thickness (m)	Static (ftbgs)	Distance between foundation base (9mbgs) and top of next utilized aquifer (m)	Reported Overburden Lithology (ft)/Comments
HIGHWAY #89											
Side Road 30											
	10063561	44.069741	-80.20085	46.3	bedrock	25.6	not present	0.0	25	16.5	clay(61'); clay/rock(23')
	10059842	44.0685980	-80.2008890	29.9	bedrock	29.0	not present	0.0	18	19.8	clay(30'); clay/sand(20'), gravel/clay(45')
	10060166	44.0685550	-80.2011400	33.5	bedrock	28.7	not present	0.0	15	19.5	sand/clay(30'); clay/stones(33'); clay(7'); limestone/clay(24')
	10063441	44.065375	-80.199585	39.3	bedrock	37.8	not present	0.0	37	28.7	clay (100'); clay/gravel(24')
	10062261	44.068424	-80.201791	43.6	bedrock	33.5	not present	0.0	43	24.4	gravelly clay(23'); clay(39'); hardpan(48')
	10061501	44.061653	-80.19153	37.8	bedrock	35.1	5.5	6.1	65	25.9	clay (18'); sand (20'); clay (77')
	10060900	44.059109	-80.198371	36.0	bedrock	18.0	not present	0.0	35	8.8	clay and boulders (59')
	11762620	44.056996	-80.197514	31.1	bedrock	30.5	0	7.0	34	21.5	sand/stones(23'); clay/silt(62'); clay/limestone(15')
	10043542	44.056805	-80.197317	29.3	bedrock	27.4	0	4.6	31	18.3	sand (15'); silt/clay/gravel(75')
	10058776	44.053752	-80.19838	38.7	bedrock?	>38.7	17.6	9.8	48	>29.5	clay(58')' sand(32'), clay/gravel(37')
	7178776	564337	4878220	48.8	bedrock	32.3	not present	0.0	58	32.3	clay/stones(15'); clay(20'); clay/silt (55'); clay(16')
	10530350	44.051202	-80.194258	28.7	bedrock	22.9	2.8	5.2	21	13.7	sand/silt (9'); sand(17'); clay (27'); gravel and clay (22')
	10043425	44.049808	-80.194453	17.4	bedrock	16.8	not present	0.0	22	7.6	clay (55')
	23052250	44.048149	-80.194238	19.8	bedrock	18.9	not present	0.0	23	9.8	clay (62')
	10058760	44.047496	-80.196042	30.5	bedrock	28.0	0	28.0	20	0.0	sand(92')
	10060349	44.044632	-80.195856	35.7	bedrock	29.3	not present	0.0	20	20.1	clay (96')
	10062141	44.044773	-80.196828	38.7	bedrock	30.8	not present	0.0	18	21.6	clay/sand(64'); clay/boulders(37')
	10062425	44.045149	-80.187598	38.1	bedrock	14.3	0	12.8	26	3.7	sand(42'), clay/stones(5')
	10062138	44.043507	-80.184526	24.4	bedrock	16.5	not present	0.0	29	15.2	sand/clay(54')
	10062685	44.041337	-80.193355	28.3	bedrock	19.5	not present	0.0	26	10.4	sand/clay(33'); clay/gravel/stones(31')
Side Road 25											
	10062425	44.045149	-80.187598	38.1	bedrock	14.3	0	12.8	26	5.2	sand(42'), clay/stones(5')
	10062018	44.041472	-80.189572	20.4	bedrock	17.4	not present	0.0	7	8.2	sand (18'); sand/clay (36'); clay/gravel (3')
	10062874	44.041493	-80.188721	26.8	bedrock	16.5	0	9.1	10	7.3	sand(30'); clay/gravel(24')
	10062387	44.040622	-80.191556	37.2	bedrock	18.3	not present	0.0	25	9.1	sand(7'), clay/stones(53')
	10063462	44.040405	-80.192793	78.6	bedrock	14.6	not present	0.0	18	5.5	clay/stones(9'); silt/gravel(38')
	10058774	44.039918	-80.195121	28.7	bedrock	21.9	0	10.4	20	12.8	sand(34'); clay/gravel/sand(38')
	10063463	44.040489	-80.19318	42.0	bedrock	21.3	2.1	11.9	17	12.2	silt(7'); sand(31'); clay/gravel(6'); gravel/sand(8'); clay(2'); gravel/silt/sand(16')
	10064267	44.039531	-80.18634	41.5	bedrock	14.3	6.4	0.6	9	5.2	silt(21'); gravel(2'); silt/gravel/rock(23'); clay(1')
	10061258	44.032704	-80.192261	15.8	bedrock	9.8	2.1	3.7	12	0.6	clay(7'); sand (12'); clay (13')
	10058759	44.029109	-80.19065	24.7	bedrock	18.3	not present	0.0	24	9.1	dug(20'); clay/sand (30'); clay/stones(10')
	10063446	44.026455	-80.192196	44.2	bedrock	19.8	not present	0.0	20	10.7	sand/clay(15'); clay/stones/sand(50')
	10061103	44.021878	-80.189288	47.2	bedrock	13.1	0	13.1	-1	0.0	sand(15'); gravel(28')
	10063246	44.016909	-80.189356	54.9	bedrock	27.7	not present	0.0	5	18.6	clay/sand(16'); clay/gravel/stones(47'); sandy clay/gravel (28')
Side Road 20											
	10062983	44.011471	-80.197053	29.0	bedrock	22.9	not present	0.0	4	13.7	clay(18'); clay/stones(57')
	10517030	44.008983	-80.196589	23.2	bedrock	17.7	not present	0.0	5	8.5	clay/stones(5'); clay(29'); clay/gravel(24')
	10058773	44.005936	-80.187111	29.9	bedrock	24.4	not present	0.0	18	15.2	dug(40'); clay/stones(40')
	23049505	44.00599	-80.185877	38.4	bedrock	26.2	not present	0.0	n/a	17.1	clay/stones/sand(37'); clay/stones(49')
	10060398	44.005258	-80.185473	43.3	bedrock	28.0	not present	0.0	20	18.9	clay(92')
	10517018	44.0035	-80.195341	29.6	bedrock	25.9	15.2	10.7	24	6.1	clay/stones(9'); clay(41'); gravel/stones(35')
	10063703	43.999763	-80.186397	51.5	bedrock	29.9	0	5.5	17	20.7	sand(18'); clay/stones/till (80')
	10062190	43.996191	-80.182952	29.6	bedrock	29.6	0	5.5	16	20.4	gravel/sand(11'); clay(56'); sand(5'); clay(7'); clay/gravel(15'); clay(3')
	10062777	43.993961	-80.180825	25.0	bedrock	17.4	10.7	1.8	1	8.2	clay/sand(15'); sand/clay/boulders(20'), sand(6'), sand/gravel/clay(46')
	10060496	43.992263	-80.191338	36.9	bedrock	33.5	n/a	n/a	8	19.5	dug(35'), clay/boulders(59'), stones(16')
	10060909	43.99123	-80.184092	50.3	bedrock	23.8	not present	0.0	2	14.6	clay/boulders/gravel/stones(78')
	10060919	43.987593	-80.179154	54.9	bedrock	36.3	not present	0.0	0	27.1	clay/boulders(57'); clay/gravel(34'); clay/boulders(28')
Side Road 15											
	10062289	43.984451	-80.186717	21.3	bedrock	10.7	0	3.7	n/a	1.5	sand(12'); clay(23')
	10058757	43.985355	-80.179733	55.8	bedrock	42.7	n/a	n/a	45	42.7	dug(46'); boulders/clay(94')
	10060783	43.983109	-80.18171	34.1	bedrock	27.1	15.2	5.5	15	18.0	clay/stones(50'); sand(18'), clay/boulders (21')
	1000041471	43.981094	-80.179422	55.5	bedrock	29.3	0.0	29.3	16.2	0.0	sand(96')
	10060507	43.980404	-80.181123	32.9	bedrock	29.0	7.9	7.3	15	19.8	clay(15'); hardpan(11'); sand(24'); hardpan/gravel(45')
	10058756	43.979841	-80.177914	56.3	bedrock	29.9	not present	0.0	14	19.8	clay/stones(30'); sand/clay(65'); clay(3')
	10061584	43.972743	-80.179982	50.3	bedrock	22.9	not present	0.0	9	13.7	clay/sand (67'); clay/boulders(8')
	10060617	43.967456	-80.178521	65.5	bedrock	28.0	22.3	5.8	40	13.1	clay/gravel (73'), sand (19')

ATTACHMENT 1: WATER WELL RECORD INFORMATION

Location	BH/Well ID	Latitude	Longitude	Depth of well (m)	pumped aquifer	depth to bedrock (m)	Depth to top of Overburden aquifer type material (m)	Overburden aquifer material thickness (m)	Static (ftbgs)	Distance between foundation base (9mbgs) and top of next utilized aquifer (m)	Reported Overburden Lithology (ft)/Comments
Side Road 10											
	11316792	43.958607	-80.176129	24.7	overburden	>24.7	4.6	6.7	n/a	13.4	gravel(15'); gravel/clay (59'); gravel(7')
	10061800	43.954252	-80.17525	61.0	bedrock	35.1	11.6	23.5	4	25.9	sandy clay(12'); clay/stones(26'); stones(77'); shale/stones(33') - layer described as stones has been conservatively interpretted as an aquifer
	7185586	566166	4867025	49.4	bedrock	11.3	not present	0.0	3	2.1	clay/stones(39')
	7178766	566197	4866767	30.5	bedrock	17.1	12.5	4.6	8.3	3.5	clay(12'); clay/stones(29')
	10063381	43.951355	-80.171813	50.6	bedrock	22.9	not present	0.0	32	13.7	silty clay(14'); clay till (44'); clay(17')
	10062196	43.949076	-80.171721	34.1	bedrock	17.1	not present	0.0	12	7.9	clay/sand(13'), clay(8'), clay/gravel(35')
	1001658556	43.944974	-80.170921	22.3	bedrock	18.3	not present	0.0	6	9.1	gravel/clay(60')
	10060038	43.944754	-80.169151	51.8	bedrock	24.7	not present	0.0	15	15.5	clay(19'); gravel/clay(63')
	10061799	43.943213	-80.170194	50.3	bedrock	15.8	not present	0.0	4	6.7	sandy clay(12'); clay/stones(7'); clay/rock(33')
	10063789	43.940385	-80.170147	21.3	bedrock	17.4	not present	0.0	n/a	8.2	clay(20'); clay/sand(28'); clay/stones(9')
	10063786	43.940412	-80.170172	68.6	bedrock	18.3	not present	0.0	n/a	9.1	clay(21'); clay/stones(39')
	10062607	43.940232	-80.170148	21?	bedrock?	??	17.1	3.7	n/a	7.9	clay/stones(56'); gravel/sand(12')
	10063790	43.939229	-80.169578	30.5	bedrock	18.9	not present	0.0	1	9.8	clay/stones(20'); gravel/clay(3'); clay/stones(39')
	10060423	43.938737	-80.168774	42.0	bedrock	32.3	not present	0.0	30	23.2	clay/stones(80'); sand/clay(26')
	10060742	43.938002	-80.169245	18.3	bedrock	19.2	17.7	0.6	2	8.5	clay(58'); gravel(2')
	10062497	43.937697	-80.169411	25.0	bedrock	21.6	not present	0.0	6	12.5	clay/boulders(71')
	10063976	43.935369	-80.168685	24.4	bedrock	21.9	not present	0.0	6	12.8	clay(53'); sand/clay/stones(19')
	10064298	43.933492	-80.169446	21.3	bedrock	18.3	15.2	3.0	7	8.2	clay(14'), clay/gravel(20'), clay/silt(16'), sand/silt(7'), gravel/sand(3')
	10063699	43.933484	-80.168275	31.4	bedrock	21.9	not present	0.0	13	12.8	clay/silt(37'); silt/gravel(35')
Side Road 5											
	11316918	43.931379	-80.167335	35.9	bedrock	23.2	not present	0.0	22	14.0	silty/clay(59'); gravel/silt/stones(17')
	10060964	43.930795	-80.168722	18.3	overburden	>18.2	17.4	1.0	6	8.2	clay(57'); gravel(3')
	1003301300	43.930248	-80.168983	67.1	bedrock	21.6	not present	0.0	5	12.5	clay/stones(32'); clay/gravel(39')
	1003301298	43.930238	-80.168921	n/a	n/a	n/a	n/a	n/a	5	n/a	n/a
	10058750	43.925564	-80.166216	32.3	bedrock	32.3	not present	0.0	40	23.2	dug(50'); sand/clay(20'): clay/silt (36')
	11764199	43.921779	-80.166933	67.1	bedrock	50.3	not present	0.0	91	41.1	sandy clay(60'); clay(21'), clay/stones(84')
	10058767	43.918436	-80.169143	43.0	bedrock	36.9	15.2	21.6	60	6.1	clay/gravel(50'); sand/boulders(60'), gravel(11')
	10063273	43.917494	-80.165818	42.7	bedrock	39.9	not present	0.0	69	30.8	clay(50'); sand/clay(65'), clay/rock(16')