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Wind Turbines and Groundwater Contamination: An Analysis

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Summary

Allegations of water well interference, sediment infiltration and aquifer contamination due to ground borne vibrations from wind turbine construction and operation have been levied against a wind farm in Chatham-Kent, Ontario, Canada. Ground vibration measurements revealed nothing extraordinary. Baseline water analyses before construction revealed poor water quality overall. There were few complainants after construction began. Retesting of water post construction from the complainants revealed a smaller proportion of wells with turbidity than in the baseline samples. The data submitted to the Ministry of the Environment are summarized and analysed. These data do not support the notion that seismic vibrations from wind turbines are damaging wells nor causing contamination of the aquifer.

Introduction

In Chatham-Kent, Ontario, Canada, the North Kent 1 wind farm received Ontario *Ministry of Environment* approval (REA) on 29 June 2016 as a Class 4 wind facility up to 100 megawatts.[1] The project consists of 45 Siemens SWT series utility scale wind turbines rated as 104-106 dBA sound power. As objections to the project had been expressed based on the theoretical possibility of ground borne vibrations affecting the aquifer, the Ministry ordered extensive pre- and post-construction vibration monitoring and water testing as a condition of approval. On July 13, 2016, Kevin Jakubec appealed the REA to the Environmental Review Tribunal under s. 142.1(2) of the Environmental Protection Act on the grounds that the Project will cause serious harm to human health and serious and irreversible harm to the natural environment via groundwater interference from vibrations of operating wind turbines, but the appeal was withdrawn prior to the hearing[2]. Despite that, members of an activist group have complained about sediments in well water since the construction began and have alleged that the entire aquifer has been contaminated due to pile fracturing of the shale bedrock and mobilization of shale sediments. Shale is known to contain trace amounts of heavy metals. Ongoing concerns are expressed to Provincial and Municipal agencies and the media about heavy metal poisoning from drinking and even bathing in water from wells in the area and a health hazard investigation has been demanded. This paper summarizes the data submitted to the Ministry of Environment by the wind farm operator and discusses the implications to groundwater and health.

Results

1. Preconstruction Water Survey

An extensive background water survey was done by AECOM Canada.[3] 959 properties were identified within the project boundary, of which 827 were privately owned by 581 property owners (143 owned more than one property). Survey packages were mailed to the 581 property owners and 393 responses were received. Of the 393 respondents, 210 were identified by survey responses as having active water wells, 167 had no active wells and six respondents were unclear about whether they had active wells.

201 respondents agreed to a *Detailed Well Assessment* (DWA), but further analysis revealed that 10 of these did not actually have active wells and one respondent did not provide well information nor contact information for clarification. A total of 189 DWAs were completed and analysed for multiple chemicals and parameters based on the criteria of the *Ontario Drinking Water Standards, Objectives and Guidelines* (ODWSOG).

36 (20%) of wells failed on baseline bacteriology, 53 (29%) failed on turbidity and 155 (85%) failed on colour.

2. Postconstruction Complaints of Well Water Turbidity Alleged from Pile Driving[4]

There was a total of 17 complaints of well water turbidity during the study period, and 15 of these had been in the group of 189 with completed baseline DWAs. One of the complaints without a DWA was questioned as invalid since the turbidity allegedly began 35 days after pile driving was completed and the well was 9 Km from the turbine construction. Post construction water sampling was completed on 13 of the 15 complainants with DWAs which permitted comparison with baseline results.

11 wells passed turbidity testing postconstruction, two wells had measurable turbidity arising postconstruction and two were not resampled. Of 189 wells with DWAs completed, 185 (98%) either did not report turbidity problems postconstruction or were free of water turbidity upon retesting.

3. Vibration Monitoring

Phase 1, Test Pile Program[5] The pile driving hammer energy was selected to be as large as possible for the equipment. Accelerometer data from the monitoring of three wells indicated that the peak particle velocity was less than 0.035 mm/s during pile driving. At times when pile driving was not occurring, the maximum particle velocity was nearly double this value as related to other activities on and near the monitored wells. The character of the vibrations at the three wells as measured by the sensitive instrumentation was similar to or less than those induced by common day-to-day activities (e.g., traffic, walking nearby, farming equipment and light vehicles) and by walking or jumping near the well casing.

Phase 2[6]**:** Measured pile-driving vibration magnitudes at the well casings were significantly smaller than those identified at the turbine site where measurements in the bedrock were made, consistent with known vibration distance attenuation. The measured turbine site vibrations were less than those anticipated, based on the test pile program (Phase 1) and use of the CALTRANS (2004) model for predictive vibration

magnitude estimation. Peak vibration velocities at the turbine sites were less than 14 mm/s. Well pumps were the largest sources of well casing vibrations measured during the monitoring program. The peak vibration velocities at domestic water well casings that were directly attributable to pile driving were less than 0.04 mm/s at the closest well to pile distances. These measured velocities are one or more orders of magnitude less than vibrations induced by typical pump operations where the pumps are connected in relatively close proximity to the wells and less than vibrations induced by local road traffic.

Discussion

Complaints about wind turbine sounds and sometimes shadow flicker are often expressed as the basis for objecting to wind farm projects but allegations of aquifer contamination and water well interference from ground vibrations arising from construction (specifically pile driving) or operation of wind turbines had not been encountered in Ontario.

Ground vibrations can be measured by peak particle velocity (PPV) in mm/s, root mean square velocity (RMS) or particle displacement. There is an abundance of published literature and standardized methods for estimating ground vibrations from pile driving and other sources at various distances; for example, the California State Department of Transportation formula (CALTRANS 2004). In soft ground Deckner[7] found PPV of magnitude 2-30 mm/s, 1-3 m from the pile hammer. In loose soils there is rapid attenuation of ground vibration waves; typically, 85-95% at 10 m from the pile and 99% attenuation by 30-50 M. No changes to well performance were noted at PPV 21-220 mm/s.[8-10] At normal wind turbine setback distances to homes (usually 550 M in Ontario) it is not plausible for structural damage to occur to wells from pile driving. The notion that extensive fracturing of bedrock could result from piles is ludicrous.

Ground borne vibrations from the operation of wind turbines are exceedingly small, requiring extremely sensitive measuring equipment to even detect. Even at the turbine base, Styles[11] found RMS velocities of approximately 0.07 mm/s, well below the threshold of human perception. Snow[12] found RMS velocities not exceeding 0.015 mm/s at 100 m distance, about 10 times less than the threshold of perception. Styles[11] and Schofield[13] looked at particle displacement 100 m from a wind farm (>6 turbines) and found that the maximum motion induced to be 120 nanometres, or 1.2×10^{7} m, about 10 times the diameter of a human hair. The measurements obtained at the North Kent 1 wind farm were consistent with these published data. This range of seismic motion could not result in structural damage to well casings etc. particularly when the vibrations from passing traffic and especially well pumps are much greater. The notion that particular kinds of sediment particles (black shale) could be translocated over long distances by ground borne vibration waves is scientifically implausible and is probably based on a fundamental misunderstanding of wave physics.

It was evident from the baseline assessment that well water quality in the study area of Chatham-Kent was poor from the outset. Of 571 private property owners, 17 (3%) registered complaints about deterioration of well water during the study. Only 15% (two wells) of the 13 complainants which could be resampled had significant postconstruction turbidity and 85% (11 wells) had no significant turbidity. These numbers are small, but the proportion of complainants with documented postconstruction well water turbidity was less than the proportion with turbidity in the pre-construction baseline study. This does not support the hypothesis that well water is being adversely impacted. Overall, 98% of wells studied had no documented deterioration in water turbidity postconstruction. These findings are inconsistent with widespread contamination of the aquifer. There is no evidence that water wells are being systematically affected by construction or operation of wind turbines. This evidence was examined by officials from Ministry of the Environment who agreed that there is no evidence implicating wind turbines

to well problems. Furthermore, this has been recently tested at the Ontario Environmental Tribunal. In the case of Concerned Citizens of North Stormont v. Ontario (Environment, Conservation and Parks, 2019 Can LII 287[14], approval of a wind farm was appealed partially on allegations that turbine construction in Chatham-Kent caused turbidity in drinking water wells. This was refuted by experts retained by the Approval Holder and by the Director, Ministry of the Environment. The Tribunal accepted the evidence that there was no causal relationship between pile driving, wind turbines and well water issues and that sediment in wells is usually due to construction and maintenance of those wells. The appeal was dismissed.

Sediment in well water is due to structural issues with the well casing, screen or seals or sometimes because the well is being overpumped. These causes need to be investigated before implicating unproven theories of causation such as external ground vibrations. Bacteria and dissolved heavy metals etc. in water are health hazards at sufficient concentrations, but turbidity in the absence of other problems is considered an esthetic issue. Most people do not drink noticeably turbid water and filter or settle sediments out before consumption. Ingested inorganic particulates in suspension pass through the body unabsorbed.

Conclusion

There is no evidence that wind turbine construction or operation results in the contamination of groundwater and no scientifically plausible mechanism has been offered by which groundwater contamination with translocated sediments or associated health hazards could theoretically occur.

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