The Industrial Wind Turbine Seismic Source: Appendix A
Details and Displays of Tests 2 to 5

Test 2 – Walk-away test from the outer edge of Large Cluster of IWTs

Test 2 was conducted on August 24, 2018, and the reported wind was 20 kph from the south. The IWT blade-pass interval was measured to be 1.3 seconds.

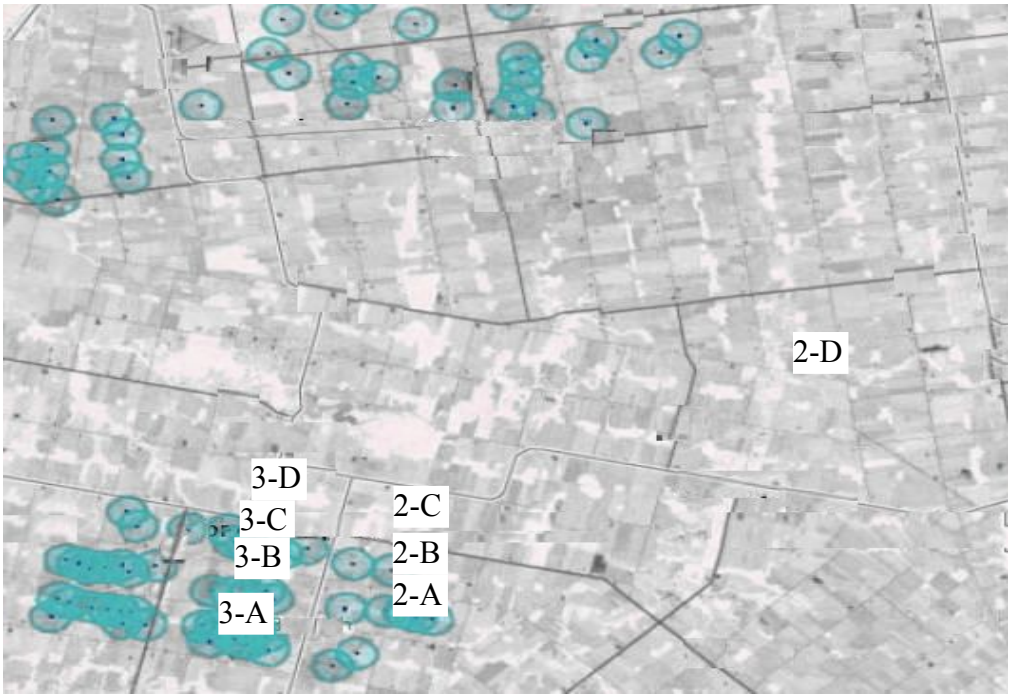
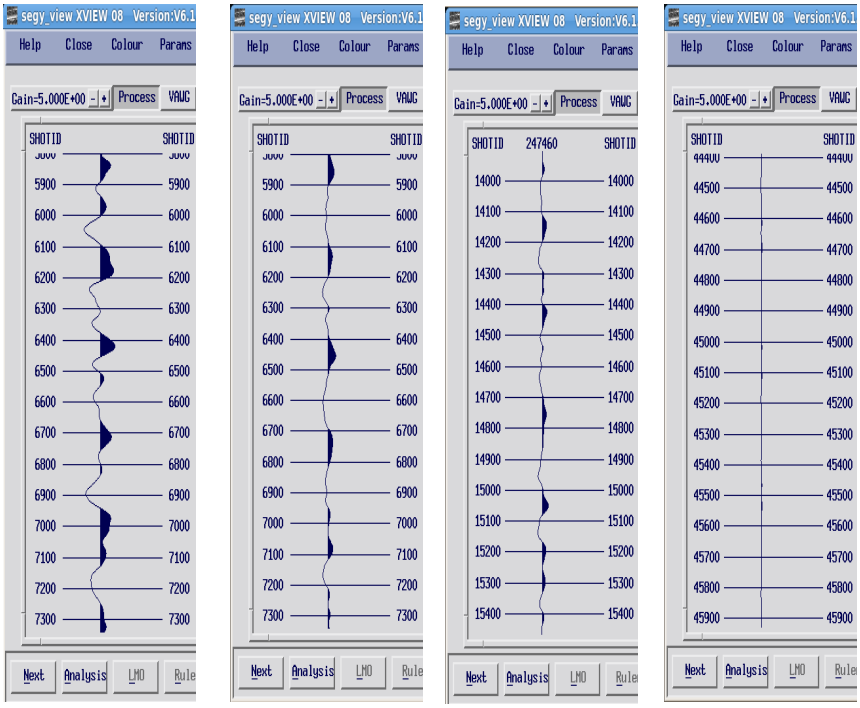


Figure 12: Relative locations of recording stations for Test 2 and Test 3.

Station:	2-A	2-B	2-C	2-D
Offset:	400 m	1500 m	2500 m	9000 m



Timing-lines
100 milliseconds

Figure 13: Time series from stations A-D with fixed gain, bandpass filter 0.1, 0.4, 15, 25 Hz.

The pulses recorded in this test series appear lower frequency due to interference from the other turbines in the cluster at distances over 400 m farther away from the geophone. At 2500 m offset, there is about 1/3 the amplitude of seismic waves compared to those recorded at 400 m offset. The recording at 9000 m offset shows no seismic energy in the range of this fixed gain display resolution.

Figures 14 and 15 show examples of frequency spectra from Test 2, calculated from the 1.6 seconds of data shown, with fixed gain and no filter.

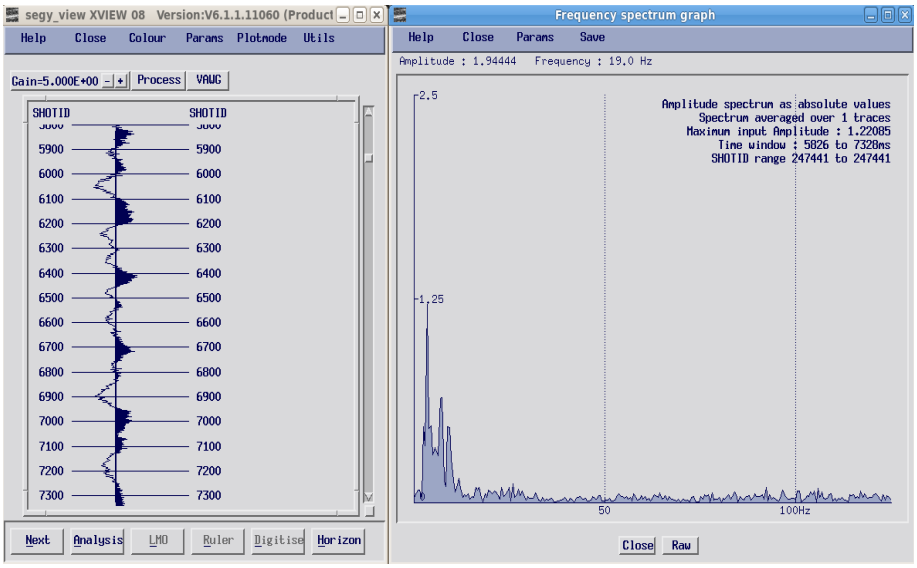


Figure 14: Test 2-A, offset of 400 m, time series and corresponding amplitude spectrum.

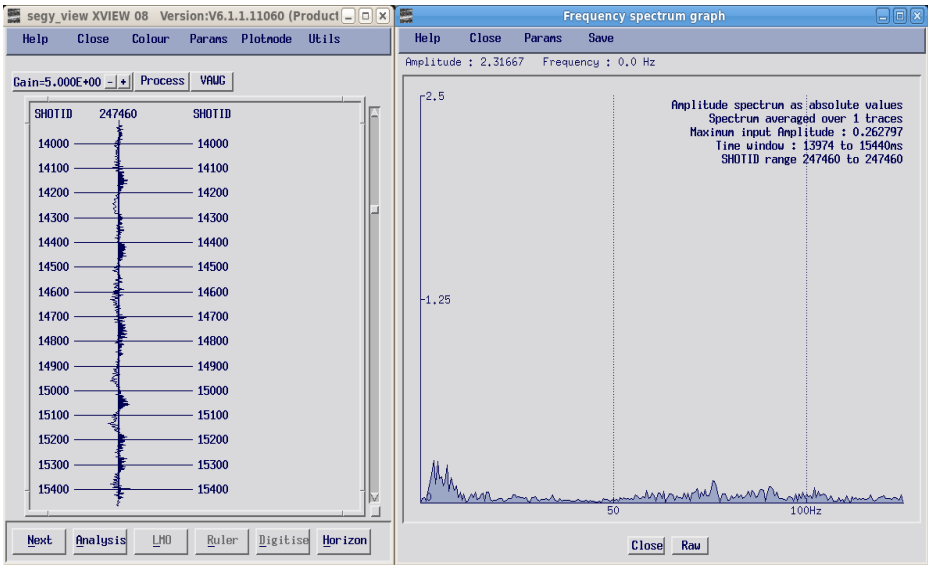


Figure 15: Test 2-C, offset of 2500 m, time series and corresponding amplitude spectrum.

Test 3 – Walk-away test starting inside of Large Cluster of IWTs

Test 3 was conducted on August 25, 2018, and the reported wind was 20 kph from the south. The IWT blade-pass interval was measured to be 1.3 seconds.

Station:	3-A	3-B	3-C	3-D
Offset:	350 m (in middle)	700 m (near north end)	700 m (north of cluster)	2500 (north of cluster)

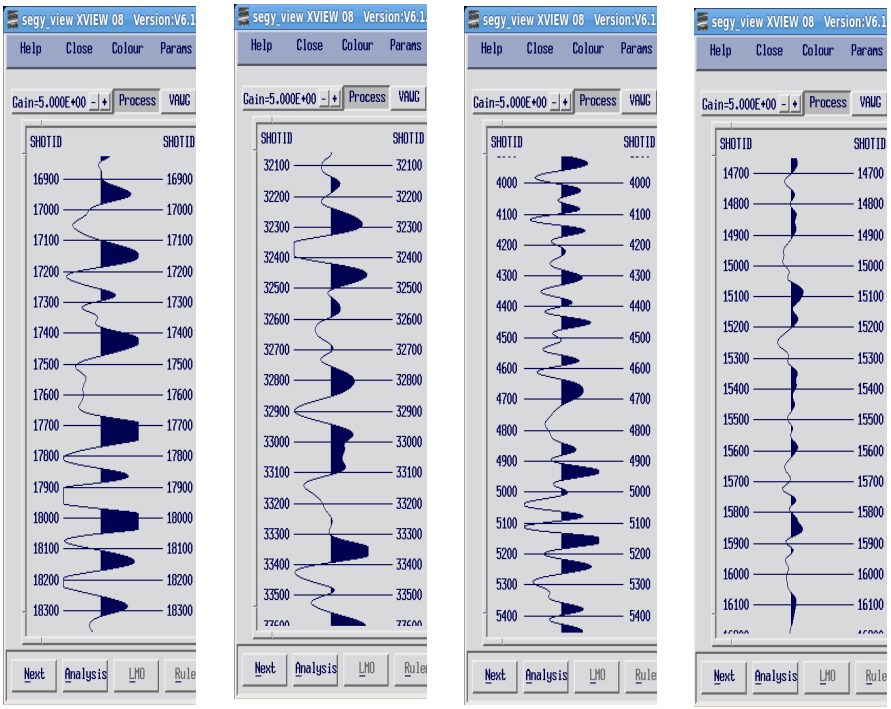


Figure 16: Time series from stations A-D with fixed gain, bandpass filter 0.1, 0.4, 15, 25 Hz.

This test shows that the amplitude of seismic waves in the middle of the cluster is much higher than at the edge (compare to Test 2) despite the concept of horizontal wave cancellation from the use of multiple turbines. This could be due to the high density of turbines in this particular cluster where land is leased from private land owners and some of the turbines seem to be closer together than the nominal 400 meter separation used in planning.

Figures 17 and 18 show examples of frequency spectra from Test 3, calculated from the 1.6 seconds of data shown, with fixed gain and no filter.

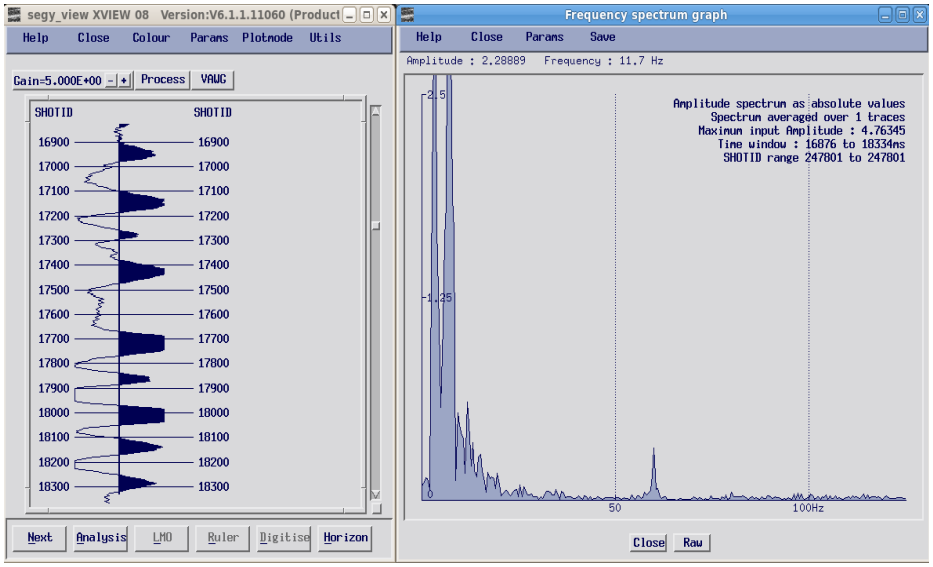


Figure 17: Test 3-A, offset of 350 m, time series and corresponding amplitude spectrum.

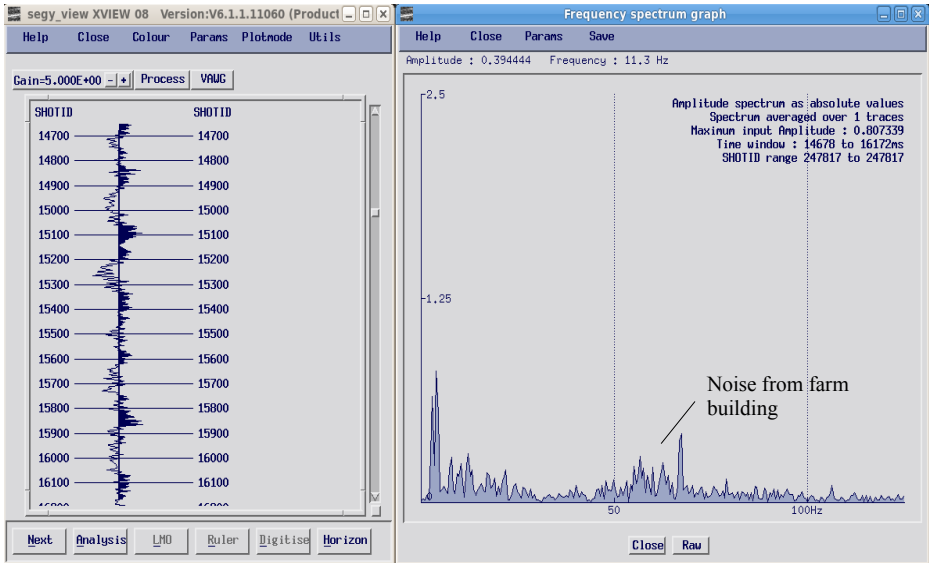


Figure 18: Test 3-D, offset of 2500 m, time series and corresponding amplitude spectrum.

Test 4 – Calibration Tests with 5 kg (12 lb) sledge hammer.

Test 4 was conducted on September 4, 2018.

Method: At a distance of 15 m (50 ft.) from the receiver, drop the 5 kg. sledge-hammer twice within 1.5 second from a height of 1 meter. Compare the seismic data recorded from the hammer-drops with 0.25 to 20 Hz bandwidth to one of the other Test recordings with approximately similar amplitude and note the offset distance of that recording.

2 drops
15 m offset
(filter out)

2 drops
15 m offset
(filter in)

Test 1-C
1100 m offset

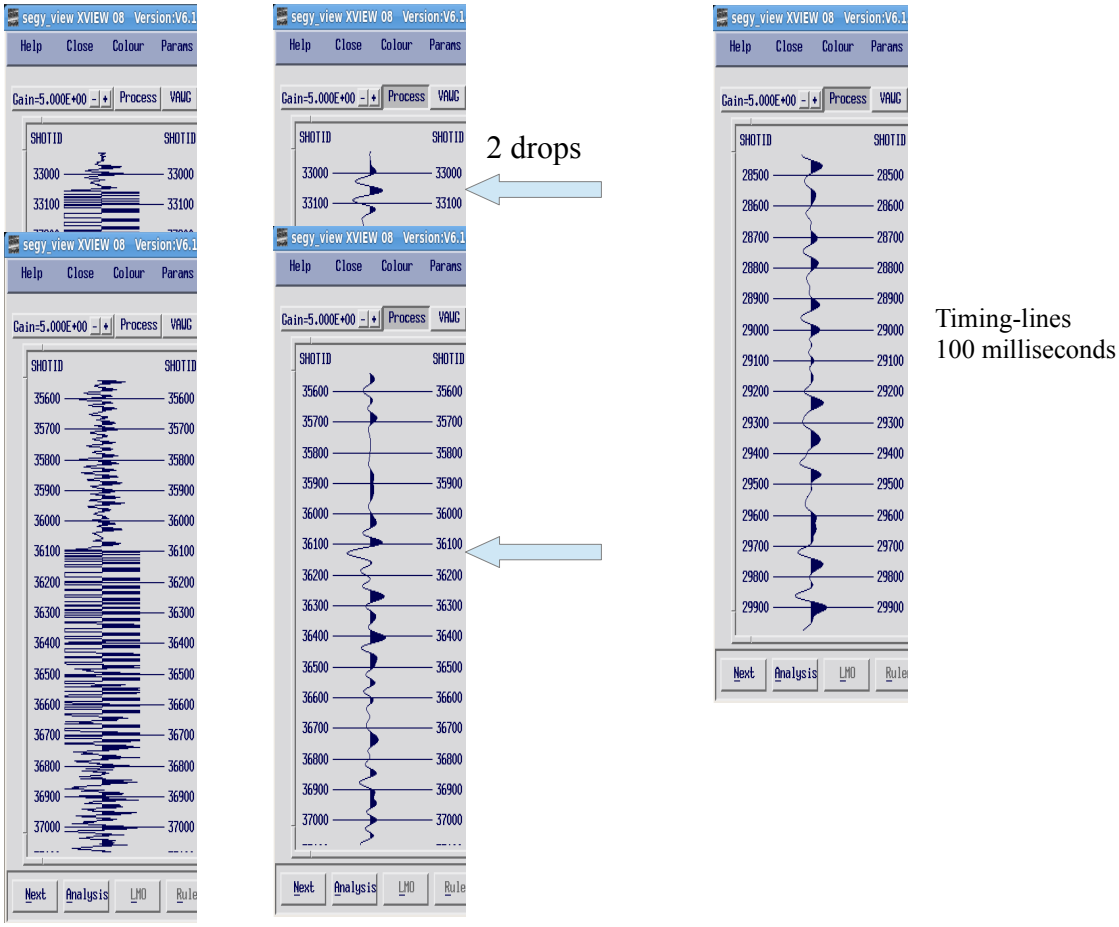


Figure 19: Time series from hammer-drops compare to time series from Test 1-C.

The recording of Test 1-C at a distance of 1100 m from the IWT source was chosen to compare to the recordings of the hammer drops. The seismic pulses recorded at 1100 meters offset from the IWT source are about the same amplitude as the low-frequency part of the pulses generated by dropping a 5 kg hammer onto the ground, at a distance of 15 m (50 ft.) from the receiver.

Figure 20: 5 kg sledge hammer drops from 1 meter height.

Test 5 - Record the near-surface seismic waves and pulses in the City of Toronto (no wind turbines within 20 km) and compare to the amplitude of the seismic pulses from an IWT source located in a, rural-residential area of SW Ontario.

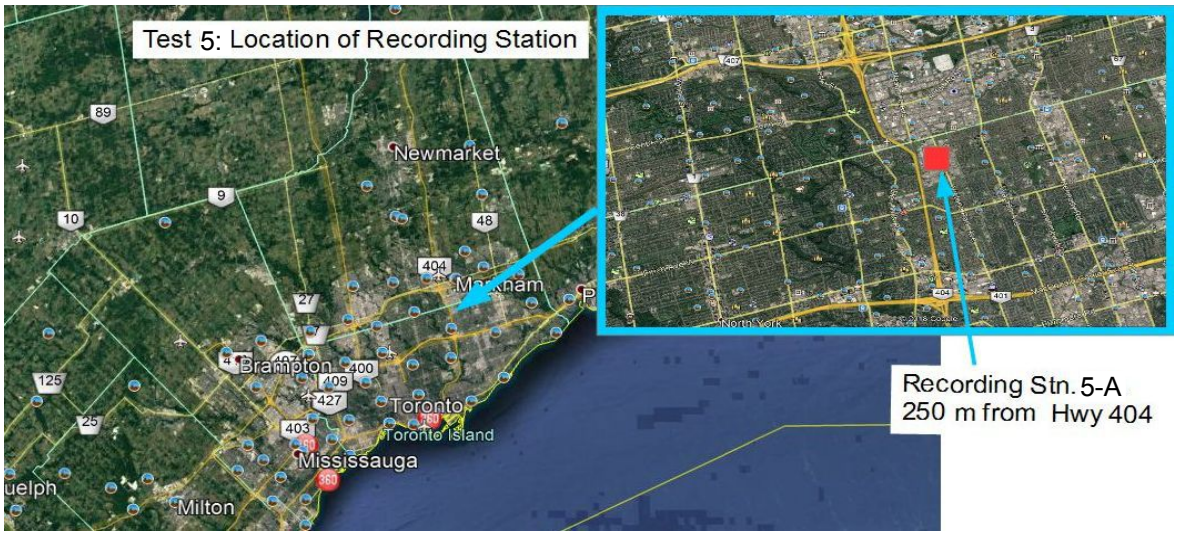
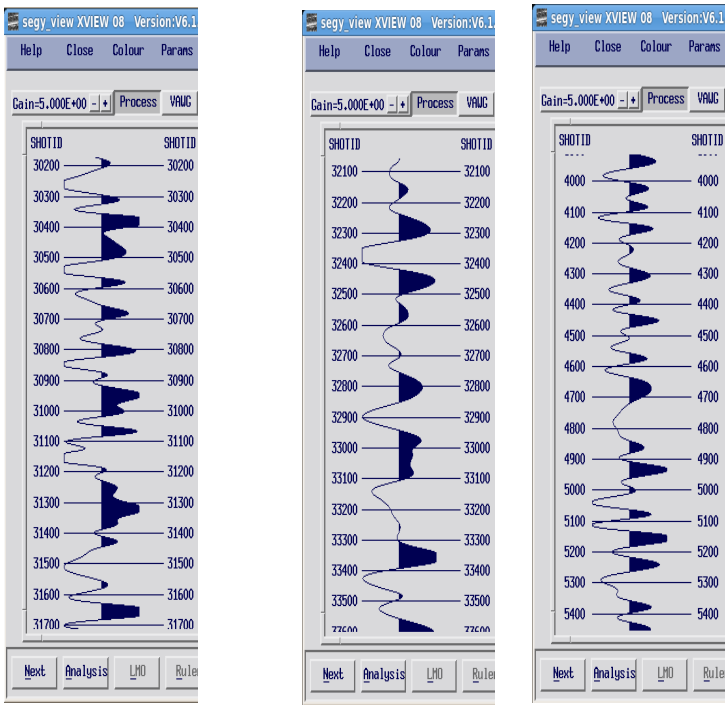


Figure 21: Location of Toronto recording station for Test 5-A.

Station:	Toronto 5-A (hwy404/401/407)	3-B (near north end)	3-C (north of cluster)
Offset:	250 m, 1 km, 1km	700 m	700 m



Timing-lines
100 milliseconds

Figure 22: Time series from station 5-A in Toronto and 3-B and 3-C

The amplitude of seismic data at locations 3B and/or 3C which are both 700 m downwind of a large cluster of wind turbines is about the same as seismic noise in the near-surface in this area of Toronto near 3, 12-lane highways. This type of repetitive low-frequency noise does not occur in nature. An occasional earthquake generates waves in the very low range below 1 Hz. The Toronto noise is from trucks hitting holes and curbs on the roads and construction. Note that the IWT noise, carries on 24 hours a day when the wind is blowing over 15 kph.