



# Preliminary Field Report

Project: Independent Infrasonic Investigations  
Location: Vicinity of Golden West Wind Facility, El Paso County, CO

Report Date: 29 January 2016

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## 1.0 Summary

Differential acoustic pressure measurements were acquired and logged at three homes in the vicinity of the Golden West Wind Facility in El Paso County, Colorado during December 2015 and January 2016. A week of data was analyzed for each of the three homes and daily spectrograms produced which are attached. Each day's data consisted of approximately 4.3 million differential pressure samples with a week comprised of some 30.5 million samples.

Preliminary investigation confirmed the presence of recurring acoustic pressure oscillations at 0.2 to 0.85 Hz (the "blade pass frequency" or BPF) which are associated to the Golden West wind turbine rotations. At times multiple oscillation frequencies were observed, consistent with multiple turbines operating at different rotation rates. Oscillations appeared to be more pronounced when the turbines are more upwind rather than downwind. Neighbors reported they are mostly downwind due to turbine location relative to home location and for the prevailing winds in the region.

Typical BPF total acoustic power were computed for example portions of the differential pressure data sets. Crest factors (the ratio of RMS to peak levels) were also computed for segments dominated by wind turbine rotation and uncontaminated by other noise, with typical crest factors of 13-19 dB. Totalized BPF RMS levels ranged from 56 to 70 dB re 20uPA, with peak levels from 71 to 89 dB. The RMS and peak levels are similar to those found at other sites with appeals to stop the noise, legal action, and homes abandoned.

It is understood from neighbors that they have experienced disturbance since the turbines started operating whereas prior to turbine operation there was no similar disturbance. It is understood that neighbors report improvement when turbines are shut down (not rotating) or when they remove themselves physically away from the Facility a distance of several miles.

El Paso County noise regulations define "Sound" as oscillations in pressure (or other physical parameter) at any frequency, and, prohibits noise disturbance due to acoustic oscillations.

The analysis is far from complete in that numerous segments of each day at each monitoring location could be analyzed and associated to journal entries and/or medical data. The reported association of proximity to the operating facility to disturbance in health and quality of life appears supported by the acoustic data acquired for this preliminary investigation. These preliminary investigations suggest that there is a condition of noise disturbance due to very low frequency acoustic pressure oscillations in the vicinity of the Golden West Wind Facility when it is operating, with more severe impacts downwind.

## **2.0 Project Description**

Investigations of possible infrasonic acoustic oscillations on properties were requested in 2015 by neighbors living in El Paso County in the vicinity of the newly constructed Golden West Wind Facility.

### **2.1 Methodology**

Independent data acquisition for acoustic, sensation, and medical data. This report presents acoustical data primarily, with reference to neighbor journal reports. Medical data are not discussed in this report.

### **2.2 Acoustic data acquisition**

- Sensors:** Infiltec INFRA-20 solid-state differential pressure sensor as micro barometer, +/-25Pa, 16-bit, serial data output at 9600 baud, 0.000945 Pascals per count, 50 Hz sample rate. High-pass pneumatic filter at 0.05 Hz and high pass digital filter at 0.125 Hz. Analog 8 Pole elliptic filter with 20 Hz corner frequency for anti-aliasing.
- Loggers:** Rand Acoustics SDL2 Serial Data Logger. Serial data stored hourly to SD card files with time synchronized to GPS.
- Calibration:** INFRA-20 micro barometers operate as differential (not absolute) pressure sensors with differential sensitivity calibrated at factory. Digital gain in INFRA-20 serial data output fixed at 0.000945 Pascals per count. Total pressure range, +/-25 Pascal.
- Setup:** Installation by INCE member or through trained instruction by INCE member on installation and operation of infrasonic sensor and data logger system in home. Sensor and logger set up in quiet location in home and run unattended. SD storage card changed at intervals as required.
- Analysis:** SpectraPlus SE time series, spectrogram and spectrum analysis. Imported INFRA-20 data Digitally resampled to 50 Hz using linear phase bandlimited interpolation algorithm combined with large oversampling, passband 0 to 22 Hz. Typical FFT frame used 8192 samples, Hanning weighting, 81.92 second FFT frame, no averaging, 50 percent overlap.

### **2.3 Sensation data acquisition**

- Journals:** Journals kept by neighbors to document sensation and conditions.

### **2.4 Medical data acquisition**

- Data:** Acquired by neighbors with medical supervision independent of acoustic data acquisition.

### **2.5 Survey bias description**

None. Acoustic data collected blind from journal and medical data sets.

Figure 1. Monitoring locations and Golden West Facility scaled in Google Earth.

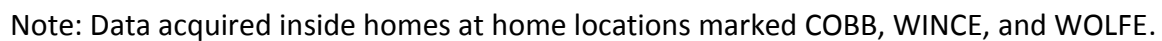




Figure 2. Detail map showing proximity of turbines to WOLFE and WINCE homes.

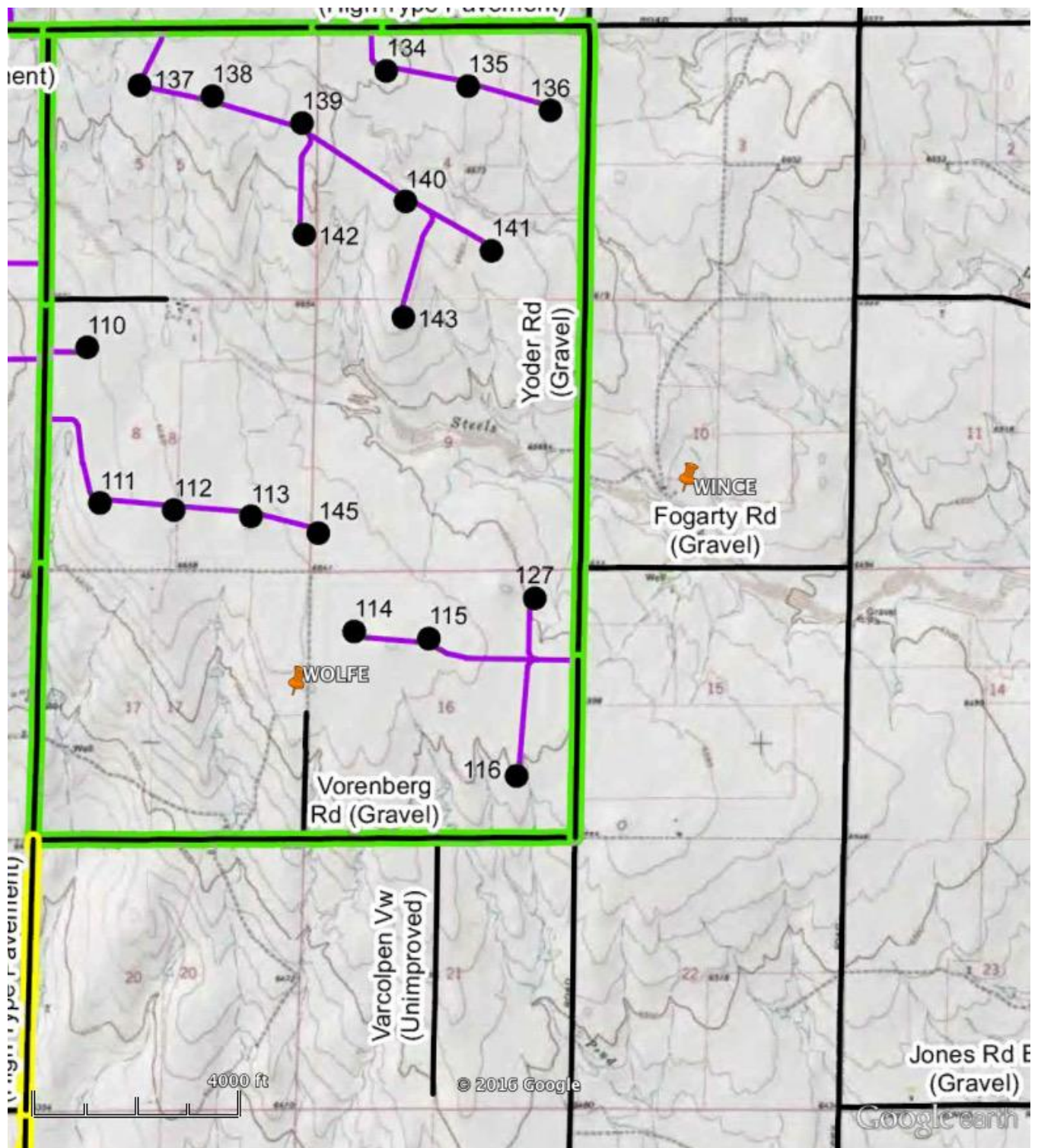


Figure 3. Weather December 11-17, 2015 (nearest airport, KFLY, Peyton, CO).

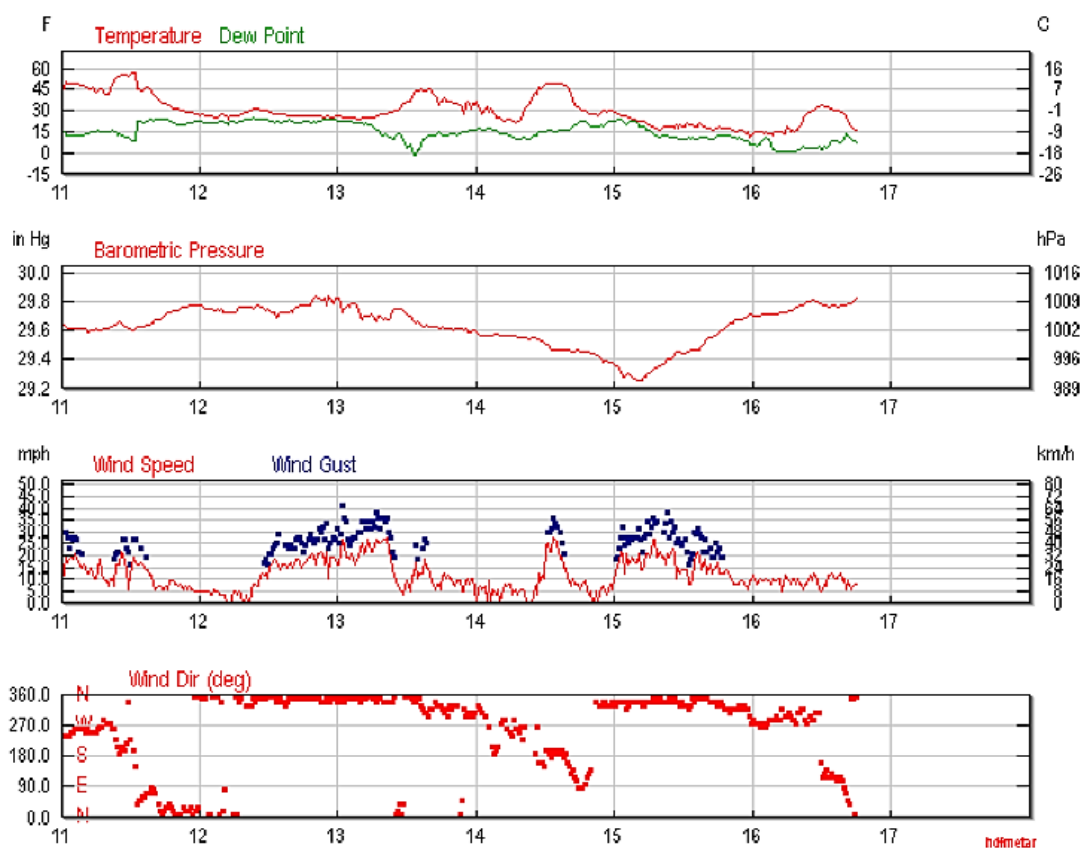
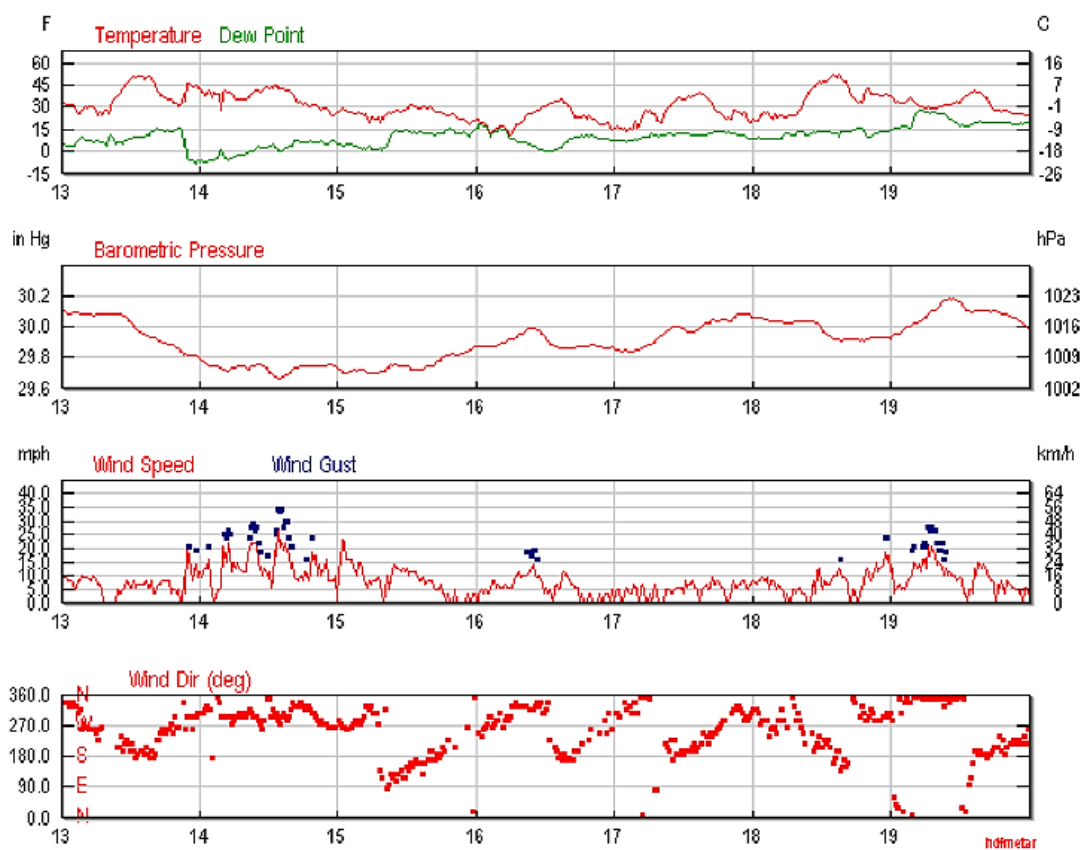


Figure 4. Weather, January 13-19, 2016 (nearest airport, KFLY, Peyton, CO).





### 3.0 Background Information

#### 3.1 Applicable regulations

El Paso County has a noise regulation, Ordinance Number 02-1, adopted by the Board of County Commissioners on August 1, 2002, which prohibits noise disturbance. The law regulates acoustic pressure oscillations at any frequency including infrasonic (below 20 Hz). From Section 3:

(e) "Noise Disturbance" means any sound which is:

- (1) Harmful or injurious to the health, safety or welfare of any individual; or
- (2) Of such a volume, frequency and/or intensity that it unreasonably interferes with the quiet enjoyment of life of an individual of ordinary sensitivity and habits; or
- (3) Unreasonably interferes with the value of real property or any business conducted thereon.

and

(k) "Sound" means an oscillation in pressure, stress, particle displacement, particle velocity or other physical parameter, in a medium with internal forces. The description of sound may include any characteristic of such sound, including duration, intensity and frequency.

and

(m) "Sound Pressure" means the instantaneous difference between the actual pressure and the average or barometric pressure at a given point in space as produced by sound energy

and from Section 4:

#### SECTION 4. Prohibited Activities:

- (a.) It shall be unlawful to engage in any of the following activities, whether by use of a sound producing device, other device, or other means (either natural or artificial):
  1. To knowingly permit, make, cause to be made or continue any noise disturbance, as defined in Section 3(e) of this Ordinance.

The El Paso County law defines "Sound" as oscillations in pressure (or other physical parameter) at any frequency, and, prohibits noise disturbance due to acoustic oscillations. Large, three-bladed industrial wind turbines emit acoustic oscillations at the blade pass frequency (BPF), defined as:

$$\text{Blade pass frequency} = \text{Rotation rate, rpm} * 3 / 60, \text{ Hz}$$

A quick conversion is possible between BPF and rpm by using the multiplier or divider 20.

$$\text{BPF} = \text{rpm} / 20, \text{ Hz}; \quad \text{rpm} = \text{BPF} * 20, \text{ rotations per minute}$$

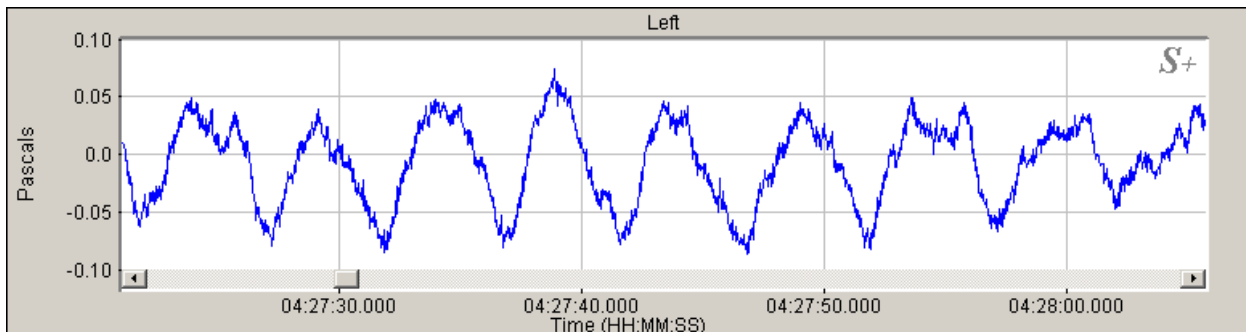
### 3.2 Acoustic pressure oscillations at infrasonic frequencies

Turbine specifications for the GE product line including the 1.7-100/103 and 1.715-100/103 list the rpm range of approximately 9.75 to 17.5 rpm (0.4875 to 0.875 Hz “blade pass frequency” or BPF) for power production.

There is a 0.2 BPF rate (4 rpm) understood to be associated with firmware- or operator-activated rotation by turbine turning gears to avoid bearing failure, requiring external power for the process.

Measurements during this preliminary investigation confirmed the presence of recurring quasi-impulsive pressure oscillations at 0.2 to 0.8 Hz at the monitoring locations in the vicinity of the Golden West Wind Facility. The presence of harmonics in FFT analysis suggests the pressure oscillations are pulse type waveforms with a narrowed duty cycle, rather than sinusoidal waveforms. This pulse type waveform is consistent with known attributes of wind turbine blade loading. From Malcolm Swinbanks: “The feature of impulsive noise is that there is a large signal present for a short period of time. Consequently, the mean, or root-mean-square (rms) level of the signal may be very low, apparently well below the threshold of hearing, but the peak level is much higher and can be perceived. This ratio of peak-to-mean level is the Crest-Factor.”<sup>1</sup>

A time series chart is shown below illustrating the impulsive oscillation waveform at 0.2 Hz rotation, or a 5-second period at the Cobb home, 12-12-15 4:27 AM; winds light or absent at ground level, turbines apparently unpowered and turned by firmware at 4 rpm with internal turning gear using grid power.



The recurring yet non-repeating pulse waveform at the BPF is associated to the variable loading and release of each blade’s power accumulation as it swings through the fastest wind aloft and then down off top azimuth, and also, from interaction of each blade encountering the slowed-wind profile in the vertical bow wake upwind of the turbine tower.<sup>2</sup> It is understood that wind turbine firmware, relying on wind data from sensors at only one central elevation at the hub, is unable to keep blade angles optimized for each

<sup>1</sup> Malcolm Swinbanks, Re: Case No U-15899, to Executive Secretary, MPSC, 12-8-2009.

<sup>2</sup> Personal communications with Malcolm Swinbanks and Stephen E. Ambrose, INCE (Board Cert.).

blade along its length as the blades swing through hundreds of feet variations in wind speed, vertical and veer shear and turbulence often exceeding manufacturer operating specifications.

Dynamic stall, excessive blade moments (range of motion) and excessive bearing loads have been documented by turbine performance research for wind turbines operated in environments with wind conditions exceeding manufacturer operating specifications. Acoustically, it appears that blade unloading and dynamic stall result in blades swinging flapwise like large paddles or long speakers, amplifying blade moments and recurring pulsatile oscillations at the blade pass frequency. Sudden encounters with changes in wind speed or direction may shock blades into ringing at their primary structural resonant frequencies which are also infrasonic.

It is understood that it is possible to rotate turbines at up to full rpm with no power output using feathered blades (no angle to wind) and externally applied voltage to internal gearing. In such operations, the blades would still be subjected to wind shear and turbulence and exhibit cyclical flapwise moments resulting in acoustic oscillations at the blade pass frequencies.

### 3.3 Motion sickness from oscillations

International ISO standard 9996:2000 defines motion sickness from exposure to actual or perceived oscillatory motion; *“motion sickness is a commonly experienced and sometimes severe but reversible (i. e. physiological) disorder specifically associated with exposure to actual or perceived oscillatory motion in the frequency range 0,1 to 1 Hz. One or more of a constellation of symptoms (with or without frank vomiting) may affect the sufferer. ”*

Naval studies identified acceleration oscillations in the range of 0.1 to 1 Hz as associated with motion sickness, with sickness strongest at about 0.2 Hz. The association of acoustic oscillations to motion sickness was documented in studies of large wind turbine noise emissions by Dr. Paul Schomer.

Review of deliberate increases in wind turbine size over several decades indicates that the rotational rate (revolutions per minute or rpm) and the blade pass frequency (BPF) have dropped, as size increased, into the range of motion sickness identified in ISO 9996:2000, 0.1 to 1 Hz and studied in naval research on motion sickness. Figure 5 below illustrates the drop in BPF with turbine size. Blade pass frequencies observed in spectrogram analysis at homes near the vicinity of the Golden West Wind Facility fall within 0.2 to 0.85 Hz, within the range associated to motion sickness.

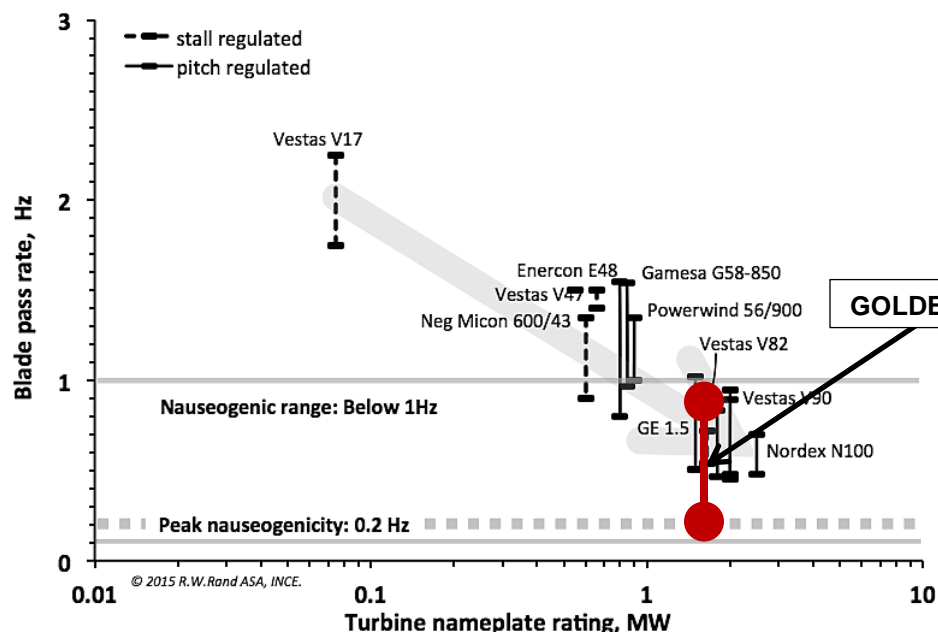
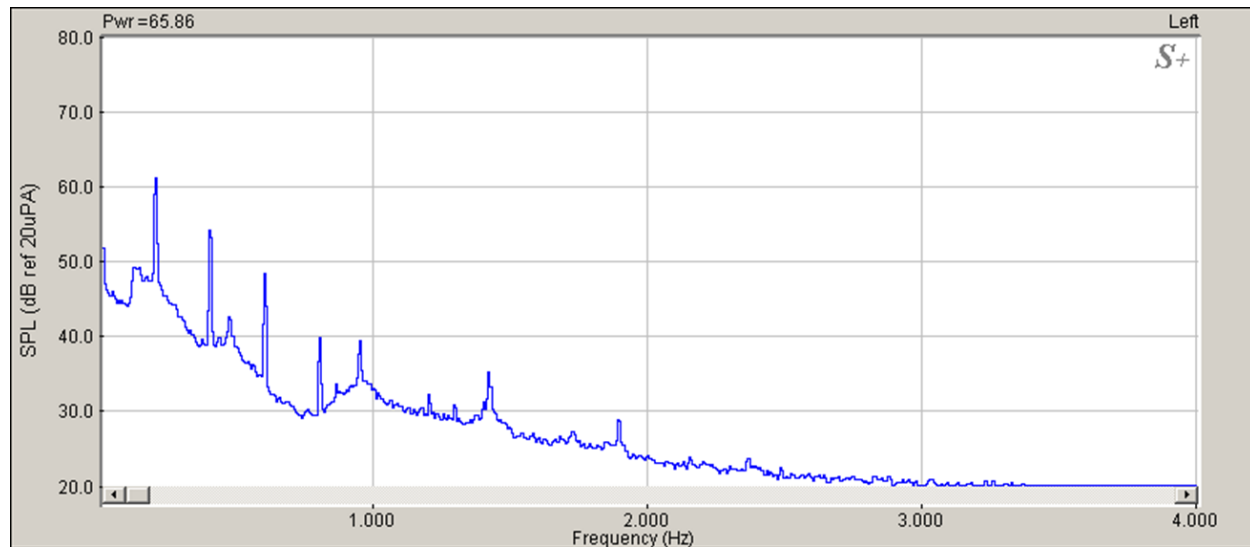


Figure 5. Blade pass rate (frequency), Hz for various wind turbine models. Nauseogenicity range is 0.1 to 1 Hz with peak nausea potential noted at 0.2 Hz. In a limited literature search, motion sickness reports were not found for older, smaller turbines, which have blade pass frequencies outside the nauseogenic range. This figure includes minor syntax changes from a figure presented at the 4pNS Wind Turbine Noise II technical at the 2015 Acoustical Society of America Meeting in Pittsburgh.

#### 4.0 Spectrum analysis of BPF oscillations

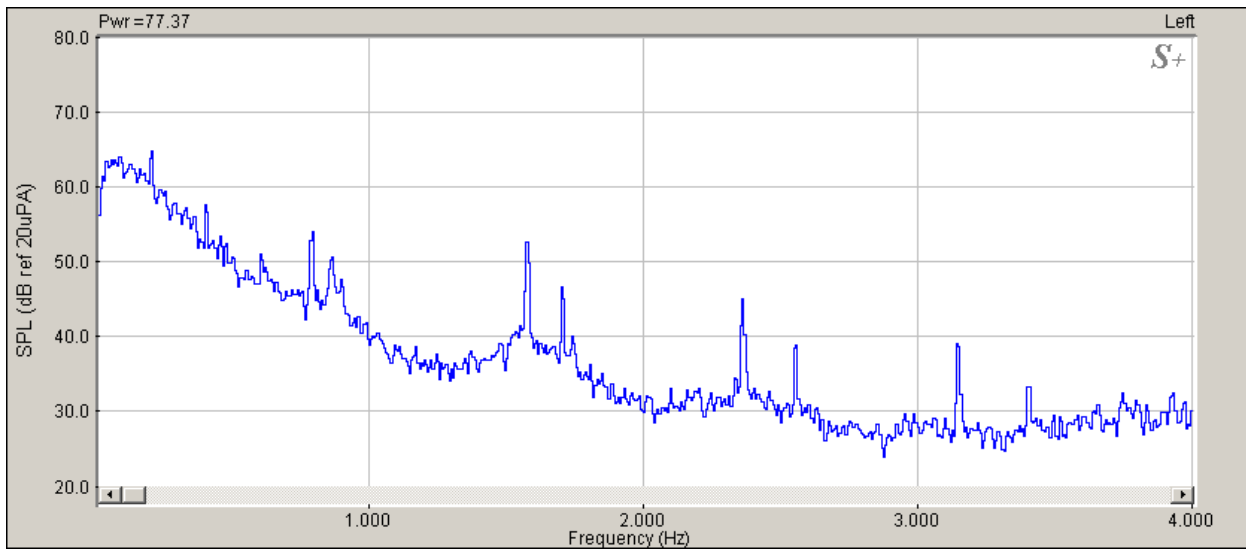
Power levels were computed for several monitoring segments by summing the first four FFT components for specific turbine rotations when the traces were clearly visible and uncontaminated by other noise. For a 0.2 Hz rotation, the FFT power for 0.2, 0.4, 0.6, and 0.8 Hz were summed using the center and two adjacent bins for each harmonic. Similar summations were performed for other rotations such as 0.85 Hz. Totalized RMS levels ranged from 56 to 70 dB re 20uPA, with peak levels from 71 to 89 dB. Crest-Factors were obtained directly in analysis software and applied to obtain the peak BPF sound level.

##### 4.1 Example 1. Spectrum analysis, Cobb Home, 12-12-15, BPF 0.2 Hz.



DATE 12/12/15  
 START TIME 1:15 AM  
 STOP TIME 6:15 AM  
 DURATION 5.00 hours

CALC OSCILLATION PWR	F, Hz	Bin, dB	Exp
BPF BIN-1	0.1953	59.2	825266.7
BPF BIN-1	0.2014	61.4	1389442.6
BPF BIN+1	0.2075	52.6	180170.1
2XBPF BIN-1	0.3906	43.7	23223.5
2XBPF	0.3967	54.4	277437.8
2XBPF+1	0.4028	53.4	218142.3
3XBPF BIN-1	0.592	41.9	15379.6
3XBPF	0.5981	48.6	72548.8
3XBPF+1	0.6042	44.3	27018.8
4XBPF BIN-1	0.7935	36.9	4918.4
4XBPF	0.7996	40.1	10188.8
4XBPF+1	0.8057	33.9	2476.3
<b>TOTAL, dB re 20uPA</b>			<b>64.8</b>
<b>TOTAL, Pascals, RMS</b>			<b>0.035</b>
CREST FACTOR, dB			17.6
<b>Peak level, dB</b>			<b>82.4</b>

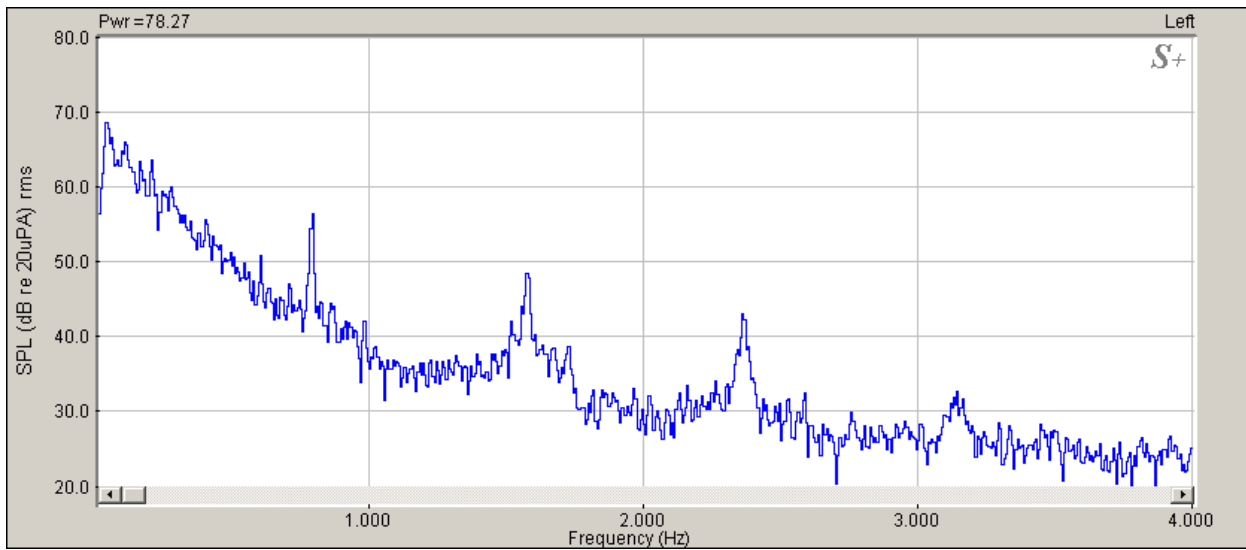
**4.1 Example 2. Spectrum analysis, Cobb Home, 12-13-15, BPF 0.2, 0.79, and 0.85 Hz.**

DATE 12/13/15  
 START TIME 6:15 PM  
 STOP TIME 6:45 PM  
 DURATION 0.50 hours

CALC OSCILLATION PWR	0.2 HZ			0.78 Hz			0.85 Hz		
	F, Hz	Bin, dB	Exp	F, Hz	Bin, dB	Exp	F, Hz	Bin, dB	Exp
BPF BIN-1	0.1953	63.9	2480279.9	0.7751	46.7	46247.0	0.8484	49.1	81903.8
BPF BIN-1	0.2014	65.0	3152360.7	0.7813	53.0	200254.0	0.8545	50.5	110926.0
BPF BIN+1	0.2075	60.4	1087195.1	0.7874	54.3	268226.1	0.8606	50.8	119487.3
2XBPF BIN-1	0.3967	57.8	602700.8	1.5625	46.3	42769.7	1.6907	39.4	8760.2
2XBPF	0.4028	56.7	467546.3	1.5686	52.7	187047.7	1.6968	46.8	48367.2
2XBPF+1	0.4089	52.0	159569.0	1.5747	50.0	100755.2	1.7029	45.2	33395.9
3XBPF BIN-1	0.5981	51.1	129169.2	2.3499	41.7	14642.2	2.5452	38.7	7441.6
3XBPF	0.6042	50.4	110293.4	2.356	45.2	33433.1	2.5513	39.1	8039.7
3XBPF+1	0.6104	48.7	74723.3	2.3621	40.5	11095.5	2.5574	31.8	1513.1
4XBPF BIN-1	0.7996	45.0	31683.0	3.1372	39.3	8498.8	3.3936	33.4	2207.1
4XBPF	0.8057	46.4	43980.1	3.1433	38.8	7545.5	3.3997	33.5	2244.0
4XBPF+1	0.8118	44.8	30323.4	3.1494	32.4	1752.2	3.4058	28.9	784.3
<b>TOTAL, dB re 20uPA</b>			<b>69.2</b>			<b>59.6</b>			<b>56.3</b>
<b>TOTAL, Pascals, RMS</b>			0.058			0.019			0.013
<b>CREST FACTOR, dB</b>			14.3			14.3			14.3
<b>Peak level, dB</b>			<b>83.5</b>			<b>73.9</b>			<b>70.6</b>



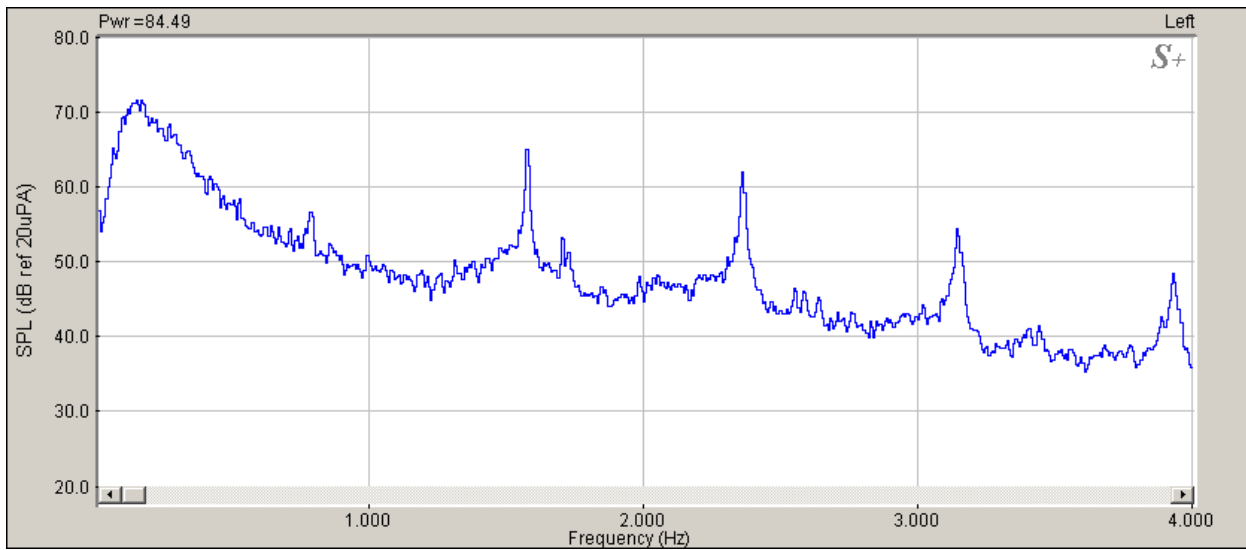
#### 4.1 Example 3. Spectrum analysis, Cobb Home, 12-17-15, BPF 0.78 Hz.



DATE 12/17/15  
 START TIME 8:10 PM  
 STOP TIME 8:25 PM  
 DURATION 0.25 hours

CALC OSCILLATION PWR	F, Hz	Bin, dB	Exp
BPF BIN-1	0.7751	48.5	71339.8
BPF BIN-1	0.7813	54.6	289792.5
BPF BIN+1	0.7874	56.5	448172.3
2XBPF BIN-1	1.5625	45.6	36015.8
2XBPF	1.5686	48.6	72421.4
2XBPF+1	1.5747	48.0	62543.8
3XBPF BIN-1	2.3499	40.0	10082.5
3XBPF	2.356	43.2	20918.2
3XBPF+1	2.3621	42.4	17341.4
4XBPF BIN-1	3.1311	31.0	1258.4
4XBPF	3.1372	32.9	1967.6
4XBPF+1	3.1433	29.6	905.8
<b>TOTAL, dB re 20uPA</b>			<b>60.1</b>
<b>TOTAL, Pascals, RMS</b>			<b>0.020</b>
CREST FACTOR, dB			13.1
<b>Peak level, dB</b>			<b>73.2</b>

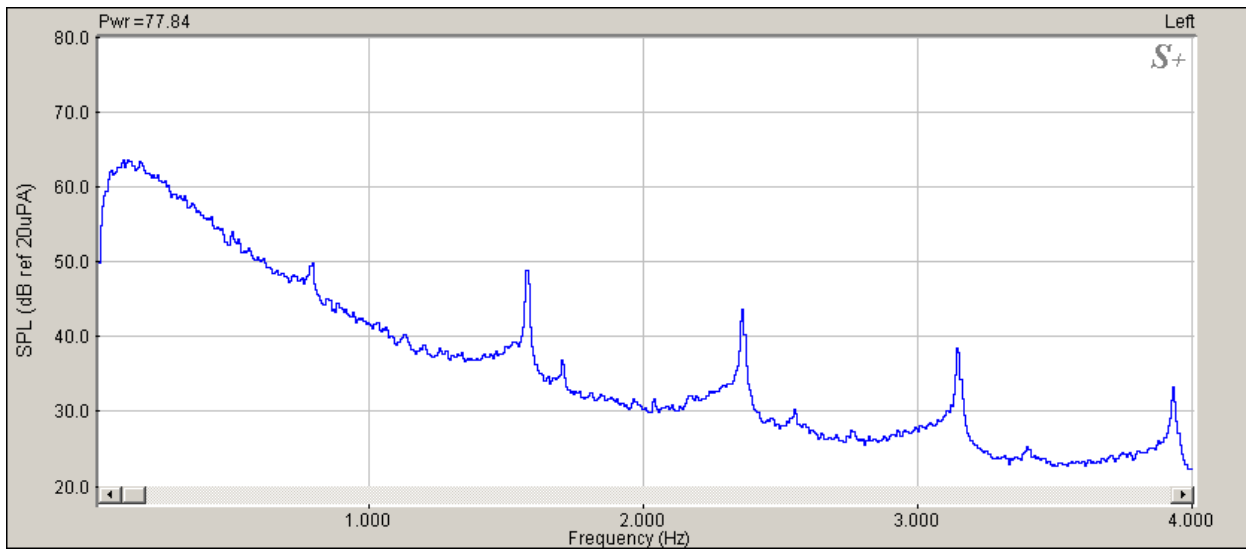
#### 4.1 Example 4. Spectrum analysis, Wolfe home, 12-17-15, BPF 0.78 Hz.



DATE 12/17/15  
 START TIME 10:40 PM  
 STOP TIME 11:40 PM  
 DURATION 1.00 hours

CALC OSCILLATION PWR	F, Hz	Bin, dB	Exp
BPF BIN-1	0.7751	55.6	367190.8
BPF BIN-1	0.7813	56.8	478888.6
BPF BIN+1	0.7874	56.1	411701.8
2XBPF BIN-1	1.5625	59.8	954050.8
2XBPF	1.5686	65.1	3225940.1
2XBPF+1	1.5747	63.0	1975497.1
3XBPF BIN-1	2.3499	60.1	1020352.4
3XBPF	2.356	62.1	1635316.1
3XBPF+1	2.3621	59.3	846885.7
4XBPF BIN-1	3.1311	51.9	155949.2
4XBPF	3.1372	54.6	291209.0
4XBPF+1	3.1433	53.7	231877.6
<b>TOTAL, dB re 20uPA</b>			<b>70.6</b>
<b>TOTAL, Pascals, RMS</b>			<b>0.068</b>
CREST FACTOR, dB			18.2
<b>Peak level, dB</b>			<b>88.8</b>

#### 4.1 Example 5. Spectrum analysis, Wince home, 1-19-16, BPF 0.78 Hz.



DATE 12/17/15  
 START TIME 6:00 PM  
 STOP TIME 11:00 PM  
 DURATION 5.00 hours

CALC OSCILLATION PWR	F, Hz	Bin, dB	Exp
BPF BIN-1	0.7751	48.5	70428.0
BPF BIN-1	0.7813	49.7	93111.6
BPF BIN+1	0.7874	50.0	100601.3
2XBPF BIN-1	1.5625	44.9	30595.2
2XBPF	1.5686	49.1	80677.5
2XBPF+1	1.5747	47.2	52168.2
3XBPF BIN-1	2.3499	42.3	16845.2
3XBPF	2.356	43.9	24320.6
3XBPF+1	2.3621	40.4	10961.0
4XBPF BIN-1	3.1311	35.1	3223.1
4XBPF	3.1372	38.7	7435.5
4XBPF+1	3.1433	38.0	6360.2
<b>TOTAL, dB re 20uPA</b>			<b>57.0</b>
<b>TOTAL, Pascals, RMS</b>			<b>0.014</b>
CREST FACTOR, dB			17.3
<b>Peak level, dB</b>			<b>74.3</b>

## **5.0 Infrasonic spectrograms**

Daily spectrograms are shown in this section for the three homes monitored:

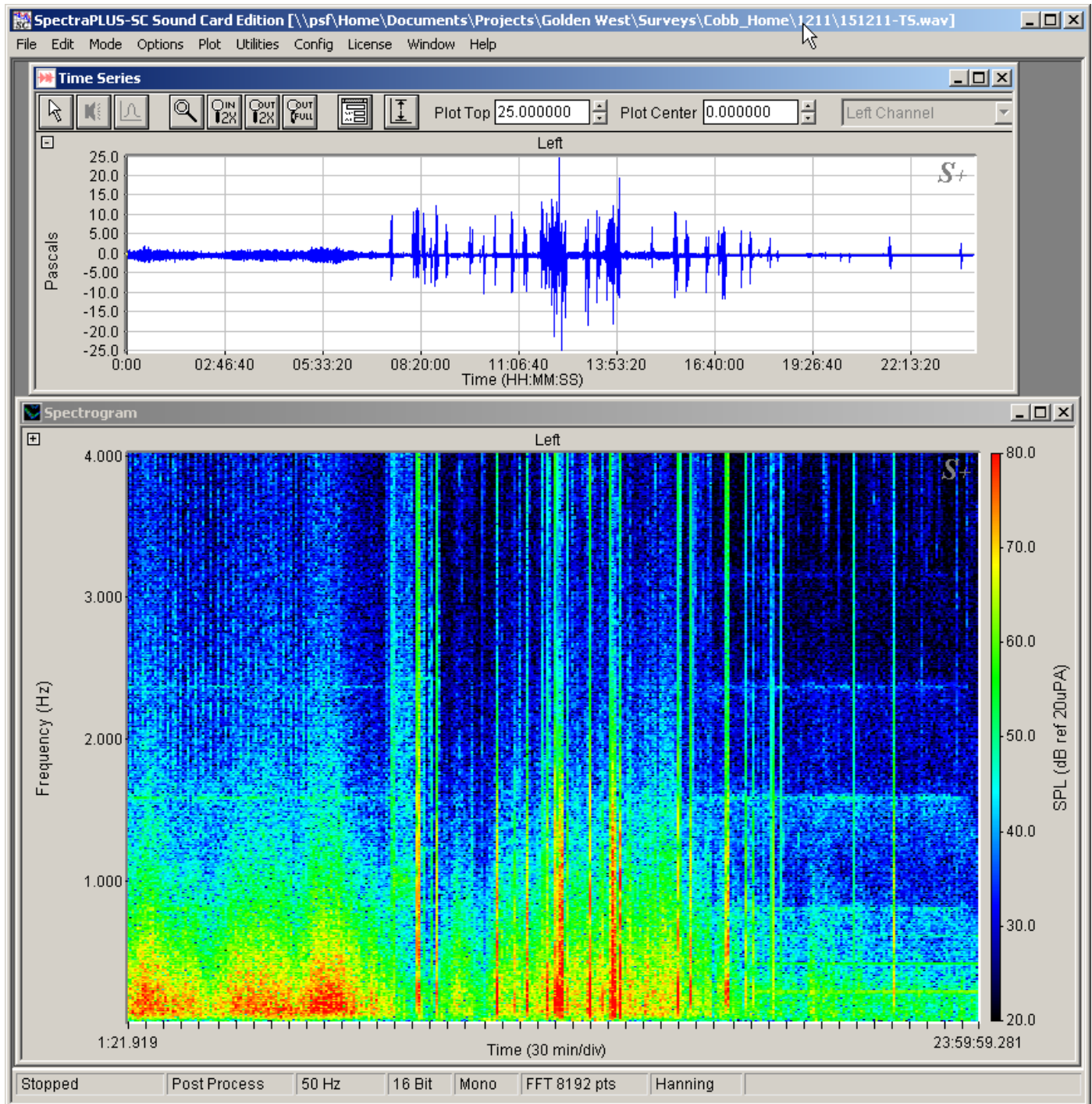
Cobb home: December 11-17, 2015

Wolfe home: December 11-17, 2015

Wince home: January 13-19, 2016

Location: COBB HOME

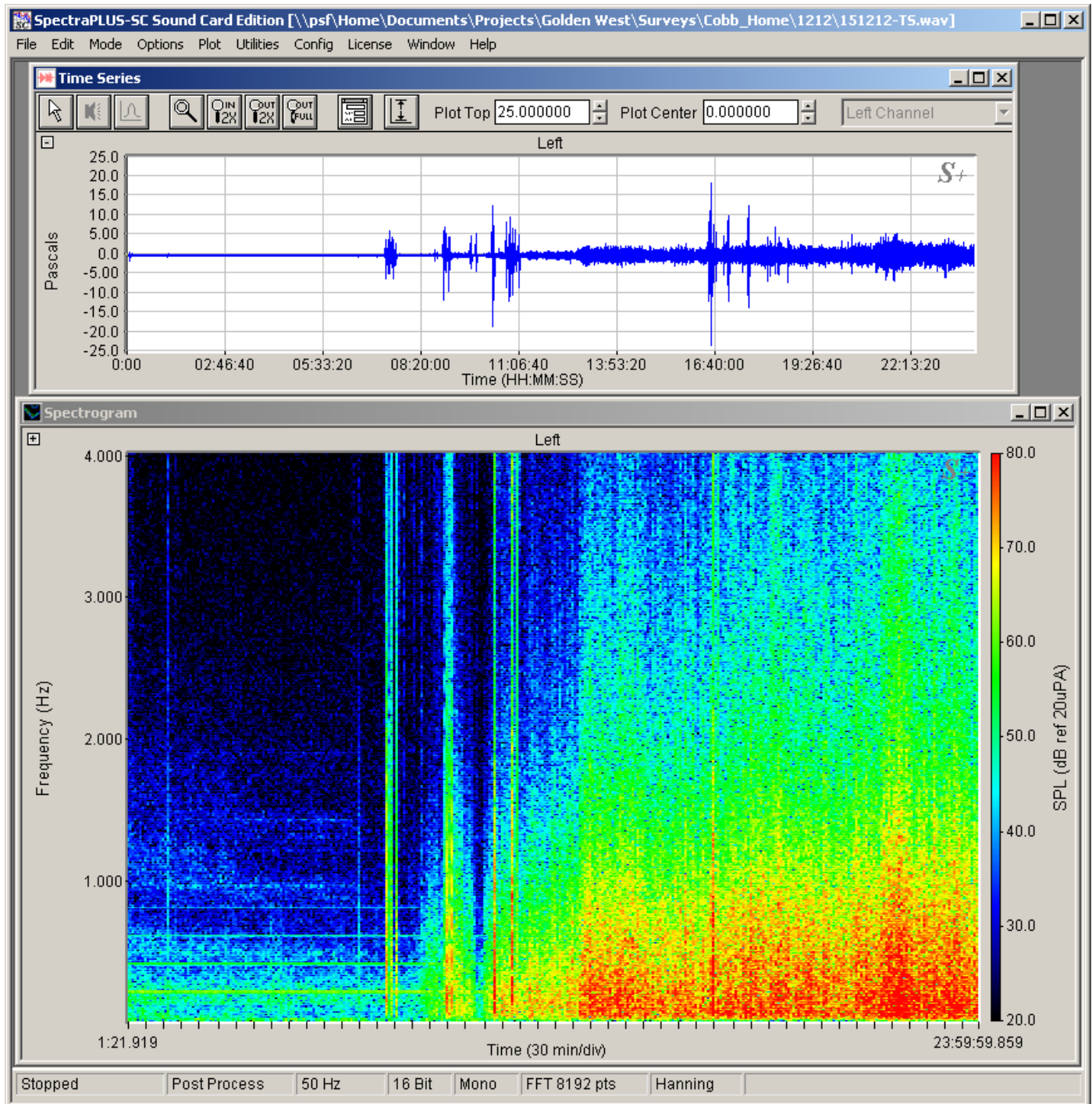
Date: 12/11/2015



Note: Horizontal traces indicate wind turbine rotation. Rotations at 0.79 Hz (15.8 rpm) and 0.2 Hz (4 rpm) was observed. Multiple rotations in the range of 0.6 to 0.7 Hz were observed consistent with differing rotation rates from a number of turbines at some distance or at lower power.

Location: COBB HOME

Date: 12/12/2015

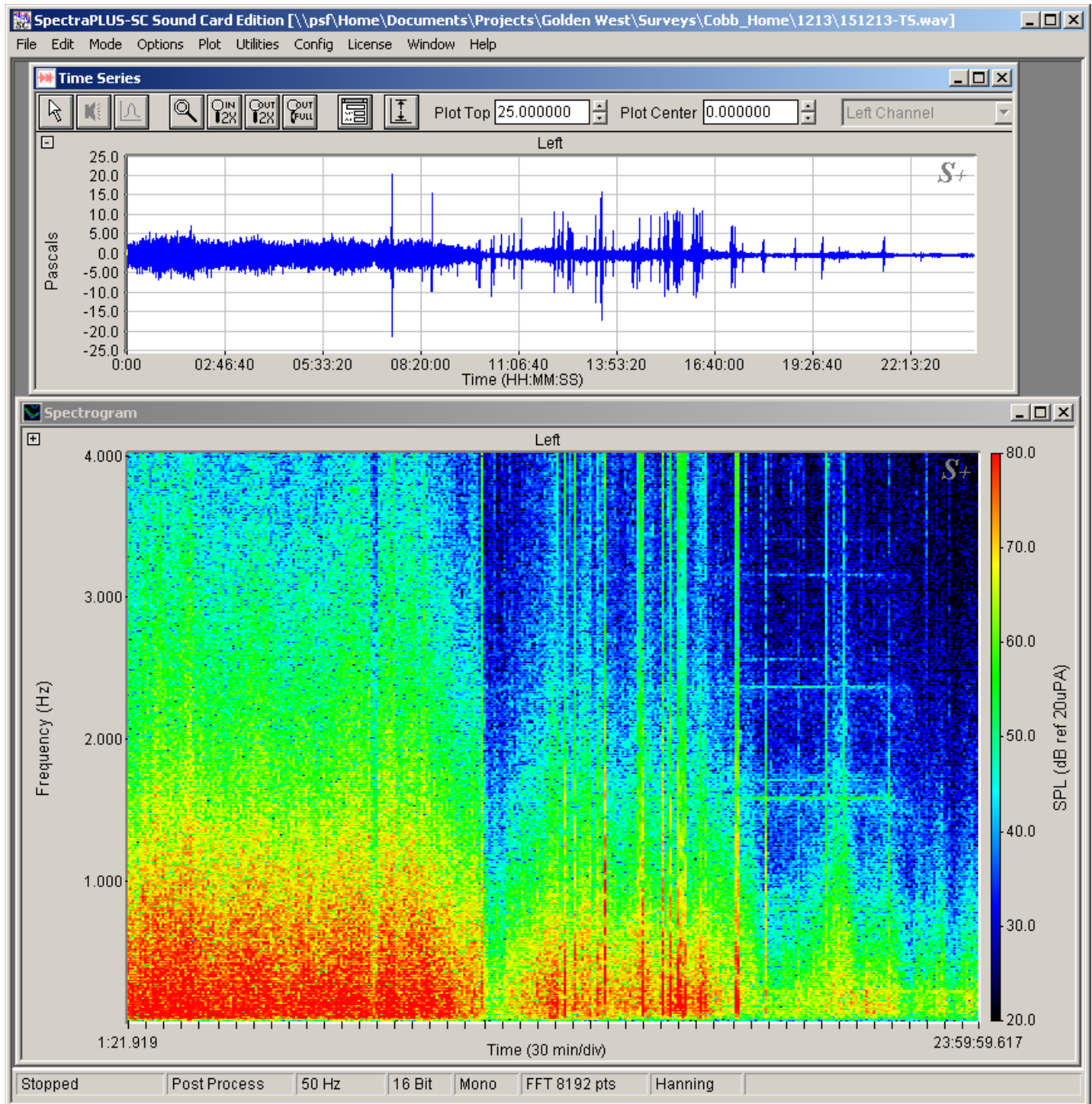


Note: Horizontal traces indicate wind turbine rotation. Rotations at 0.2 Hz (4 rpm) and 0.48 Hz (9.6 rpm) were observed. Multiple lower intensity traces in the range of 0.4 to 0.7 Hz were observed consistent with differing rotation rates from a number of turbines at some distance or at lower power. Slowing of multiple turbines from night before was observed to continue through to about 6:30 AM.



Location: COBB HOME

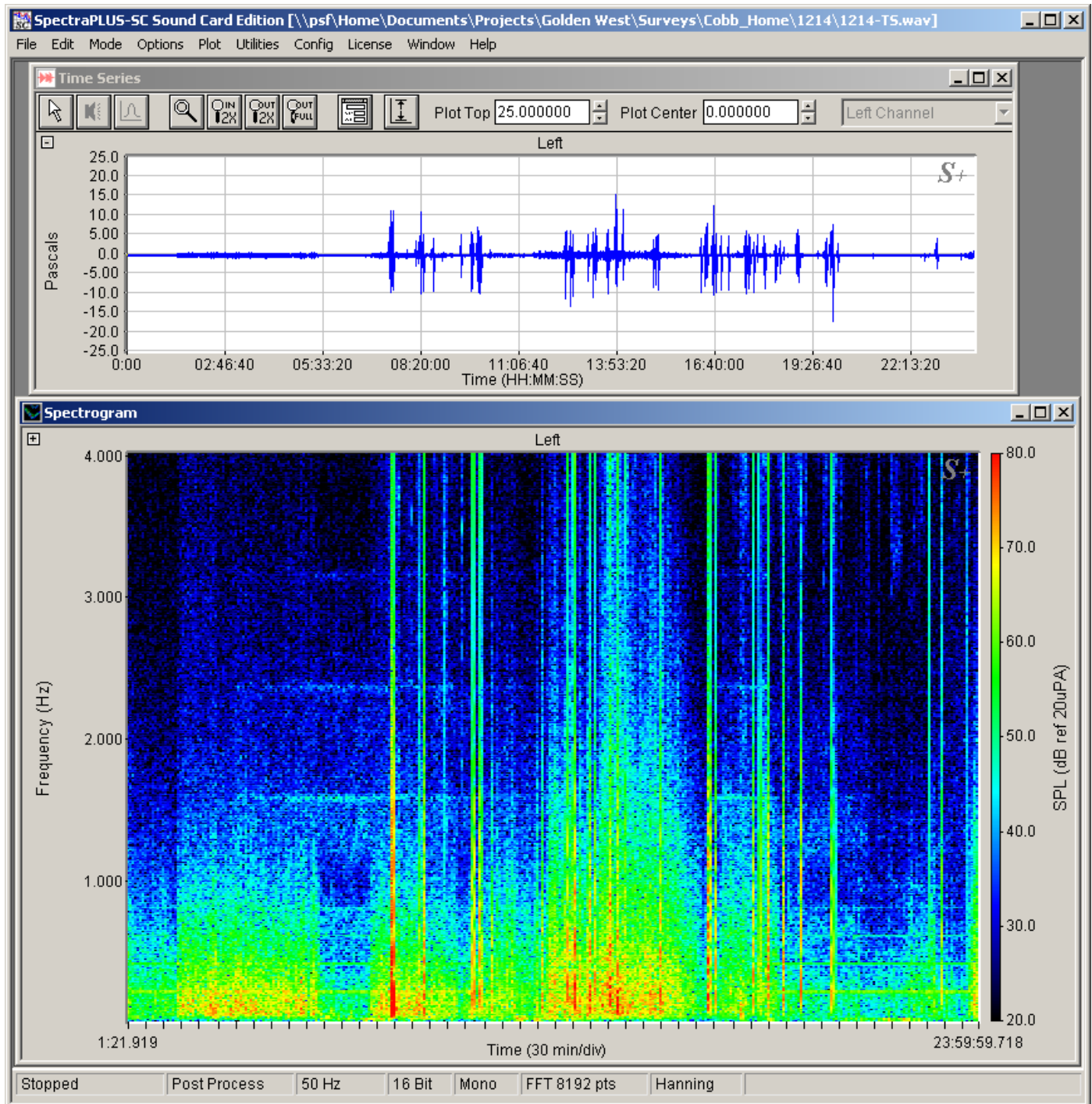
Date: 12/13/2015



Note: Horizontal traces indicate wind turbine rotation. Rotations at 0.2 Hz (4 rpm), 0.79 Hz (15.8 rpm) and 0.85 Hz (19 rpm) were observed during the evening hours.

Location: COBB HOME

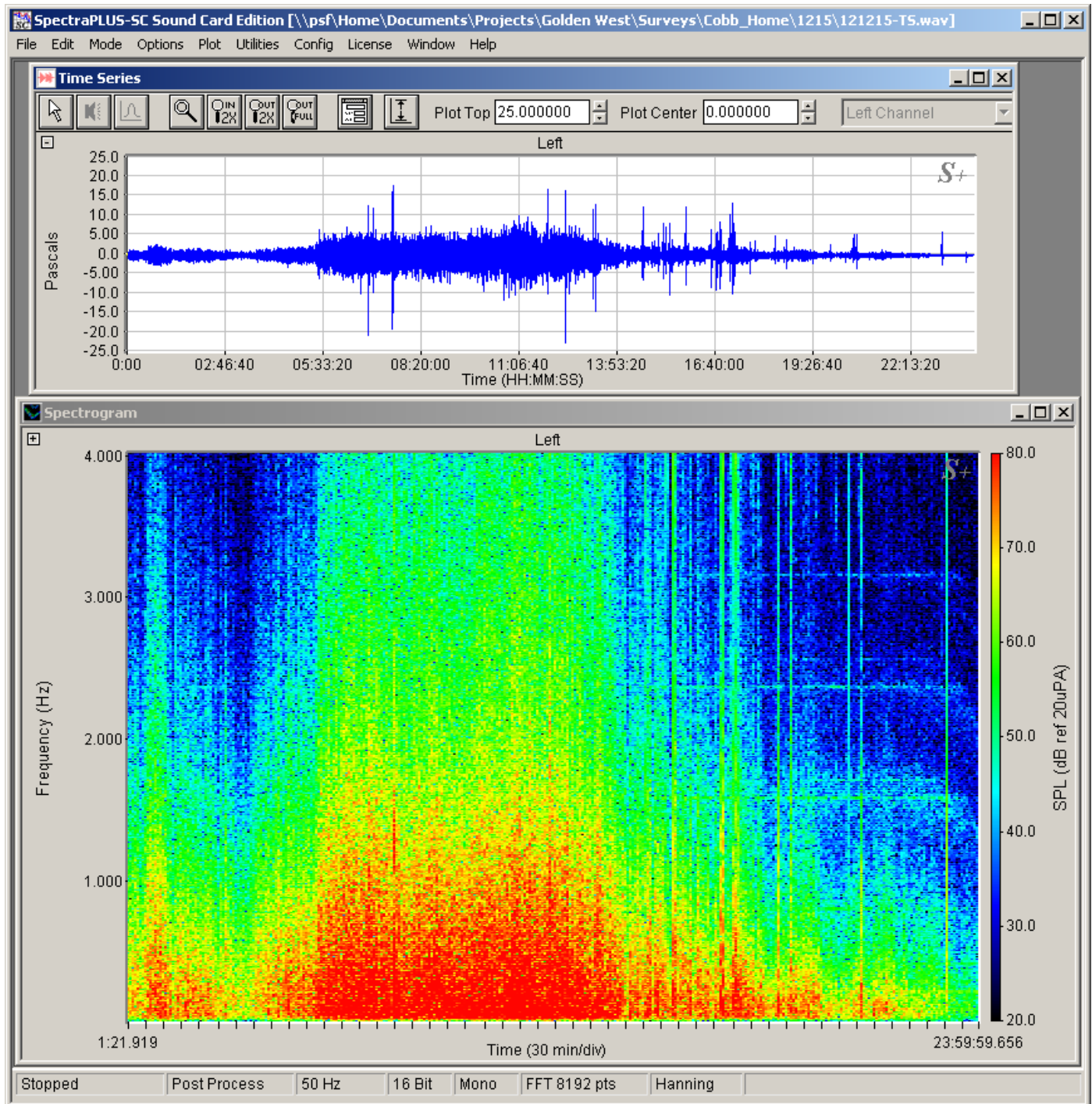
Date: 12/14/2015



Note: Horizontal traces indicate wind turbine rotation. Rotations at 0.79 Hz (15.8 rpm) and 0.2 Hz (4 rpm) were observed.

Location: COBB HOME

Date: 12/15/2015

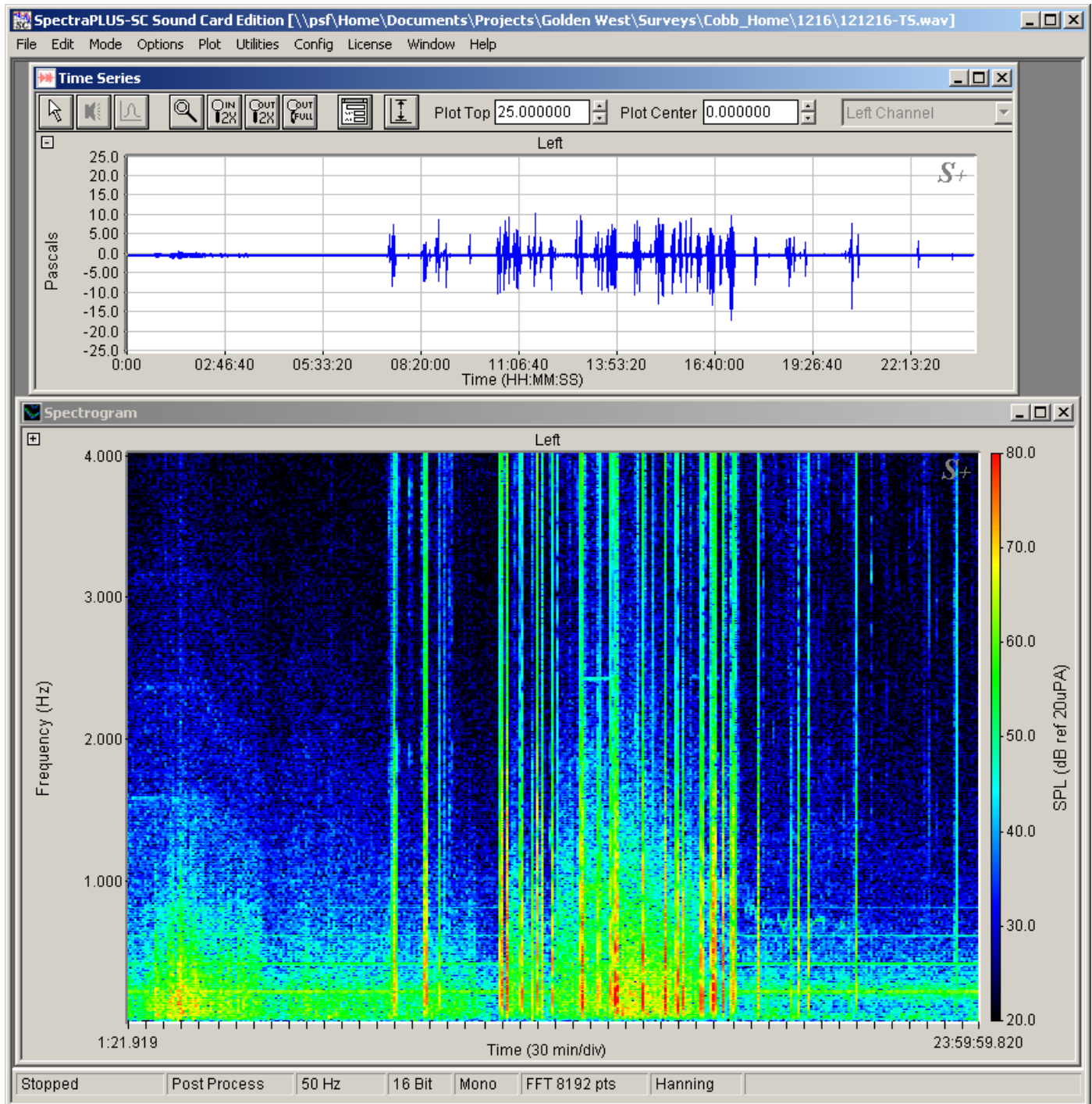


Note: Horizontal traces indicate wind turbine rotation. Rotations at 0.79 Hz (15.8 rpm) and 0.86 Hz (17.2 rpm) were observed.



Location: COBB HOME

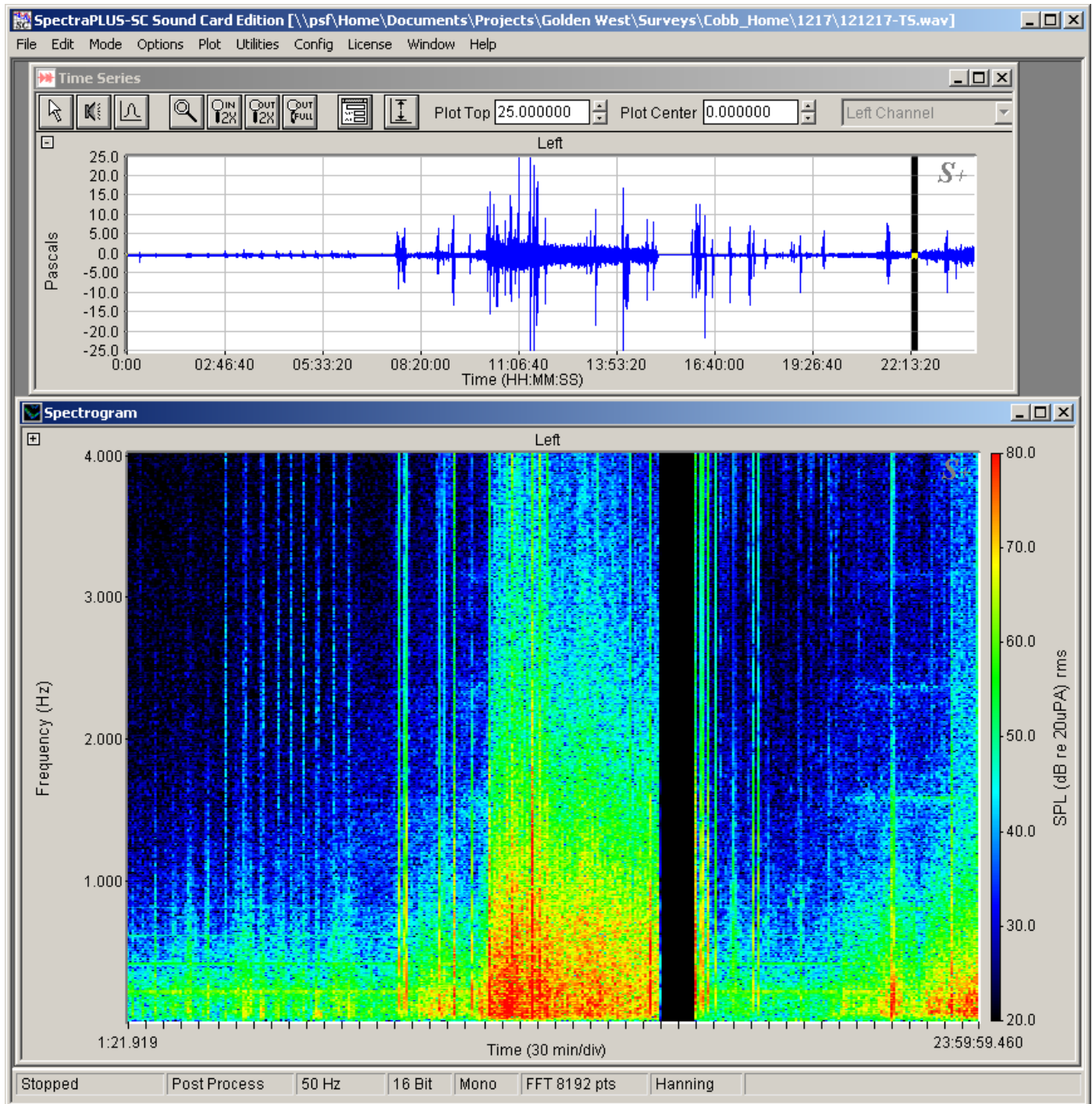
Date: 12/16/2015



Note: Horizontal traces indicate wind turbine rotation. Rotations at 0.79 Hz (15.8 rpm) were observed until about 2:30 AM and 0.2 Hz (4 rpm) was observed the remainder of the day.

Location: COBB HOME

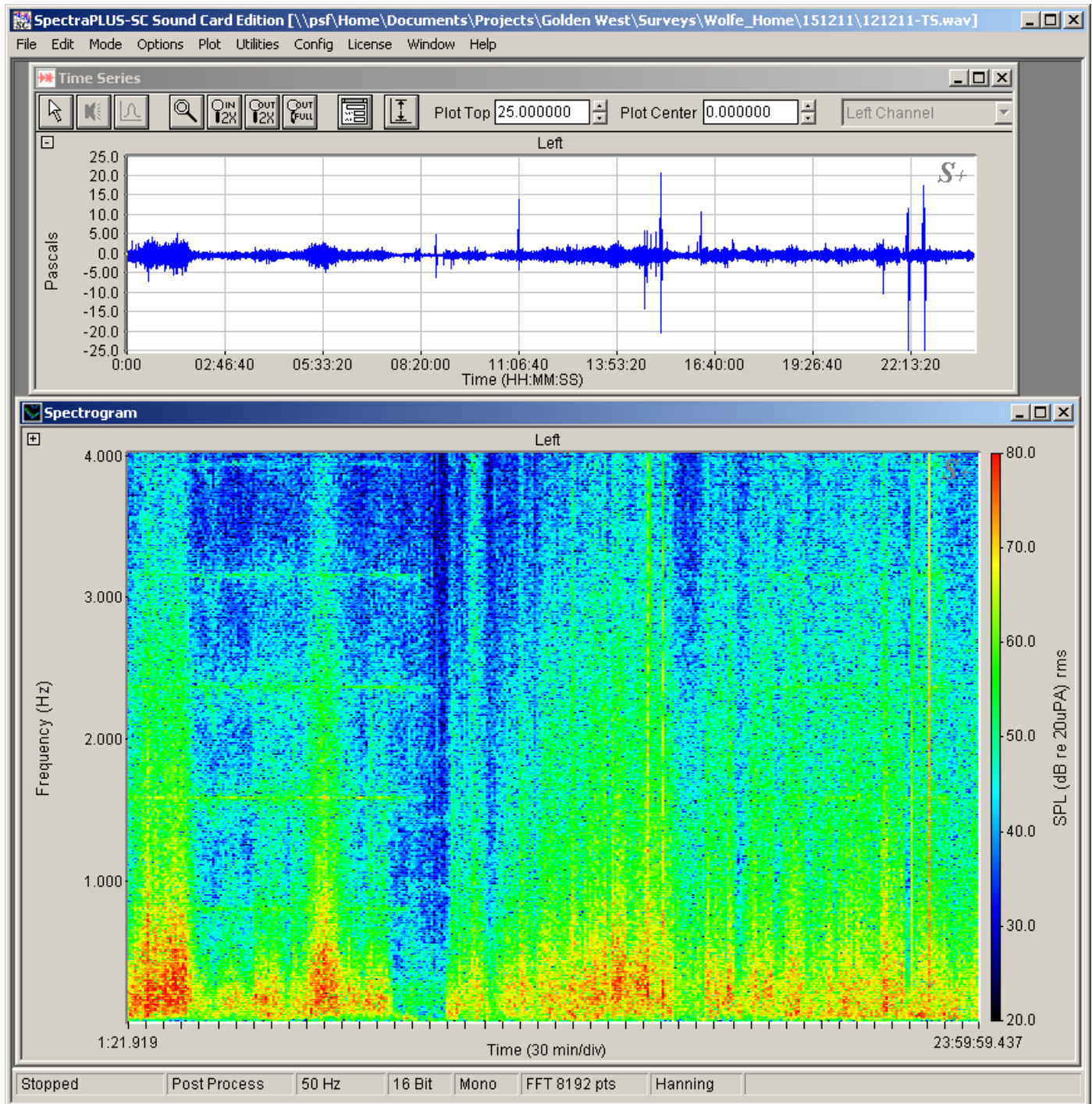
Date: 12/17/2015



Note: Horizontal traces indicate wind turbine rotation. Rotation at 0.2 Hz (4 rpm) during the first part of the day, with 0.79 Hz (15.8 rpm) rotations observed starting about daybreak, not visible in the mid-afternoon, and reappearing around 8 PM. Gap 3-4 PM for system maintenance.

Location: WOLFE HOME

Date: 12/11/2015

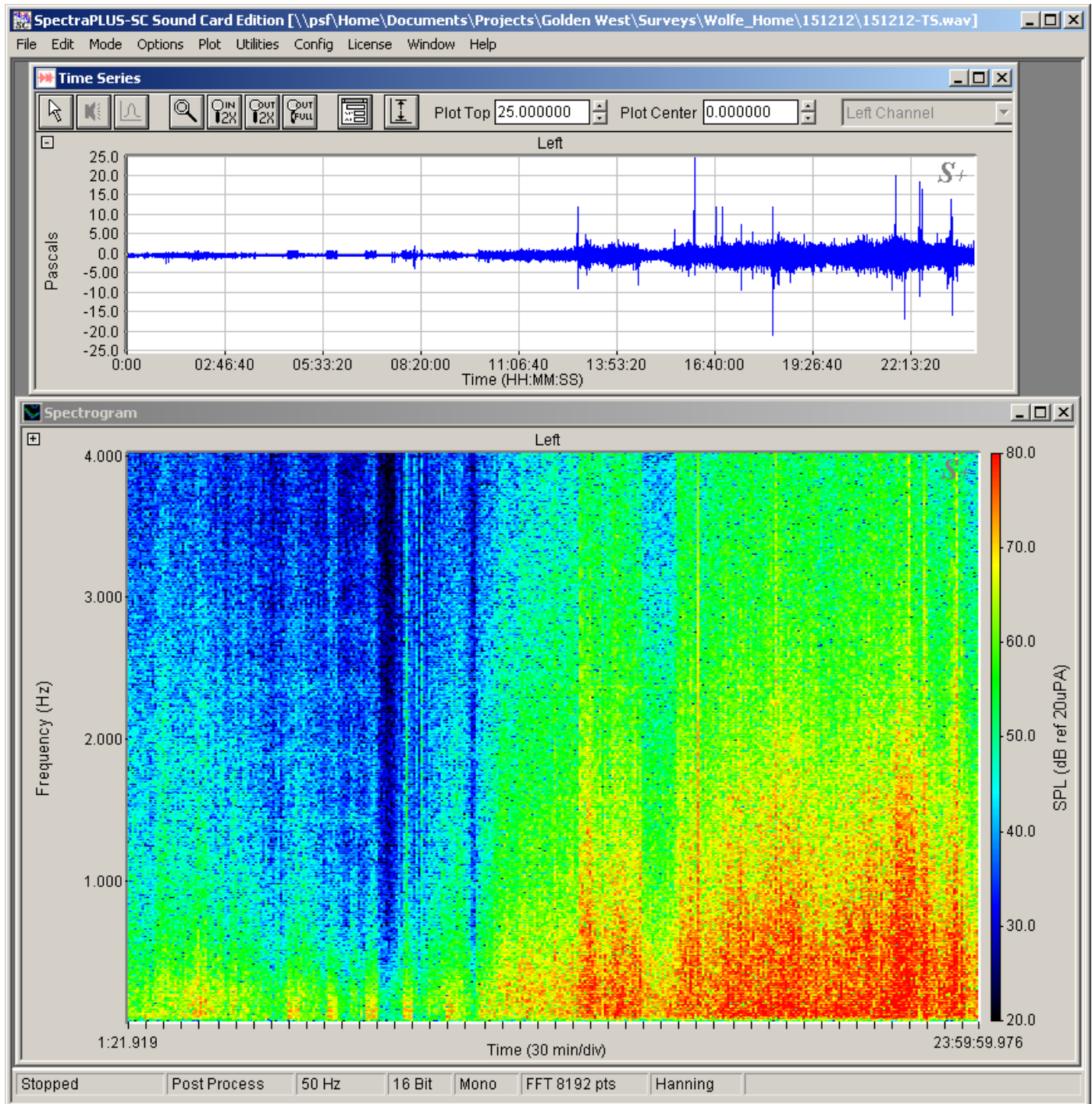


Note: Horizontal traces indicate wind turbine rotation. Rotations at 0.79 Hz (15.8 rpm) and 0.48 Hz (9.6 rpm) were observed.



Location: WOLFE HOME

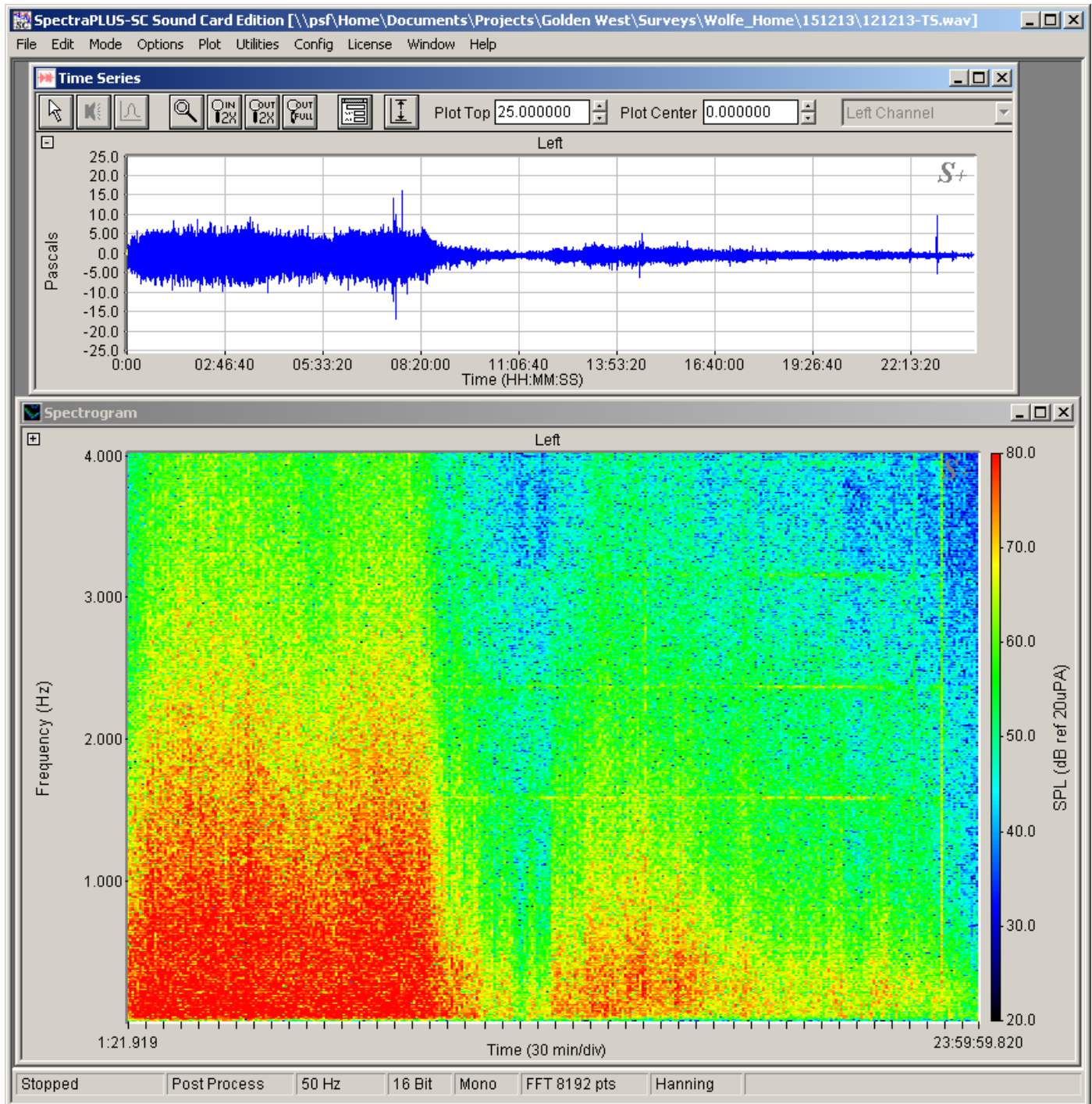
Date: 12/12/2015



Note: Horizontal traces indicate wind turbine rotation. Rotations were observed at 0.47 Hz (15.4 rpm) during early hours until 7 AM and 0.79 Hz (15.8 rpm) after 12 PM.

Location: WOLFE HOME

Date: 12/13/2015

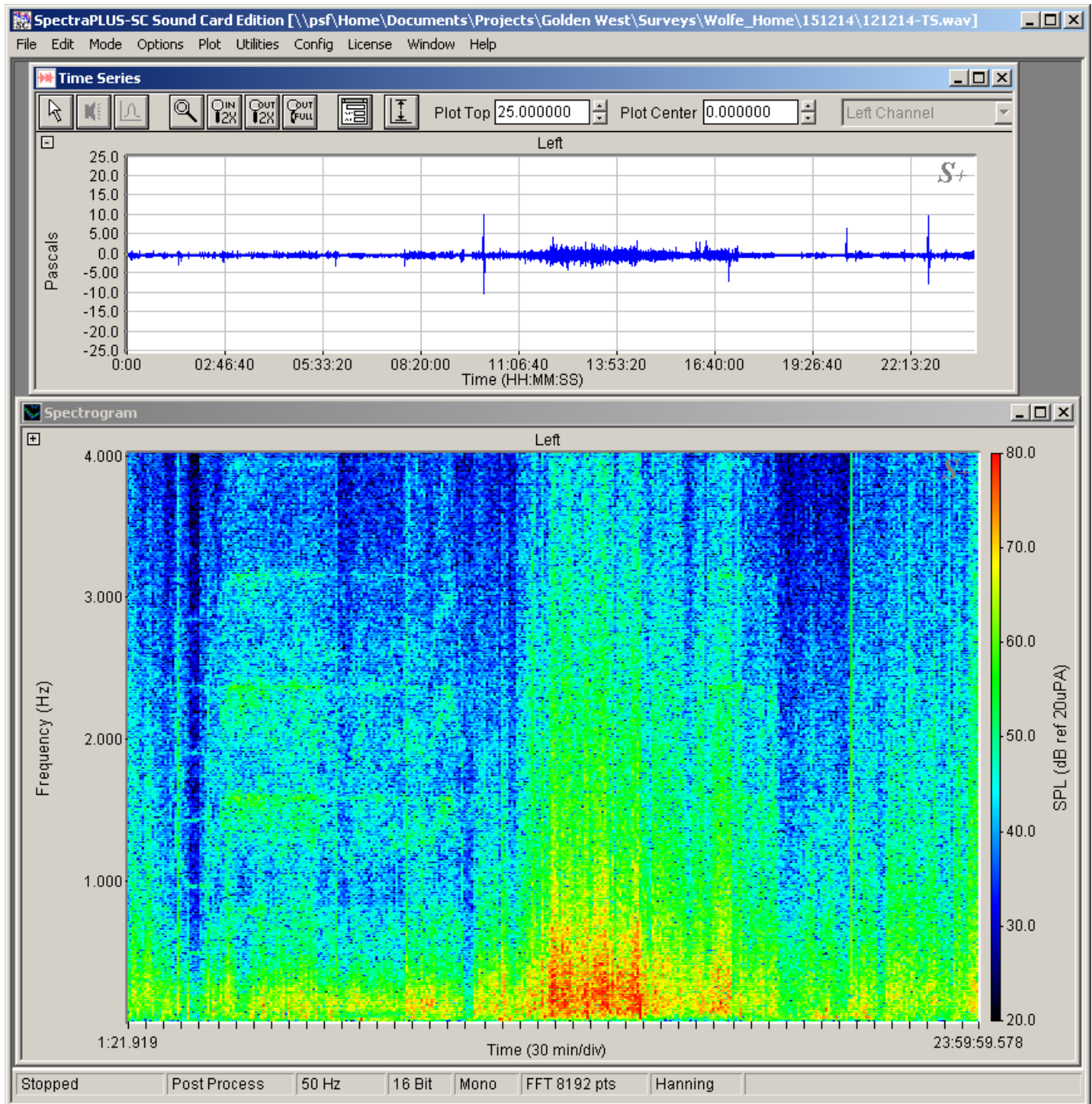


Note: Horizontal traces indicate wind turbine rotation. Rotation was observed at 0.79 Hz (15.8 rpm).



Location: WOLFE HOME

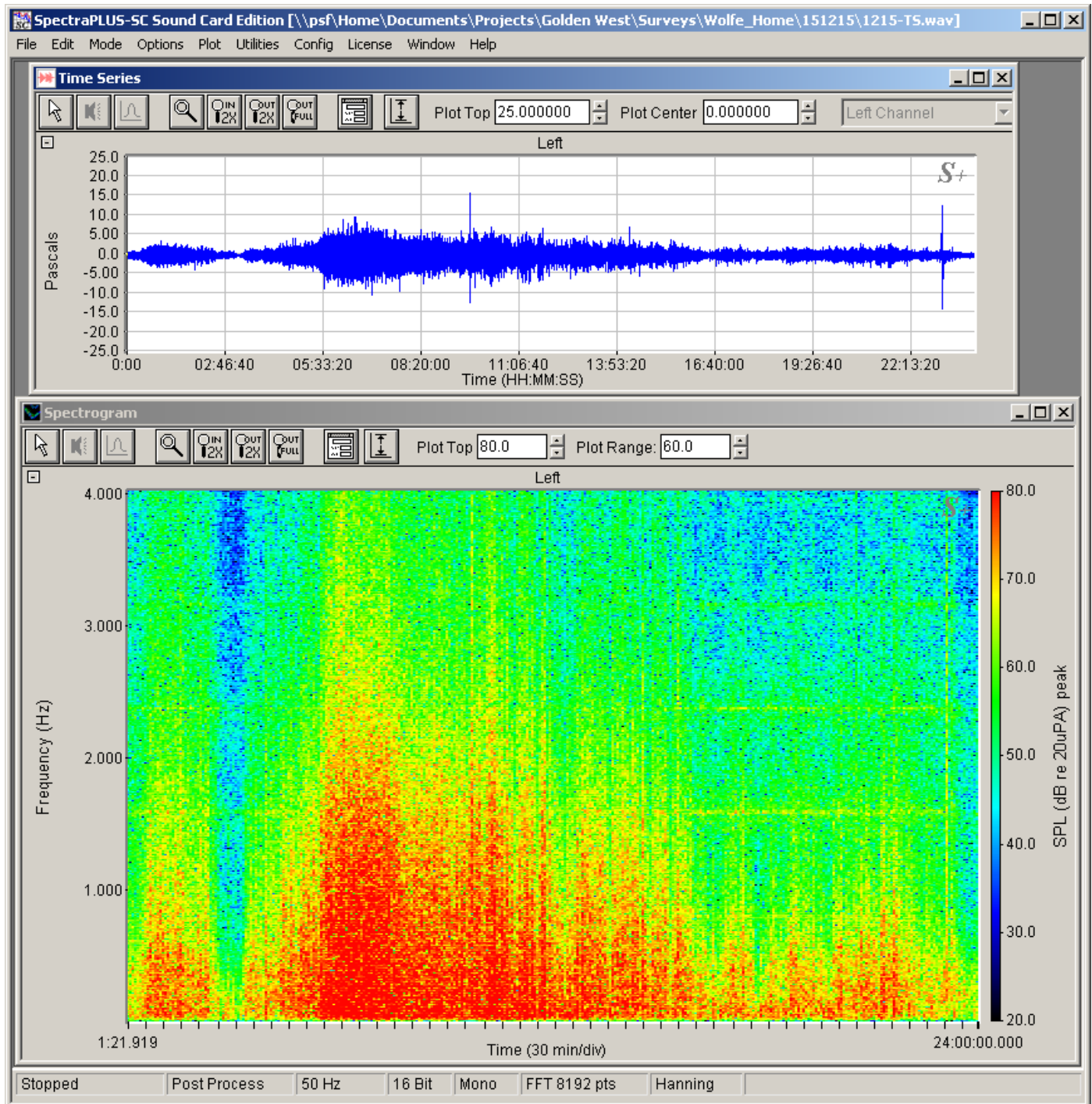
Date: 12/14/2015



Note: Horizontal traces indicate wind turbine rotation. Rotation was observed at 0.48 Hz (9.6 rpm) prior to 2 AM rising to 0.79 Hz (15.8 rpm) until 9:30 AM when traces drop away. The 0.79 Hz trace harmonics were faintly visible between 12 PM and 6:20 PM and between 10 and 11 PM.

Location: WOLFE HOME

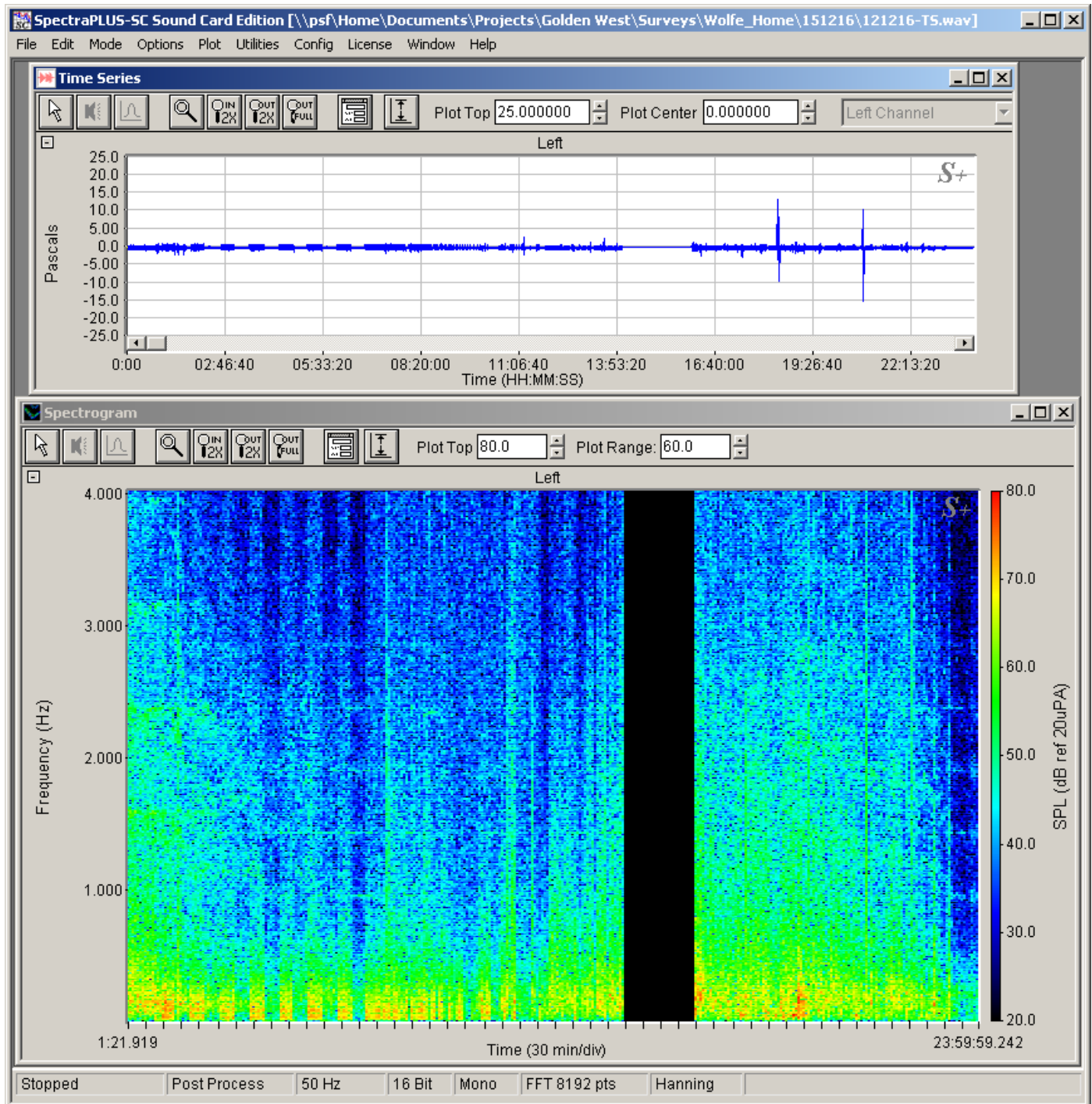
Date: 12/15/2015



Note: Horizontal traces indicate wind turbine rotation. Rotation was observed at 0.79 Hz (15.8 rpm) throughout the day however high wind levels on the house obscured details in the mid-day.

Location: WOLFE HOME

Date: 12/16/2015

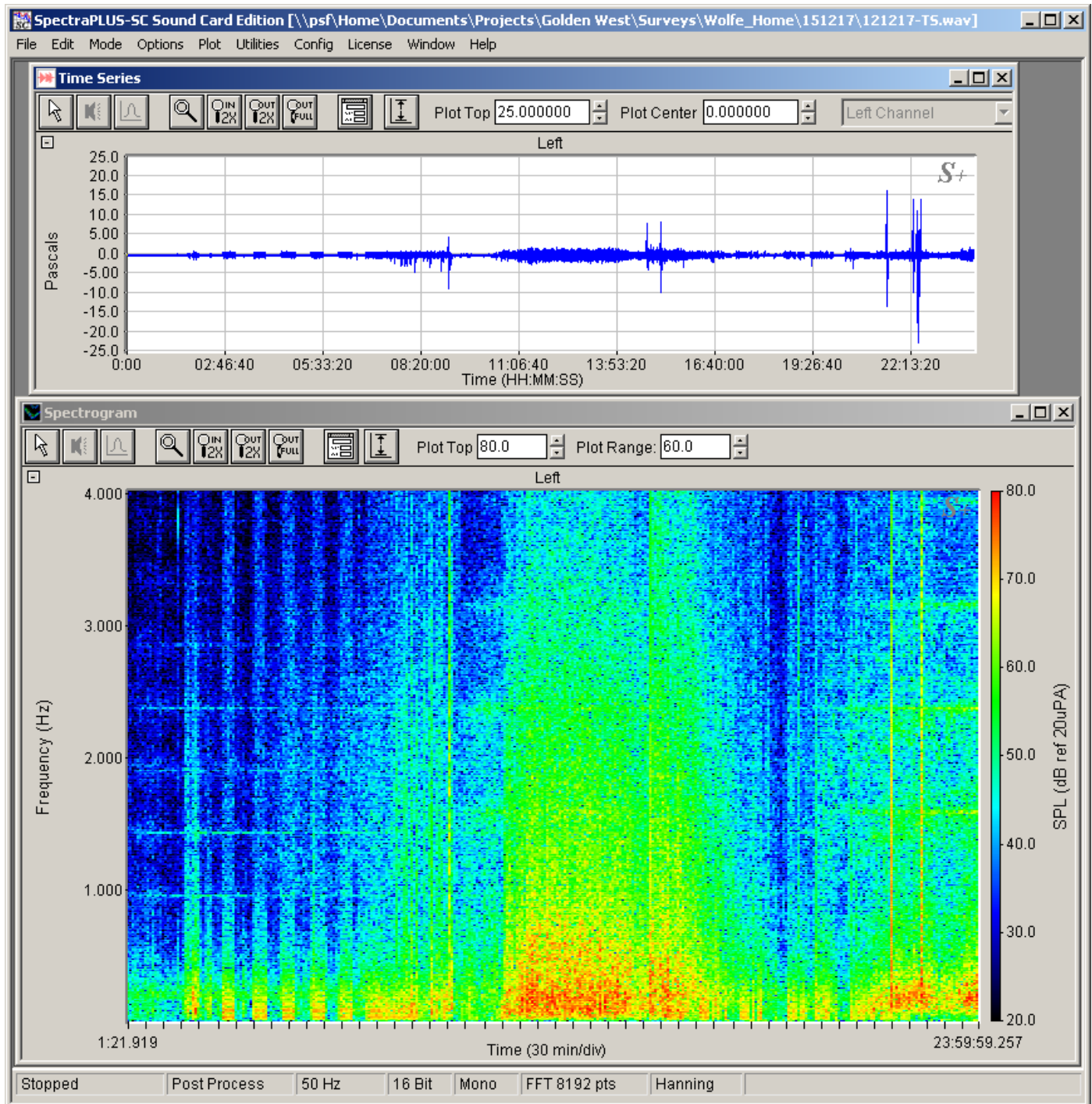


Note: Horizontal traces indicate wind turbine rotation. Rotation was observed at 0.79 Hz (15.8 rpm) until about 2:30 AM, then at 0.48 Hz (9.6 rpm) until the mid-morning. System maintenance was performed from 2 to 4 PM. Multiple variable rotation rates were observed in the afternoon. Rotations dropped to 0.48 Hz (9.6 rpm) after 11 PM.



Location: WOLFE HOME

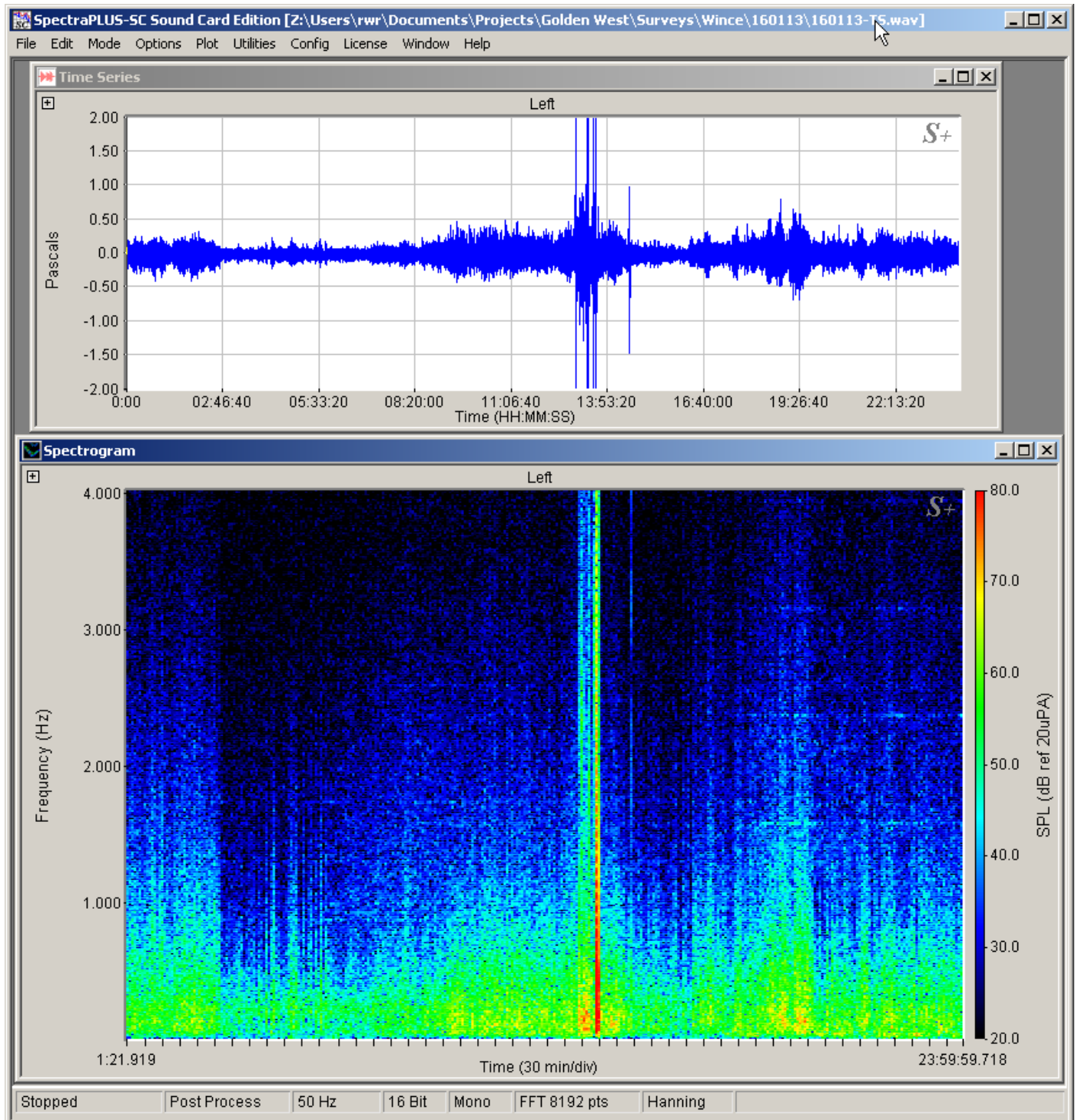
Date: 12/17/2015



Note: Horizontal traces indicate wind turbine rotation. Rotation was observed at 0.48 Hz (9.6 rpm) until about 9 AM when rotations increased to 0.78 Hz (15.8 rpm). Rotations vanished after 6 PM, and then reappeared at 0.78 Hz (15.8 rpm) after 7:20 PM.

Location: WINCE HOME

Date: 1/13/2016

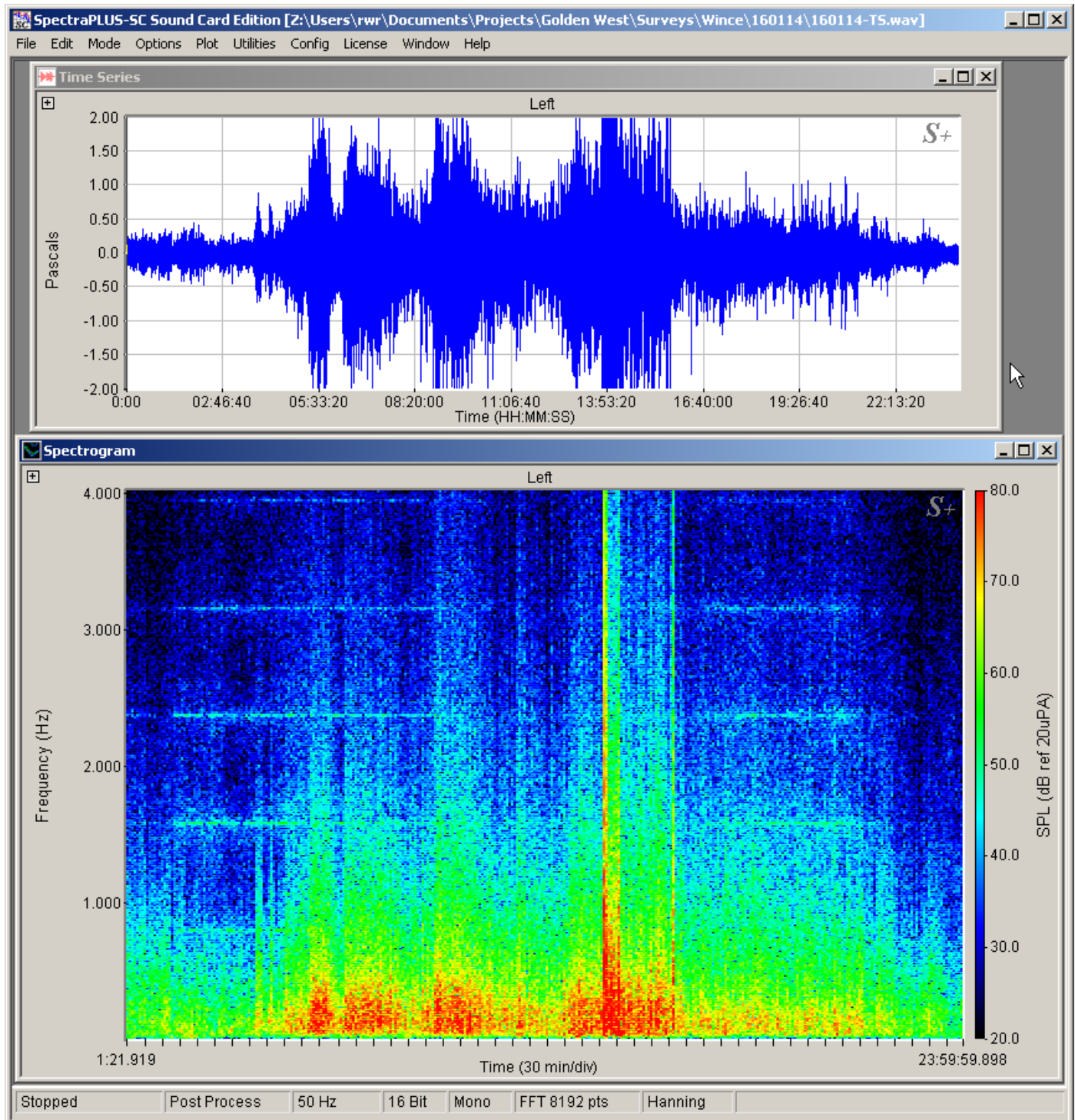


Note: Horizontal traces indicate wind turbine rotation. Rotation at 0.79 Hz (15.8 rpm) observed. Traces consistent with wind direction; stronger when winds from W-NW, lighter when winds light or from other directions.



Location: WINCE HOME

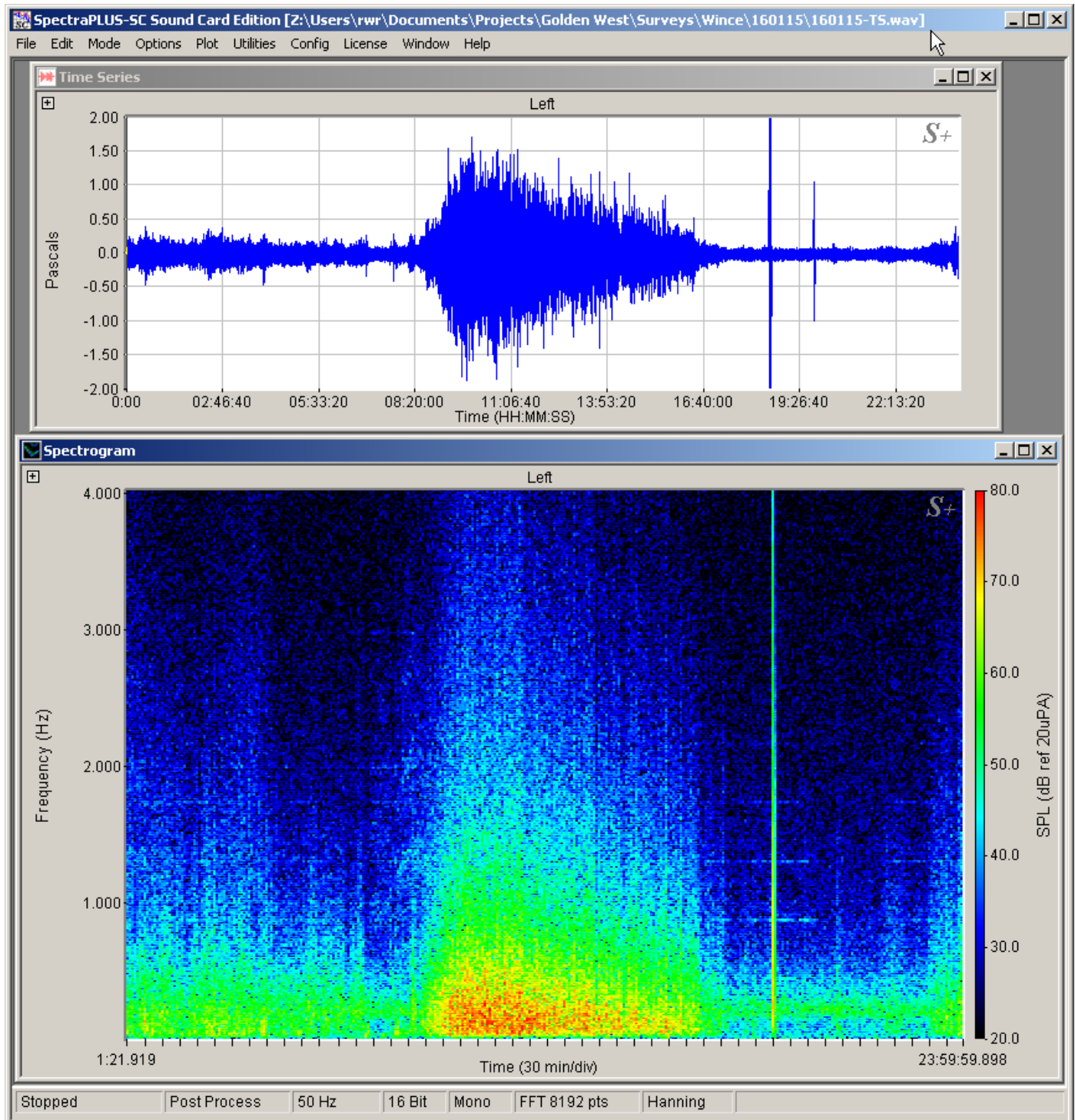
Date: 1/14/2016



Note: Horizontal traces indicate wind turbine rotation. Rotation at 0.79 Hz (15.8 rpm) observed. Traces consistent with wind direction; stronger when winds from W-NW, lighter when winds light or from other directions.

Location: WINCE HOME

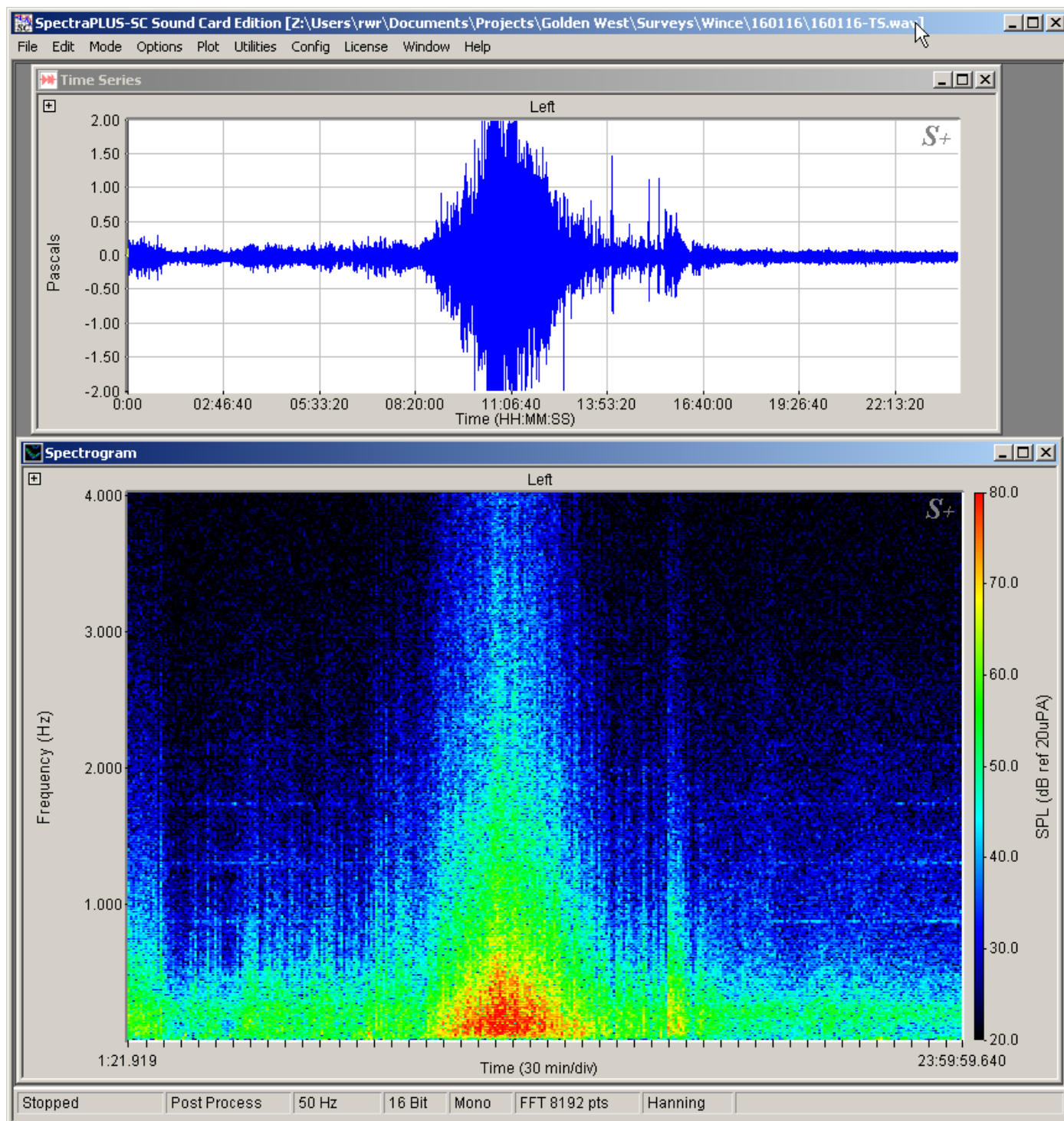
Date: 1/15/2016



Note: Horizontal traces indicate wind turbine rotation. Winds mid-day from east to south to west, dropping in strength. Rotation at 0.43 Hz (8.6 rpm) observed with light or no winds on ground.

Location: WINCE HOME

Date: 1/16/2016

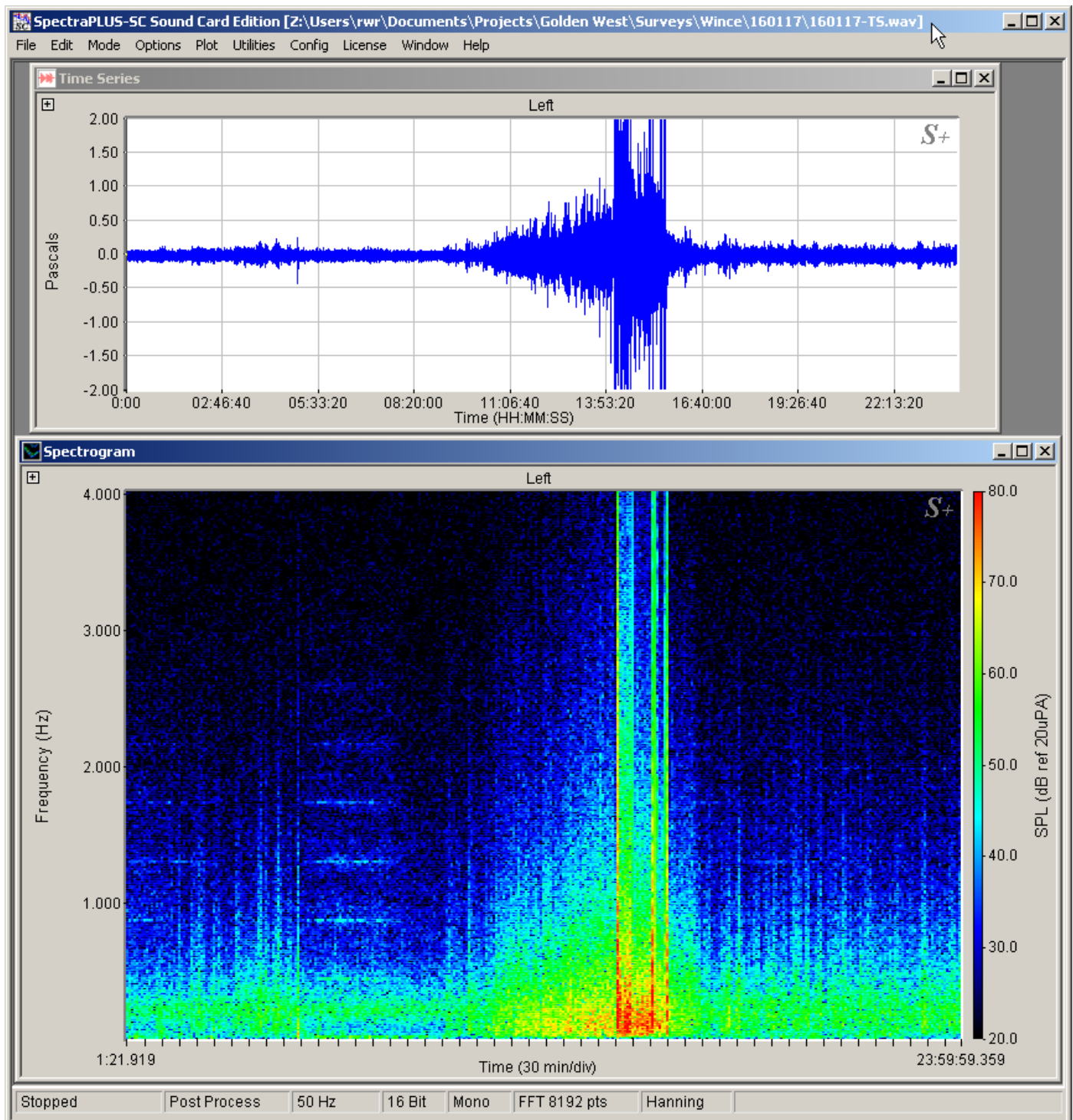


Note: Horizontal traces indicate wind turbine rotation. Rotation at 0.43 Hz (8.6 rpm) observed.



Location: WINCE HOME

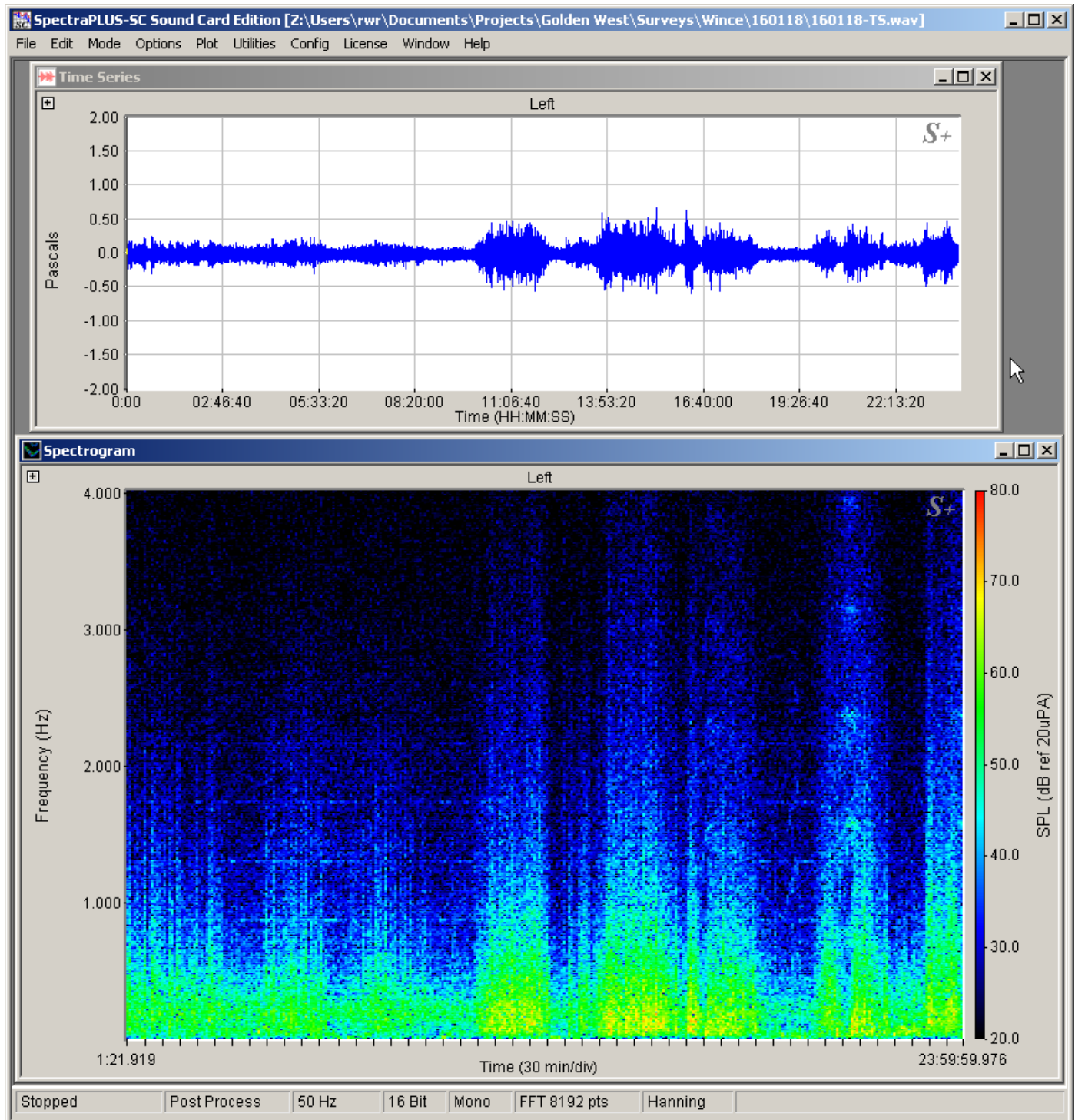
Date: 1/17/2016



Note: Horizontal traces indicate wind turbine rotation. Rotation at 0.43 Hz (8.6 rpm) observed.

Location: WINCE HOME

Date: 1/18/2016

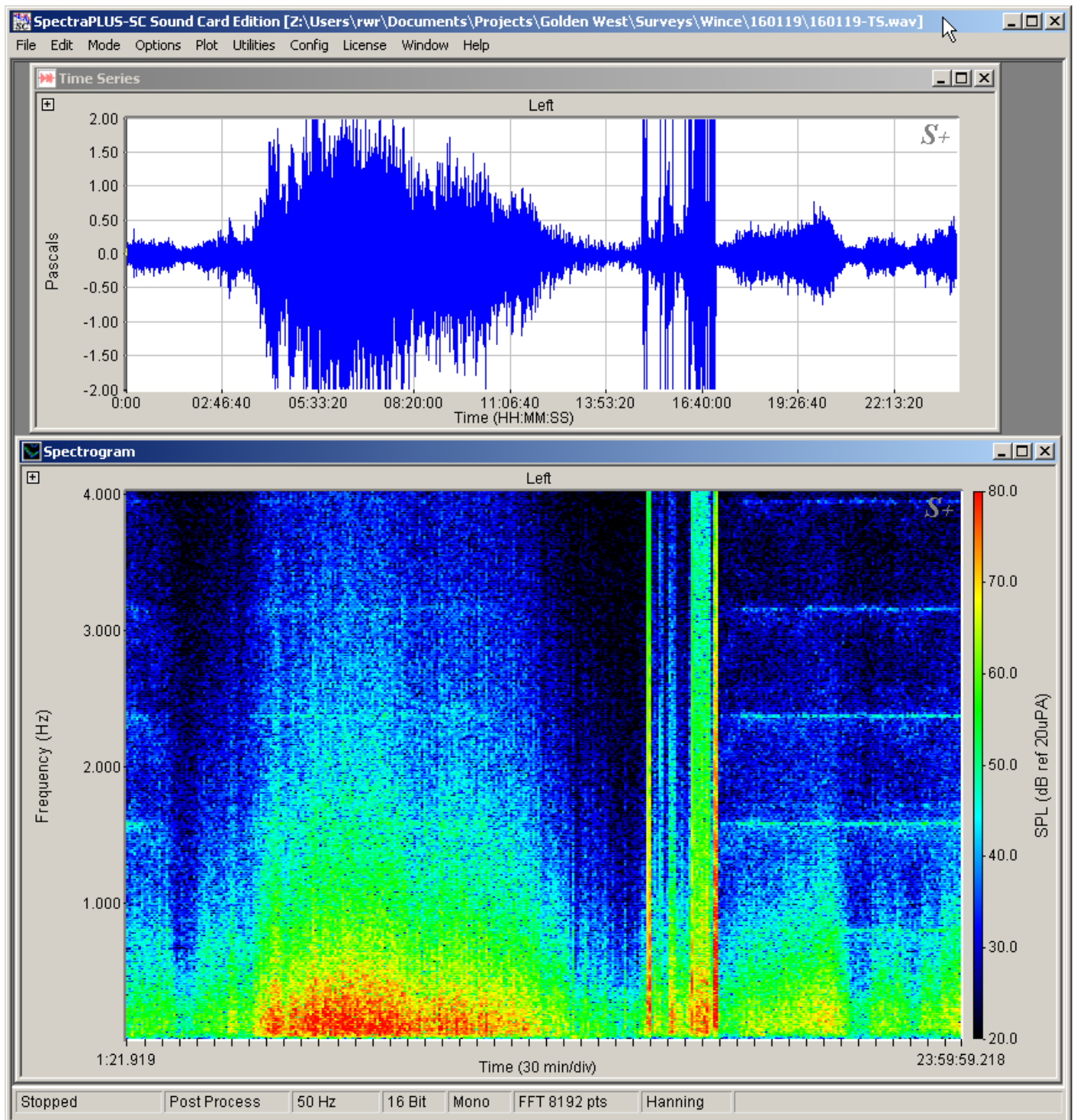


Note: Horizontal traces indicate wind turbine rotation. Rotation at 0.43 Hz (8.6 rpm) observed and a strong surge up to 0.79 Hz (15.8 rpm) in late evening.



Location: WINCE HOME

Date: 1/19/2016



Note: Horizontal traces indicate wind turbine rotation. Rotation at 0.79 Hz (15.8 rpm) observed during winds from W-NW.