Doosan Fuel Cell America, Inc.
195 Governor's Highway
South Windsor, CT 06074
T - 860 727 2200

January 30, 2017

RE: Responses to PE 1262-(12/27/16 Notice) Interrogatories – Set Three, PETITION NO. 1262 - Doosan Fuel Cell America, Inc. petition for a declaratory ruling that no Certificate of Environmental Compatibility and Public Need is required for the construction, maintenance, and operation of a 1380-kilowatt customer-side combined heat and power fuel cell facility to be located at the Borough of Naugatuck Waste Water Treatment Plant, 500 Cherry Street Extension, Naugatuck, Connecticut.

Dear Siting Council:

Please see the attached responses to the interrogatories with exhibits to the questions posed by the Connecticut Siting Council on 12/27/16 for PE 1262 – Set Three.

Please address additional questions to:

Walter Bonola
195 Governor's Highway
South Windsor, CT 06074
(860) 727-2010
Walter.Bonola@doosan.com

Thank you for your time and consideration.

Sincerely,

Doosan Fuel Cell America, Inc.

Dawn Mahoney

Dawn Mahoney, Esq.
General Counsel
Doosan Fuel Cell America, Inc.

VIA ELECTRONIC MAIL

December 27, 2016

Dawn Mahoney, Esq.
General Counsel
Doosan Fuel Cell America Inc.
195 Governor's Highway
South Windsor, CT 06074

RE: **PETITION NO. 1262** - Doosan Fuel Cell America, Inc. petition for a declaratory ruling that no Certificate of Environmental Compatibility and Public Need is required for the construction, maintenance, and operation of 1380-kilowatt customer-side combined heat and power fuel cell facility to be located at the Borough of Naugatuck Waste Water Treatment Plant, 500 Cherry Street Extension, Naugatuck, Connecticut.

Dear Attorney Mahoney:

The Connecticut Siting Council (Council) requests your responses to the enclosed questions no later than December 8, 2016. To help expedite the Council's review, please file individual responses as soon as they are available.

Please forward an original and 15 copies to this office, as well as send a copy via electronic mail. In accordance with the State Solid Waste Management Plan and in accordance with Section 16-50j-12 of the Regulations of Connecticut State Agencies the Council is requesting that all filings be submitted on recyclable paper, primarily regular weight white office paper. Please avoid using heavy stock paper, colored paper, and metal or plastic binders and separators. Fewer copies of bulk material may be provided as appropriate.

Yours very truly,

Melanie Bachman
Acting Executive Director

MB/MP

c: Council Members

Petition No. 1262
Doosan Fuel Cell America, Inc.
500 Cherry Street Extension
Naugatuck, CT
Interrogatories – Set Three

38. In Doosan's response to question 32, flood elevation data is provided, and the project would be located approximately ten feet above the 100-year base flood elevation. Approximately what is the 500-year base flood elevation in the vicinity of the project?

R38. The 500-year base flood elevation in the vicinity of the project is 180 feet taken at location 41°28'23.48 N 73°03'13.13 W. The ground elevation of the proposed site was taken as 181 feet at location 41°28'23.38 N 73°03'13.89 W, therefore, the project would be located approximately 1 foot above the 500-year base flood elevation.

39. Referencing Doosan's response to question 35, Doosan included a sound study based on testing a fuel cell facility. Please provide a site specific (i.e. consistent with the site plan) noise analysis report indicating the methodology used to compute the noise levels and identify the Connecticut Department of Energy and Environmental Protection (DEEP) Land Use Zones (A, B, or C) of the noise emitter and the noise receptors and indicate if the project is in compliance with the DEEP noise standards for the applicable emitter to receptors at the host property boundaries.

R39. Please see Naugatuck – 1 Site Specific Noise Analysis Report for Naugatuck.

ATTACHMENTS

NAUGATUCK -1 SITE SPECIFIC NOISE ANALYSIS REPORT

Prepared For: **Doosan Fuel Cell America Inc.**

Point of Contact: **Walter Bonola**

Prepared by: Acoustical Technologies Inc.
50 Myrock Avenue
Waterford, CT 06385-3008

Subject: Naugatuck WWTP
Airborne Noise Assessment

Author: Carl Cascio

Date: January 30, 2017

Revision: 1

Table of Contents

Summary

This document makes a positive acoustic assessment that should assist in meeting the acoustic noise concerns during the operation of three Doosan Purecell Model 400 fuel cells at the Naugatuck WWTP in Naugatuck, CT. An acoustic assessment plan was developed and executed to acquire acoustic information useful in explaining and mitigating the potential airborne noise issues associated with operation of the Doosan Purecell Model 400 fuel cells. It is important to show that the airborne noise generated by the fuel cells will not significantly impact the Naugatuck WWTP's neighbors.

The airborne noise levels expected to be generated by three Doosan fuel cells operating at the Waste Water Treatment Plant in Naugatuck were simulated by exciting a set of four co-located speakers at two of the fuel cell cooling module positions. The four speakers produced an overall airborne noise level that was about 12 dB higher than the levels measured for a similar Doosan fuel cell installed at Mount Sinai Hospital in Hartford, CT. One-third octave band analysis showed the speakers to match the fuel cell noise signature at frequencies below 400 Hertz where the A-weighted levels were low and to exceed the fuel cell signature by a large amount at higher frequencies where the fuel cell signature was higher.

Airborne noise levels were measured at distances from five to seventy meters from the fuel cell locations. The speakers produced overall A-weighted sound pressure levels from 88 to 81 dBA reference 20 microPascals at distances of 5 and 10 meters from the proposed cooling module locations. The airborne noise levels at nearby homes to the northwest varied from a low of 40 to a high of 50.5 dBA reference 20 microPascals (just below the residential 51 dBA noise requirement). Airborne noise levels at the property line 21 meters west across the street from the fuel cell location were 68 to 69 dBA and just below the 70 dBA limit for an Industrial Zone. The high ambient noise (57 dBA) generated by the Treatment Plant prevented measurement of the speakers' airborne noise on the east and south sides of the site. Since the 57 dBA ambient noise level in these areas is below the 70 dBA noise requirement in an Industrial Zone there are no acoustic issues expected with operation of the three fuel cells in the Industrial Zone.

Three fuel cells are expected to produce 5 dB more airborne noise than one fuel cell. Since the speakers generated an airborne noise level about 7 dB higher than the levels expected to be produced by three operating fuel cells, the speaker results discussed above exceed the expected noise levels from three fuel cells by about 7 dB. This allows 7 dB more margin to be added to the results in Table 2 reducing the airborne noise levels expected at the nearby property lines. The end result is that airborne noise at all the property line locations are expected to meet the state Overall Sound Pressure Level requirements at all the locations.

The Connecticut's Noise Code (Reference 1) also calls for review of acoustic issues associated with impulse noise, prominent discrete tones, infrasonic and ultrasonic noise. Operation of the three fuel cells is expected to meet all of these requirements at all of the nearby property lines.

Introduction

Acoustical Technologies Inc. was tasked as part of a Doosan site permitting process with an assessment of potential acoustic issues associated with fuel cell airborne noise reaching the properties adjacent to the Naugatuck Waste Water Treatment Plant (WWTP) location in Naugatuck, CT. Responding to a request from Walter Bonola, a site visit was made on January 19, 2017. During the visit a survey of the airborne noise levels produced by a set of speakers simulating the airborne nose produced by a Doosan Fuel Cell was made in order to identify potential airborne noise issues. Airborne noise measurements were taken to quantify the propagation of the simulated fuel cell airborne noise to the adjacent properties. Background airborne noise levels were also made with the speakers off. This document provides an acoustic assessment to assist in meeting acoustic noise concerns during the permitting process for siting the Doosan fuel cell at 400 Cherry Street Ext. on the Naugatuck WWTP property.

Development of the Acoustic Assessment Plan

The purpose of this effort is to acquire acoustic information useful in explaining and mitigating the potential airborne noise issues associated with the operation of three Doosan Purecell Model 400 Fuel Cells at the Naugatuck WWTP in Naugatuck, CT. The site on Cherry Street Ext. is located in an Industrial Zone adjacent to the Naugatuck River. The closest homes are to the northwest on Cherry Street. A wooded area lies to the west and south. Grove cemetery lies to the east and northeast across both the Naugatuck river and CT route 8. The industrial area continues to the north. It is important to determine whether the airborne noise generated by the Doosan fuel cell equipment will impact these neighbors.

The acoustic impact is assessed in the following way. The fuel cells are yet to be installed so there is no way to measure fuel cell operating airborne noise levels at the new site. The fuel cell airborne noise has been measured at other sites and one-third octave band airborne noise levels of a typical Doosan Purecell Model 400 fuel cell are available for reference. Using this data, a set of four speakers will be programmed through a set of two octave band filters to generate a noise spectrum similar to that of the fuel cell. This spectrum will then be played through an audio amplifier to create the electrical voltage necessary to drive the four speakers. In order to overcome the high background noise at the site the speaker output will be increased to a level about 12 dB higher than the overall dBA level measured on a fuel cell at 10 meters. With the speakers on, this approach then follows the traditional “What is the airborne noise level at the neighbor’s property line?”. The four speakers were run and airborne measurements made near the fuel cell and at several of the neighbor’s property lines. This measured site data can also be used to estimate noise levels at other neighbor’s property lines as well. The town of Naugatuck noise ordinance and the State of Connecticut Noise Code have been consulted to assess the impact of the measured and estimated acoustic levels. Noise mitigation may be recommended if the airborne noise estimated from the fuel cells exceed the town and state noise requirements at the neighbor’s property lines.

Acoustic Measurement Program

The acoustic data necessary to assess the impact of the Doosan Fuel Cell is described below: Airborne sound pressure measurements and audio tape recordings were conducted at the Naugatuck WWTP property on and near 400 Cherry Street Ext. during the morning hours of January 19, 2017. This testing established both background airborne noise levels and simulated airborne noise levels with the speakers operating. The overall A-weighted airborne noise measurements were made with an ExTech model 407750 Digital Sound Level Meter (s/n 3072577) that had been calibrated just prior to and after the test with a Quest model QC-10 Calibrator (s/n Q19080194). Measurements were taken with A-weighting (frequency filtering that corresponds to human hearing) and with the sound level meter in a Slow response mode. For reference, a noise level increase of 1 dB is equal to an airborne sound pressure increase of 12.2 per cent. The audio tape recordings were conducted with a Sony Digital Audio Tape Recorder (model TCD-D8 s/n 579588 on channels 1 and 2). Two PCB microphones (model 130C10 s/n 11283 and 130C10 s/n 10641) were powered by two Wilcoxon P702B power supply/amplifiers (s/n 1992 and 1995 respectively). The PCB microphones were also calibrated just prior to and after the test with a Quest model QC-10 Calibrator (s/n Q19080194). All measurements were made with the microphones at a height between four and five feet. A Hewlett Packard model HP3561A Dynamic Signal Analyzer, s/n 2338A00659, was used to perform A-weighted spectral analysis on the tape-recorded data.

At the WWTP site “source on” and background airborne noise measurements were taken at six neighbor’s property lines on Cherry Street Ext. (P1 – P6) and at the property line just behind the WWTP entrance gate on adjacent property (P0). Measurements were also taken at the entrance to adjacent property on the east side near the Naugatuck river (P7). See the Google satellite map in Figure 1 for the locations. Measurements near the operating fuel cell were simultaneously taken with a sound level meter and two microphones recording on the digital tape recorder. Figure 2 provides a drawing of the site locations for the three fuel cells. Figure 3 below shows a photograph of the speakers at one of the two source locations. The other location is marked by a small wood slab in the photograph. These locations were chosen because they are closest to the nearby homes. Measurements were taken from 9:30 am to 12:50 pm. At locations X and Y thirty minute records of the acoustic noise were stored for both background and speakers on.

Airborne noise measurements taken outside are corrupted by rain and wind so a day was selected when the weather was dry and the winds were 10 miles per hour or less. Table 1 provides the weather data in Naugatuck for the measurements on January 19, 2017. Measurements were taken over the period from 9:30 am until 12:50 pm. The table below shows the temperature and wind speeds in hourly intervals. Wind conditions were excellent and the wind did not affect the operating and background airborne noise measurements. There was no rain. Motor traffic was light and it was possible to wait for periods of time when no traffic was seen or heard at the measurement locations. Continuous operation of the waste water treatment plant did cause high background noise levels in the vicinity of the plant. (Airborne noise levels were around 57 dBA.)

Data Analysis

This section analyzes the airborne noise levels measured at the Naugatuck site and then estimates the property line airborne noise expected during operation of three Doosan Purecell Model 400 fuel cells. These levels are compared to the regulations in the Connecticut and town of Naugatuck noise ordinances. Both background noise levels at the Naugatuck WWTP site and estimated Doosan Fuel Cell equipment operating noise levels will be reported. Comparing these Naugatuck WWTP measurements with the state and town noise requirements will identify which nearby locations are quiet and meet the requirements and which locations are not quiet enough. The complete set of measured overall A-weighted airborne noise levels are given in Table 2 below for the conditions with the speakers on and off. The CT and Town of Naugatuck daytime noise requirement is 61 dBA and the nighttime requirement is 51 dBA for residential areas. The requirement in the Industrial Zone is 70 dBA. Figure 4 shows the Naugatuck zoning in this area. Figure 5 provides a photograph showing the WWTP and the homes to the northwest.

Figure 1. Naugatuck WWTP Site Map from Google

A comparison of the airborne noise produced at 10 meters by the Doosan fuel cell on the Mount Sinai Hospital site with the airborne noise produced by the speakers at the Naugatuck WWTP site is shown in Figure 6. The speakers match the fuel cell airborne noise for frequencies below 400 Hertz and greatly exceed the fuel cell airborne noise at higher frequencies. The overall dBA levels are about 12 dB higher for the speakers at both Positions X and Y.

Table 1. Naugatuck Weather on January 19, 2017

Date	Time	Temp. (ºf)	Humidity (%)	Dew Point (ºf)	Barometer (in HG)	Wind Speed (mph)	Wind Direct
Thursday	3:50 PM	42.8	60.77	30.2	29.96	8	nw
Jan 19	2:00 PM	44.6	56.72	30.2	29.97	5	nw
	12:50 PM	44.6	61.02	32	29.98	7	nnw
	11:55 AM	42.8	65.37	32	29.99	6	nw
	11:00 AM	41	75.32	33.8	30.02	5	nnw
	9:50 AM	39.2	86.79	35.6	30.03	5	wnw
Jan 19	8:55 AM	35.6	86.58	32	30.02	-	-

Figure 2. Doosan Fuel Cell Installation Drawing

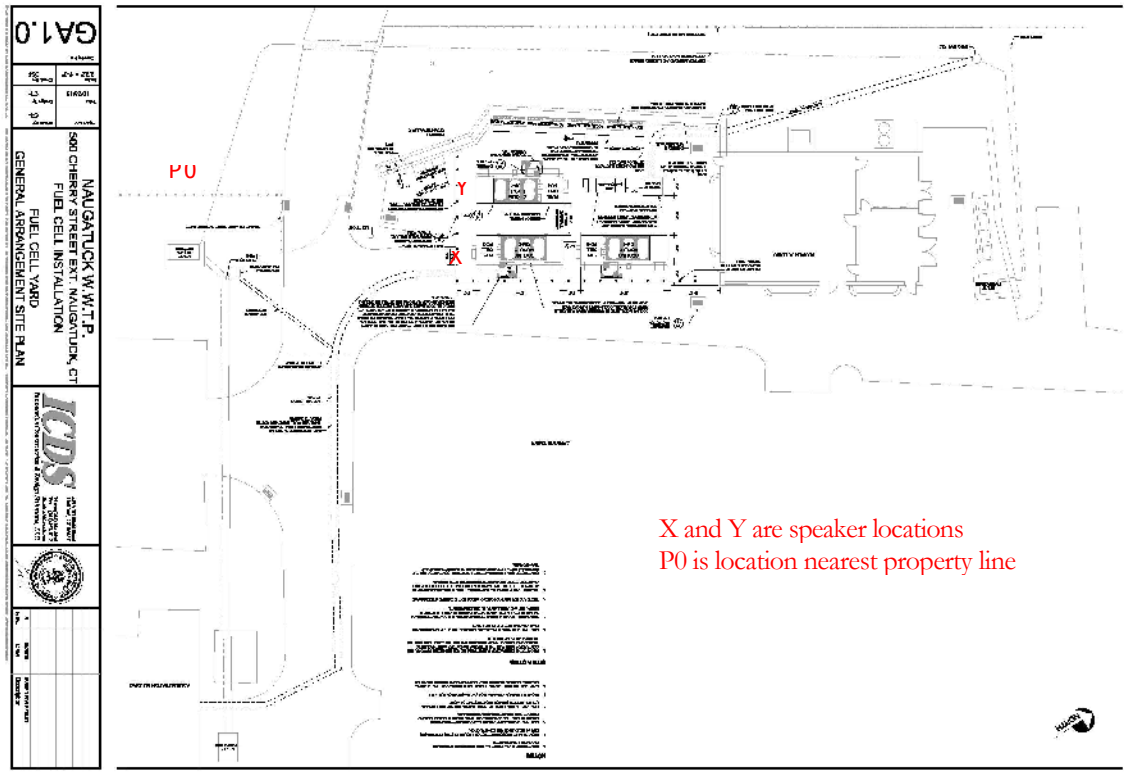


Figure 3. Source at Position Y on the Pad where Three Fuel Cells Will Be Located

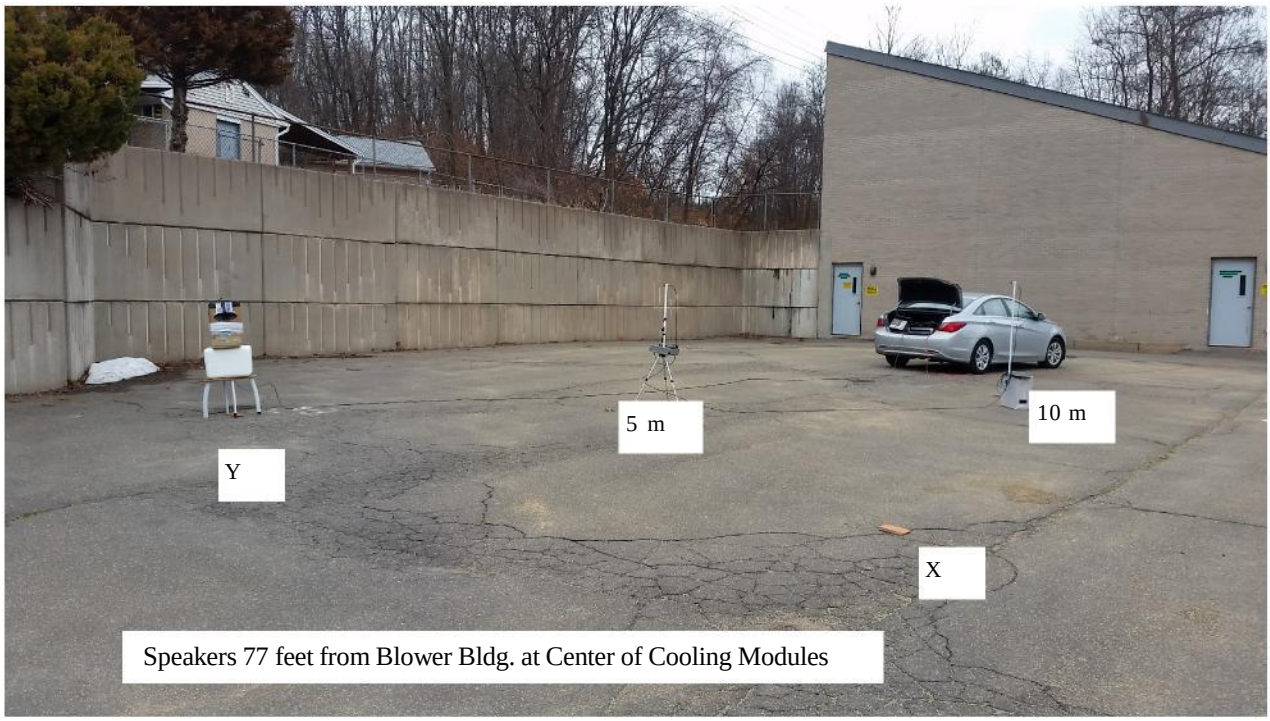


Figure 4. Naugatuck Zoning Map

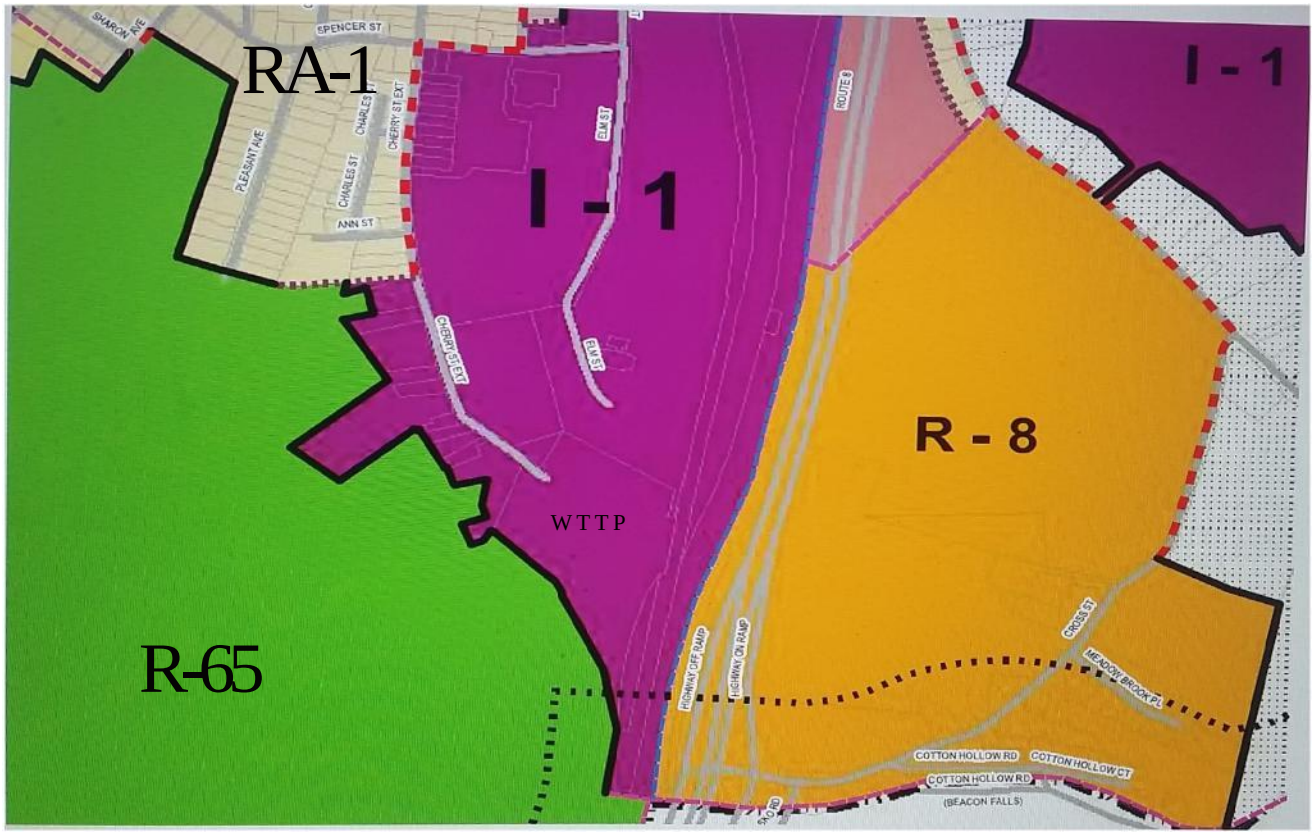


Figure 5. Steep Hillside Showing Homes to Right and Naugatuck WWTP at Bottom Left

Figure 6 The Four Speakers Generate Airborne Noise Well Above That of a Single Fuel Cell

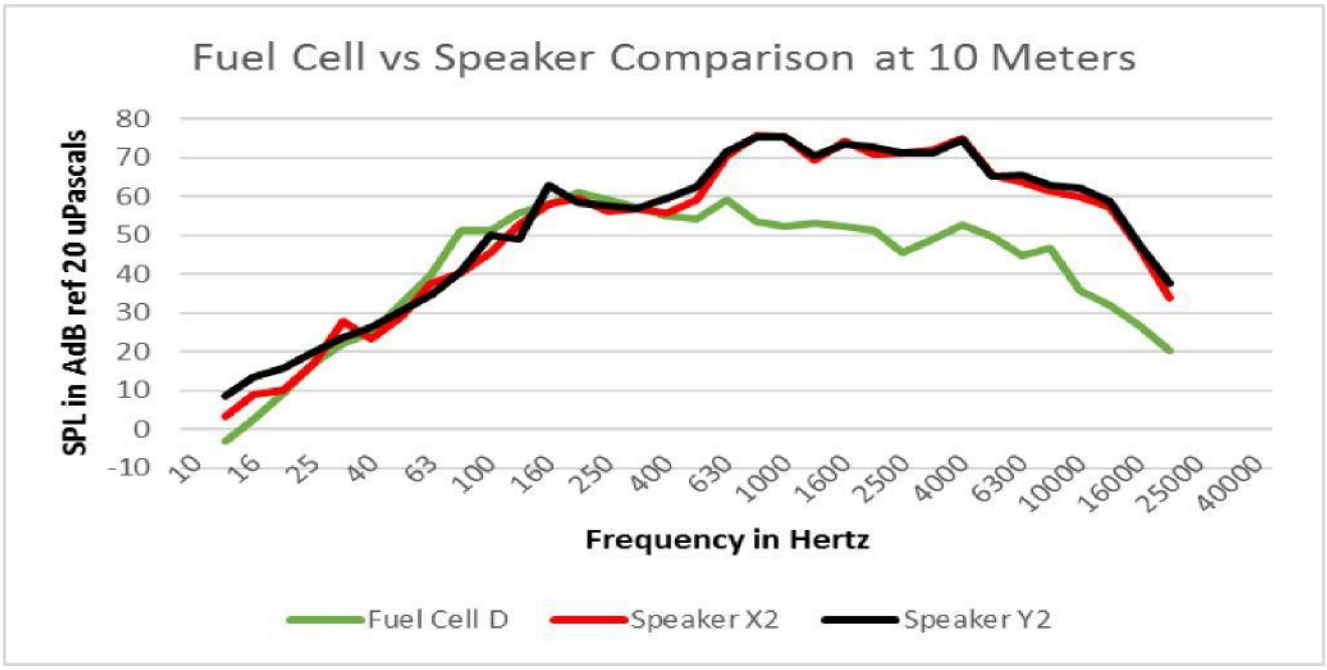


Table 2. Overall Sound Pressure Levels in dBA ref. 20 microPascals at Naugatuck WWTP Site

Location	Range in Meters	Speakers On X	Background	Background Corrected	Speakers On Y	Background	Background Corrected
Pos. X Ch 1	5	85.3	57.5	85.3			
Pos. X Ch 2	10	81.5	57.5	81.5			
Pos.Y Ch 1	5				87.6	57.5	87.6
Pos. Y Ch 2	10				81.7	57.5	81.7
P 0 - Entrance Fence	21/22 m	68.2	52.5	68.1	69	52.5	68.9
P 1 - Dog Pound Fence	44/39 m	54	51.5	50.5	52.5	51.5	45.8
P 2 - 497 Cherry St	59/55 m	50.8	49.5	45.1	50.5	49	45.3
P 3 - 501 Cherry St	48/40 m	50.8	49	46.2	50	49	43.3
P 4 - 505 Cherry St	44/42 m	52	51	45.3	50.5	52	< 47
P 5 - 506 Cherry St	30/36 m	51.5	51	42.3	51	52	<47
P 6 - 507 Cherry St	59/60 m	53.2	53	40.7	53	53	<47
P 7 - River Gate	63/70 m	57.2	57	<51	56.5	57	<51

Allowable Noise Levels

The Connecticut regulation for the control of noise provides in *CT section 22a-69*-3 (Ref. 1) the requirements for noise emission in Connecticut. *CT section 22a-69*-3.1 states that no person shall cause or allow the emission of excessive noise beyond the boundaries of his/her Noise Zone so as to violate any provisions of these Regulations. The Naugatuck Noise Code (Ref. 2) does not modify the pertinent sections of the CT Noise Code so the CT Noise Code will be used to evaluate the noise generated by the Doosan Fuel Cell Power and Cooling Modules. The following subsections discuss each type of noise and describe the results obtained from the measurements at the Naugatuck WWTP site.

The appropriate section of the Naugatuck zoning map is given in Figure 4. The map locates the Naugatuck WWTP in Industrial Zone I-1. Some of the homes at the end of Cherry Street Ext also appear to be in the Industrial Zone. The residential zones R-8 and RA-1 are too far away (more than 300 meters) to hear the speakers and by comparison the operation of the three fuel cells. The residential zone R-65 is currently undeveloped near the WTTP and while the R-65 zone is closer, it can be shown to be still far enough away to be unaffected by the airborne noise expected from the three operating fuel cells. The closest point of the R-65 zone is about 115 meters from the fuel cell location. The Mount Sinai Hospital report (Reference 3) showed that its single fuel cell was estimated to be below the 45 dBA Hartford noise limit at about 75 meters. Operating 3 fuel cells would add 4.8 dB bringing the 75 meter noise level to about 50 dB which is still below the 51 dBA residential limit at the Naugatuck site. The additional 40 yards of distance would further reduce the noise by about 5 dB bringing it well below the required level.

Impulse Noise

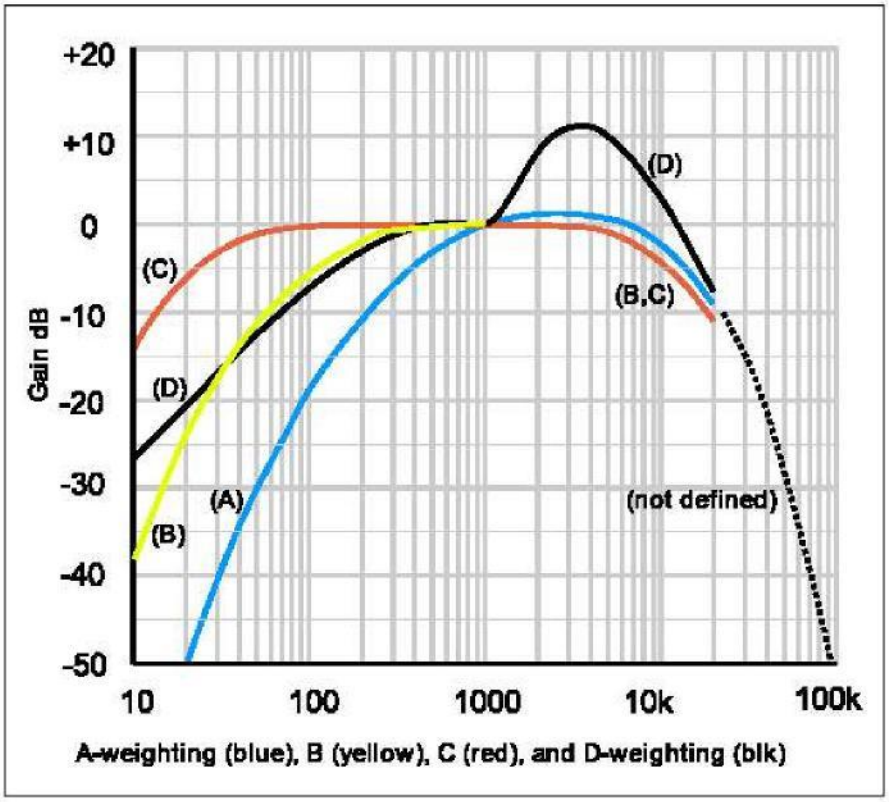
The Connecticut regulation for the control of noise states in *CT section 22a-69*-3.2 (part a) *Impulse Noise* that no person shall cause or allow the emission of impulse noise in excess of 80 dB peak sound pressure level during the nighttime to any class A Noise Zone. Class A Noise Zones are residential and hotel areas. Nighttime hours are defined as 10 pm to 7 am. *CT section 22a-69-3.2 (part b) Impulse Noise* states that no person shall cause or allow the emission of impulse noise in excess of 100 dB peak sound pressure level at any time to any Noise Zone.

A few words are in order to discuss the difference between A-weighted and un-weighted impulse noise. A-weighting emphasizes the middle and higher frequencies while reducing the influence of the low frequencies. Figure 7 plots the A-weighting curve versus frequency in blue. Below a frequency of 1 kiloHertz the acoustic level is attenuated by increasing amounts. The reduction is about 10 dB at 200 Hertz, 20 dB at 90 Hertz and 30 dB at 50 Hertz. It also reduces the level at very high frequency being down by 10 dB at 20 kiloHertz.

Impulse noise in excess of 80 dB was not observed during any of the measurements of the Doosan Purecell Model 400 fuel cell made at the Mount Sinai Rehabilitation Hospital on 18 January, 2017. This fuel cell design is similar to the units that will be installed in Naugatuck. Given the steady state nature of the fuel cell's noise signature there should be no acoustic issue with the State of Connecticut's impulse noise requirements.

Figure 7. Acoustic Weighting Curves

http://upload.wikimedia.org/wikipedia/commons/3/39/Acoustic_weighting_curves_(1).svg



Prominent Discrete Tones

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.3 Prominent discrete tones:* Continuous noise measured beyond the boundary of the Noise Zone of the noise emitter in any other Noise Zone which possesses one or more audible discrete tones shall be considered excessive noise when a level of 5 dBA below the levels specified in section 3 of these Regulations is exceeded. The Regulations establish different noise limits for different land use zones. Residential (homes and condominiums) and hotel uses are in Class A. Schools, parks, recreational activities and services are in Class B. Forestry and related services are in Class C. By my reading of the Regulations Naugatuck WWTP is a Class C emitter in an Industrial Zone. The noise zone standards in *CT section 22a-69-3.5* state that a Class C emitter cannot exceed the following overall sound pressure levels:

To Class C 70 dBA To Class B 66 dBA To Class A 61 dBA (day) 51 dBA (night)

The discrete tones limits are 5 dBA lower so that no tone may be higher than the following:

To Class C 65 dBA To Class B 61 dBA To Class A 56 dBA (day) 46 dBA (night)

The requirements for operating at the Naugatuck WWTP site for discrete tones would be 56 dBA for the surrounding residential properties during the day and 46 dBA at night. For adjacent properties in the Industrial Zone the discrete tone requirement would be 65 dBA.

To address the discrete tone issue we use measured data from the January 18 testing of a similar Doosan fuel cell. The photo in figure 8 plots the airborne noise measured 10 meters from the Mount Sinai Cooling Module (Reference 3) for frequencies from 0 to 1000 Hertz. This curve shows the two largest discrete tones produced by the Doosan Fuel Cell Cooling Module. The first tone is at 86 Hertz at a level of 65 dB reference 20 microPascals. The second tone is at 630 Hertz at a level of 56 dB reference 20 microPascals. The A-weighting corrections are -21.5 dB at 86 Hertz and -1.9 dB at 630 Hertz. Incorporating these corrections gives A-weighted levels of 44 dBA at 86 Hertz and 54 dBA at 630 Hertz at a distance 10 meters from the Cooling Module. These two levels are low enough to both meet the 65 dBA requirement even if three units are operating within the Industrial Zone since the 10 meter distance places the units within the Naugatuck WWTP property.

The airborne noise decreases with distance from the source so the next question is at what distance will the 10 meter level at the two frequencies drop to the requirement of 46 dBA. Reference 3 shows a transmission drop of 18 dB starting from the overall fuel cell source level of 70 dBA at 10 meters from the Cooling Module to the neighbor with the highest overall noise level (52 dBA). This nearest neighbor was 42 meters away from the source. If this transmission loss is applied to the 86 Hertz discrete tone at Naugatuck a neighbor at 42 meters should see a level of 31 dBA with 3 units running. If this transmission loss is applied to the 630 Hertz discrete tone at Naugatuck a neighbor at 42 meters should see a level of 41 dBA with 3 units running.

The nearest residential neighbor at Naugatuck is closer at 30 meters so we have to either interpolate the Mount Sinai data or use data measured at Naugatuck. If we interpolate the Mount Sinai data, the level at 30 meters would be about 14 dB lower than the 10 meter level. Thus, the 630 Hertz level at 30 meters would be about 45 dBA, just below the requirement. The terrain at Naugatuck is not flat like the Mount Sinai location but instead is a steep hill to the residences above the Naugatuck WWTP. See Figure 5 above. Reviewing Table 2 shows that the 10 meter source levels of 81.5 and 81.7 dBA at the two source locations are reduced to about 51 dBA at the nearest residence. This is a drop of about 30 dB not the 14 dB predicted by scaling the Mount Sinai data. The steep hillside adds at least 16 dB of additional attenuation for the homes on Cherry Street Ext. Hence the discrete tones at the nearest residence will probably be at levels of about 15 dBA for 86 Hertz and 29 dBA for 630 Hertz with 3 fuel cells running. There should be no acoustic issue with the State of Connecticut's discrete tone noise requirements.

Infrasonic and Ultrasonic Noise

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.4 Infrasonic and Ultrasonic* that no person shall emit beyond his/her property infrasonic or ultrasonic sound in excess of 100 dB at any time. 100 dB with respect to the common reference of 20 microPascals is a sound pressure of 2 Pascals or 0.00029 psi. Infrasonic sounds are sound pressure fluctuations below a frequency of 20 Hertz. Ultrasonic sounds are sound pressure fluctuations at frequencies above 20,000 Hertz.

Narrow bandwidth sound pressure spectrums in dB reference 20 microPascals at the 10 meter Cooling Module location given in Reference 3 can be used to compare with these Infrasonic and Ultrasonic noise requirements. Mount Sinai Hospital data was processed in the 0 to 100 Hertz and 0 to 100,000 Hertz frequency ranges. The bandwidth of each data point is 0.375 Hertz for the 100 Hertz range and 375 Hertz for the 100,000 Hertz frequency range. The infrasonic noise for frequencies up to 20 Hertz is shown in Figure 9. The maximum level at 10 meters is 57 dB reference 20 microPascals. The entire 20 Hertz band can be power summed and equals a value of 66 dB reference 20 microPascals, well below the requirement. The ultrasonic noise for frequencies up to 100 KiloHertz is given in Figure 10. The maximum level at 10 meters is 20dB reference 20 microPascals. The entire 80 KiloHertz band has been power summed and equals a value of to 31 dB reference 20 microPascals. Both levels fall well below the 100 dB limit at 10 meters from the Cooling Module. The noise levels at the neighbors will be approximately 30dB lower based on the analysis in the previous section and there should be no issue with either infrasonic or ultrasonic noise at any of the neighboring properties. It should be noted that while the spectrum analysis covers frequencies up to 100 kiloHertz, the microphone sensors lose some sensitivity above 25 kiloHertz. The flat response below 25 kiloHertz changes to a roll off that reduces the amplitudes at the very high frequencies. Fortunately, the measured noise levels are very low at 20 kiloHertz and decrease with frequency above that and thus, no ultrasonic acoustic issues are expected above 25 kiloHertz.

Figure 8. Discrete Tones Produced by the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20uPa)

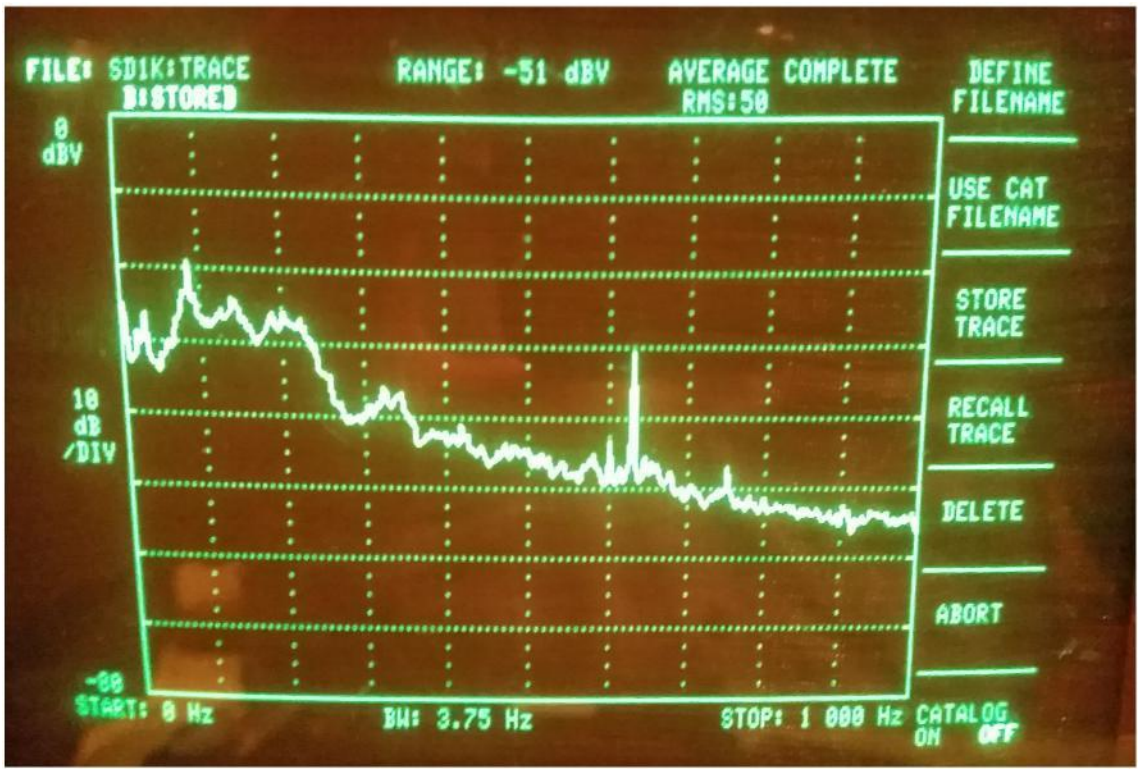


Figure 9. Infrasonic Noise from the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20uPa)

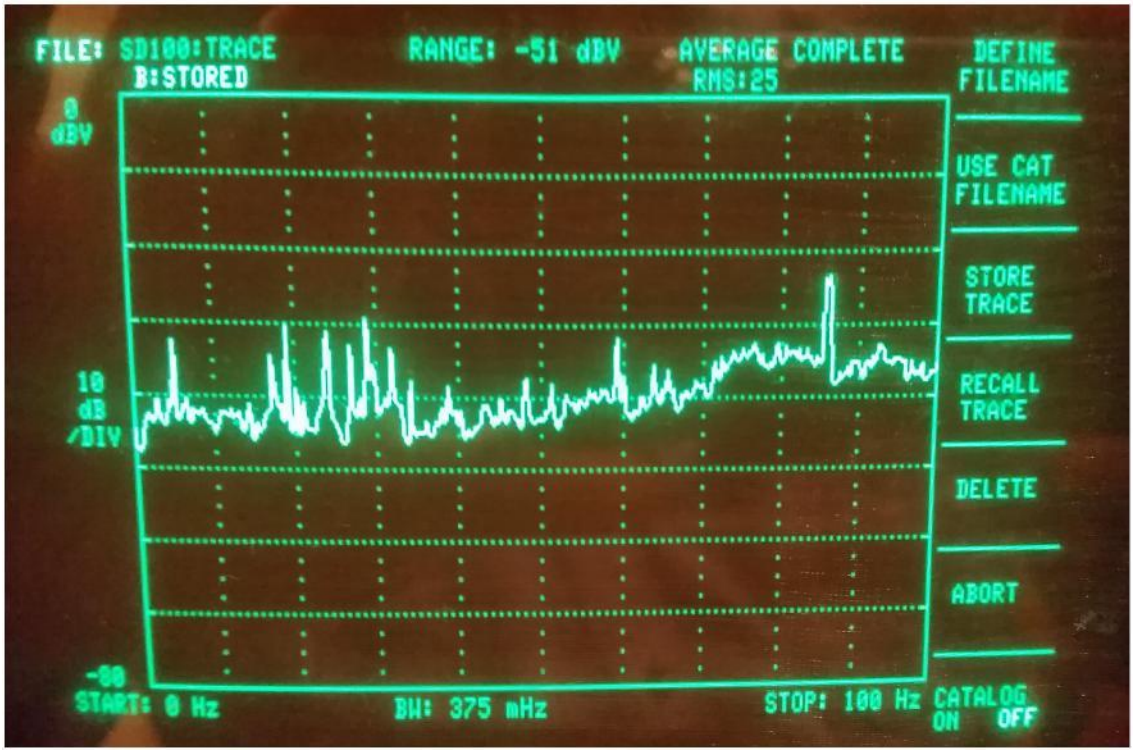
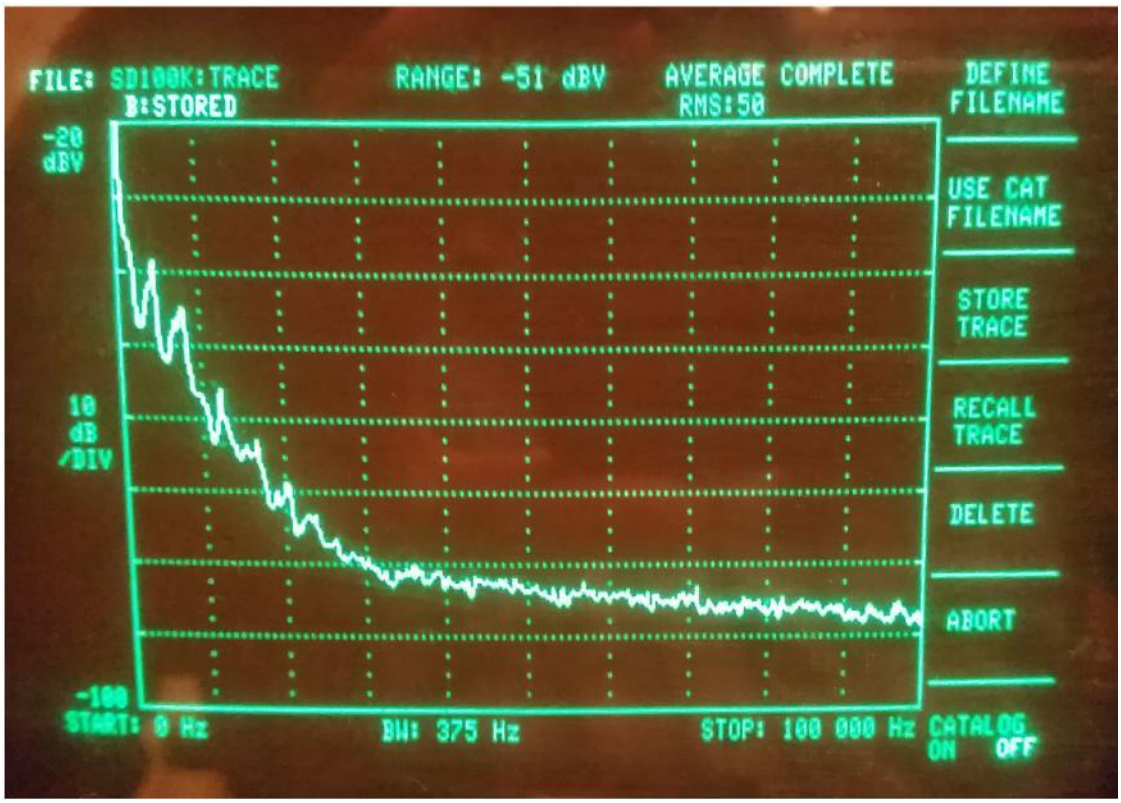


Figure 10. Ultrasonic Noise from the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20uPa)



Overall Sound Pressure Levels

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.5 Noise zone standards (a) No person in a Class C Noise Zone shall emit noise exceeding the levels stated herein and applicable to adjacent Noise Zones:*

Class C emitter to C 70 dBA B 66 dBA A/day 61 dBA A/night 51 dBA

This subsection is the most important noise requirement in the Connecticut noise ordinance. The Naugatuck noise ordinance does not alter the CT noise levels. Naugatuck WWTP falls into Class C. Please see *CT section 22a-69.2 Classification of land according to use* of the Connecticut noise ordinance for details.

It is important to establish the adjacent noise zones. In this case the nearby homes along Cherry Street Ext. to the northwest appear to be in the Class C zone (Industrial with the Naugatuck Zoning Code labeled I-1) as shown in Figure 4. Homes further to the north along Cherry Street are in the residential zone RA-1 (Class A). The Naugatuck WWTP itself and the adjacent properties to the north are also in the Industrial I-1 zone (Class C). The forested area to west is in a Residential R-65 zone while the cemetery across the river and highway to the east is in a Residential R-8 zone, both Class A.

The overall A-weighted sound pressure level measurements in dBA reference 20 microPascals are given in Table 2 above for the measurements made on January 19. The second column gives the approximate distance from the speakers to the measurement location, identified by a P number in Figure 1. The first number is the distance to the speaker at the "X" position while the second number is the distance to the "Y" position. Column 3 gives the noise levels measured with the speakers on at position "X" while column 4 gives the background levels before the speakers were turned on. Background corrections are applied to column 3 and the adjusted speaker noise is given in column 5. These levels with the background noise removed are estimates of the contribution provided only by the speakers at each location. Columns 6, 7 and 8 repeat this same information for the case with the speakers at position "Y". In this case the background was taken after the speakers at position "Y" were turned off

The following table compares the Naugatuck WWTP speaker data with the Mount Sinai Hospital fuel cell measurements. Averages are calculated for the two speaker positions and the three 5 and 10 meter locations measured at the Mount Sinai Hospital. Doubling the measurement distance from 5 to 10 meters shows a consistent drop in level from 4.5 to 4.9 dB, slightly less than the 6 dB expected. At 5 meters the speakers generate airborne noise levels 13 dB higher than the operation of one fuel cell. At 10 meters the speakers generate airborne noise levels about 12 dB higher than the operation of one fuel cell. If we assume that three fuel cells create noise levels 4.8 dB or 10*log(3) higher than one fuel cell, the speakers are about 7 dB louder than the three fuel cells using the 10 meter data. This is a conservative assumption since one of the fuel cells is blocked by a high wall and the other two fuel cells in terms of its airborne noise propagating towards the homes on Cherry Street.

Table 3 Measured Airborne Noise Levels in dBA (20 microPascals) Corrected for Background

Source	5 meters dBA	10 meters dBA	Range Difference dB	Level Difference dB	Expected dBA Level For 3 Fuel Cells
"X"	85.3	81.5			
"Y"	87.6	81.7		5 meters	78.1
Speaker Avg	86.5	81.6	4.9	13.2	
Fuel Cell Avg	73.3	69.5	4.5	10 meters	74.3
Mt Sinai "A"	74	69.9		12.1	
Mt Sinai "B"	74.3	70.3			
Mt Sinai "C"	71.5	68.3			

Reviewing Table 2 it is clear that the airborne noise levels drop significantly in propagating uphill to the homes along Cherry Street. Since the highest background corrected level was measured at 50.5 dBA along Cherry Street Ext, this level is already below the Class C requirement of 51 dBA for a residential zone. This level was created by four speakers operating at least 7 dB above the level expected during operation of three fuel cells. The Cherry Street Ext homes should see airborne noise levels no higher than 44 dBA. Location P0 across the road from the fuel cells is much closer than the nearby homes (21 meters) and showed airborne noise levels of 68.1 and 68.9 dBA with the two speaker locations. These levels are slightly below the 70 dBA allowed in an Industrial Zone. Reducing these levels by 7 dB produces estimated values

of 61 and 62 dBA during the operation of three fuel cells putting the expected levels well below the noise requirement. The other measured location at P7 on the river side of the plant showed high background levels (57 dBA) and the speakers could not be detected. Since the measured airborne noise with speakers on were less than 57 dBA, this position also meets the 70 dBA requirement for an Industrial Zone. The three fuels cells will probably generate levels less than 50 dBA at the river side of the WTTP. Airborne noise levels traveling across the river and CT Route 8 will be considerably less than 50 dBA and not observable. Operation of the three fuel cells will have no significant acoustic impact at the Naugatuck WWTP site and to the nearby neighbors.

Conclusions

The purpose of this effort is to evaluate the acoustical environment at the proposed Naugatuck WWTP fuel cell site in Naugatuck, CT. This has been accomplished and the results show that the operation of three fuel cells will meet all of the CT and Naugatuck noise requirements.

References

1) CT DE&EP *Noise Control Regulation RCSA Section 22a-69-1* to 22a-69-7.4 http://www.ct.gov/dep/lib/dep/regulations/22a/22a-69-1through7.pdf

2) Section 13-6, Naugatuck Municipal Code of Ordinances

3) Mount Sinai Rehabilitation Hospital Airborne Noise Assessment, Carl A. Cascio, Acoustical Technologies Inc., January 24, 2017