Data Center Noise Study

for

Prince William, Fauquier, and King George Counties

and the Town of Warrenton

by John W. Lyver, IV Ph.D.

Original Issue:
December 31, 2022

Foreword

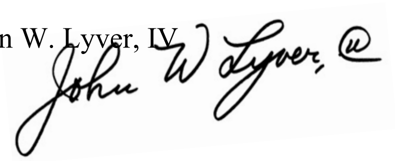
This study provides a predictive analysis of the noise intensities that will be generated by currently operating and planned data centers in northern Virginia. **Up through the date of this study, the Prince William County (PWC) government has not performed ANY noise analyses for any of the data centers within PWC. In fact, the PWC Planning Office has stated that they do not have the capability to perform a holistic noise assessment study nor the permission to do so.**

This study is a basic analysis of the noise intensities due to data centers (current or future) for several small areas. The study uses the acoustical and wave physics principles described in a pair of freshman-level introductory physics textbooks as well as internet sources. The model was developed by the author using a combination of Microsoft Excel and a freshman-level computer application/language called MATLAB^{TM}. The modeling done was based on a 3^{rd} year Computational Data Science undergraduate program offered at George Mason University and does not use more advanced methods of modeling. However, the PWC Planning Office does not have this level of analytical capability.

The only other noise analysis report that the author is aware of was developed by a small electronics firm for the Amazon Web Services' proposal for a new data center in Warrenton, VA. After a brief review of that report, it was determined to be non-credible by the author of this study (et al.). In fact, the study was subsequently withdrawn by Amazon's legal team less than two days later after the analysis was made public.

While the author of this study does not contend that the results presented in the study are exact, it is believed through numerous verification methods that the values presented are very representative of the noise intensities that will be generated and most likely conservative in nature. **Noise levels in each small area, each school, and public safety facility are projected to significantly exceed the applicable noise ordinance levels by as much as over 15 decibels.** The goal of this study is to show the leadership in the PWC, Fauquier County, Town of Warrenton, and King George County that this data center-generated noise is a serious issue which requires immediate serious attention and serious action to preclude adverse health effects on the citizens living and working in these locales.

r/s
John W. Lyver, IV



Executive Summary

The following conclusions are offered:

- **PWC has not done ANY credible noise studies looking at the potential noise levels that will be created by the current data centers (DC) or building additional data centers.**
- **PWC has not done ANY credible studies looking at the potential noise-related health impacts that will be created by the current data centers or building additional data centers.**
- The study shows that currently, the maximum noise levels in the PWC Noise Ordinance #14 are probably being exceeded in more places than where resident complaints have been filed.
- This study shows that many residential areas, school, and public safety facilities will be negatively impacted as data centers are built. **Noise mitigation should be mandated at data center sites currently operating and should be an integral part of the design for data centers in the planning process. Local government should NOT permit this essential consideration to be an afterthought, only addressed through belated enforcement measures.** The county should demand strong, contractual commitments for noise control.
- This study shows that external noise levels are already excessive at several schools, and it is predicted that internal noise levels will exceed ANSI recommended classroom noise levels. The PWC Schools should immediately test and prepare noise mitigation strategies inside classrooms.
- **PWC has not done ANY credible studies looking at the need for mitigation to Public Schools, Private Schools, or Public Safety Facilities due to the elevated noise levels.**
- The current exemption in the Noise Ordinance for Heating, Ventilation, and Air Conditioning systems operating needs to be removed so that data centers do not claim these exemptions.
- Other public facilities like libraries, and hospitals, need to be studied for noise impacts.
- **No additional rezoning permits should be approved until PWC has done a comprehensive noise study for <u>each</u> proposed site.**

Table 1: Summary of Noise Readings for Small Areas Studied

Small Area Studied	Range of Current Noise dB(A)	Range of Projected Noise with all DC Built dB(A)	Closest DC feet	Estimated % of Small Area will violate PWC Noise Ordinance #14
Heritage Hunt, Gainesville, VA	45 – 56 (1)	67 - 72	980’	100%
Oak Valley, Gainesville, VA	47 – 57 (1)	68 - 77	180’	100%
Greenhill Crossing, Gainesville, VA	44 – 66 (1)	62 - 77	195’	100%
Manassas National Battlefield Park	54 – 63 (1)	59 - 83	750’	> 90%
Great Oak, Manassas, VA	58 – 64 (1)	67 - 73	490’	100%
Amberleigh Station, Bristow, VA	49 – 54	70 - 77	335’	100%
Warrenton, VA	49 – 57 (2)	56 - 70 (2)	(2)	~ 90% (2)
King George County VA	43 – 54	65 - 77	250’	100% (3)

Notes on Table 1:

(1) *Highest current readings: Heritage Hunt is at entrance on Heathcote Blvd, Oak Valley is along Sudley Road, and Greenhill Crossing and MNBP is along I-66.*

(2) *Warrenton noise readings were predicted at the DC property boundary and measured against Town of Warrenton Noise Ordinance*

(3) *King George County noise measured against the King George County Noise ordinance.*

(4) *Doubling the energy is 3 dB(A). A 10 dB(A) increase is 10 times the noise energy and 20 dB(A) increase is 100 times the noise energy.*

Public and Private schools will be subject to excessive noise from the DCs currently operating and in the planning stages. Throughout this study, it has been noted that several public schools will have noise levels 10-16 dB(A) higher than the PWC Noise Ordinance #14. These levels of noise will impact student learning in three ways: (1) excessive noise in the classroom will disrupt the quality of learning, (2) a vital part of a rounded education is for students to play, learn, and interact outside the school building in learning and physical activities, and (3) stress induced health issues in children and school staff personnel. With excessive noise around our schools, students may experience the health effects that a stressful environment will produce because they will wake up in the noise environment, be at school in the noise environment, play at home and sleep in the noise environment. Basically, they will not escape the noise environment. Some of the schools with predicted noise levels of over 70dB(A) after full 'build-out' of data centers include:

Table 2: Predicted: Public Schools with Excessive Noise

Grade Level	School	dB(A) after build-out of all DCs
Elementary School	Bristow Run ES	76.1 dB(A)
	Chris Yung ES	81.1 dB(A)
	George P. Mullen ES	70.1 dB(A)
	Piney Branch ES	79.5 dB(A)
	Tyler ES	70.3 dB(A)
	Victory ES	70.3 dB(A)
Middle School	Gainesville MS	77.1 dB(A)
High School	Gainesville HS	78.7 dB(A)
Non-Traditional	PACE West	74.9 dB(A)

The importance of knowing the noise level outside the school is to analyze the recommended noise limit inside the classroom (35 dB(A)) for 'permanent classrooms'.[1] Part II of reference 1 provides information for 'temporary' classrooms. The referenced ANSI Standard is used across the U.S.A. for limiting noise in a classroom to ensure that the noise does not affect the student learning environment or the health of the students. This noise levels in reference 1 are measured during the time when students would be present, but are NOT present, and includes all noise sources from both internal and external sources. Internal noise sources include building HVAC and other mechanical systems. External noise sources include road noise and other nearby facilities, etc. In this study, ONLY the noise from operating and planned data

[1] ANSI/ASA S12.60-2010/Part 1

centers has been included, **so ALL noise levels would be noticeably higher** when other internal and external noise sources like roads, and other industrial facilities are included.

With Public Schools and the Public College/University, mitigation can be programmed into annual budgets and accomplished. Conversely, the Private Schools are a different story. Private schools are either for-profit or run via public organizations such as a religious organization or a trust. Private schools do not have nearly unlimited budgets like public schools and, with the cost to mitigate the noise energy, may not be able to stay 'in business.' An example of private schools which will be experiencing excessive noise levels over 70 dB(A) from only data centers are shown on Table 3.

Table 3: Predicted: Private Schools with Excessive Noise

Grade Level	**School**	**dB(A) after build-out of all DCs**
Elementary	Bristow Montessori	74.9 dB(A)
	Minneland Academy - Gainesville	76.9 dB(A)
Middle / High / Non-Traditional	Youth For Tomorrow	71.7 dB(A)

These schools will need to perform sound mitigation inside the classroom to meet the reference 1 specifications, or they may have to close their doors.

Finally, are the Public Safety facilities. Our Fire Stations are manned 24/7 with highly trained professionals who spend 24 hours on duty at the fire stations. When they are not on call, they are maintaining their equipment in the garage bays protected from the excessive noise by only a simple 'glass' door or no door at all. With the noise levels predicted, they will need to wear aural protection when they are at the fire station. Additionally, the fire fighters sleep at the station on their duty nights, and with excessive noise inside the sleeping quarters, many may have trouble sleeping. The fire-fighting profession is a stressful profession, and more noise will only make their work harder. Noise levels at three PWC Fire stations will exceed 70 dB(A). They include: Fire Station 4 [76.3 dB(A)], Fire Station 22 [72.3 dB(A)], and Fire Station 25 [71.5 dB(A)]. Additionally, let us not forget the Western District PWC Police Station which will have a constant noise energy of 71.3 dB(A). More mitigation will be needed there.

Noise is not just a problem for residents, but also for our educational system and our public safety. PWC MUST take this seriously.

Bottom Line Conclusion:

(1) The PWC should immediately have a professionally done noise analysis performed covering **ALL** of the materials discussed in this Study at a minimum. To date, **NO** such study has been done.

(2) The PWC should immediately freeze processing of rezoning applications and site/building plans until a quality noise ordinance has been approved and quality noise studies performed. Penalties for violating the noise ordinance should be increased to be taken seriously.

(3) Additionally, the City of Manassas should begin a thorough noise analysis to help protect their citizens, school children, and public safety personnel.

Noise is a serious issue which MUST be taken seriously!

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AWS	Amazon Web Services
CPA	Comprehensive Plan Amendment
dB	Decibel [Also: dB(A), dB(C), and dB(Z)]
DC	Data Center(s)
DCOZOD	Data Center Overlay Zone Opportunity District
Ele	Elementary (as in Elementary School)
ES	Elementary School
FC	Fauquier County
GPIN	Grid Parcel Identification Number
GIS	Geographical Information Systems
HOA	Homeowners Association
HQ	Headquarters
HS	High School
HVAC	Heating, Ventilation, and Air Conditioning
Hz	Hertz (aka: cycles per second)
LFN	Low Frequency Noise
m	meter
MCPS	Manassas City Public Schools
MNBP	Manassas National Battlefield Park
mph	Miles per Hour
MS	Middle School
NIOSH	National Institute of Occupational Safety and Health
NIOSH-SM	NIOSH – Sound Meter
NoVa	Northern Virginia
NT	Non-Traditional School
OSHA	Occupational Safety and Health Administration
PC	Planning Commission
PWC	Prince William County
PWCS	PWC Schools
PWDG	Prince William Digital Gateway
P-MC	Private Schools in City of Manassas
P-PWC	Private Schools in PWC
REZ	Rezoning Application
sq ft	Square Feet
SUP	Special Use Permit
TM	Trademark
ToW	Town of Warrenton
VDOT	Virginia Department of Transportation
W	Watt
WTC	Warrenton Training Center
ZA	Zoning Administrator

I. Background

A. Definitions

- Sound is defined as:
  - "Mechanical radiant energy that is transmitted by longitudinal pressure waves in a material medium (such as air) and is the objective cause of hearing." [2]
  - "Sound Waves are longitudinal mechanical waves … sound waves being confined to the frequency range which can stimulate the human ear and brain to the sensation of hearing. This range is from about 20 cycles/sec (Hertz – Hz) to about 20,000 Hz and is called the audible range." [3]
  - Music is generally defined as the art of arranging sound to create some combination of form, harmony, melody, rhythm or otherwise expressive content.[4]
  - Music is further defined as: vocal, instrumental, or mechanical sounds having rhythm, melody, or harmony; the science or art of ordering tones or sounds in succession, in combination, and in temporal relationships to produce a composition having unity and continuity [5]
- Noise is defined as:
  - "Noise and vibration are both fluctuations in the pressure of air (or other media) which affect the human body. Vibrations that are detected by the human ear are classified as sound. We use the term 'noise' to indicate unwanted sound." [6]
  - "Noise is a mixture of many frequencies which bear little relationship to one another. A sound spectrum made of that noise would not … show a continuous, or nearly continuous spectrum of frequencies. Such a sound we call noise." [7]
  - A sound "that lacks an agreeable quality or is noticeably unpleasant or loud." [8]
  - "Any sound that is undesired or interferes with one's hearing of something"[9]
  - "There is a growing body of data showing that low frequency noise (LFN), defined as broadband noise with dominant content of low frequencies (10-250 Hz) differs in its nature from other environmental noises at comparable levels." [10]

B. Sound/Noise Energy Measurement

A textbook definition of sound transmission is: [11]

- "the intensity is defined as the energy transported by a wave per unit time across a unit area perpendicular to the energy flow. … Intensity has units of power per unit area or $^{watts}/_{meter^2}$ $\left(^{W}/_{m^2}\right)$."
- "An average human ear can detect sounds with an intensity as low as $10^{-12}\,{}^{W}/_{m^2}$. … Intensity is usually specified on a logarithmic scale. The unit on this scale is a "bel", after the inventor

---

[2] https://www.merriam-webster.com/dictionary/sound#h1
[3] Halliday, D., and Resnick, R, "Physics", John Wiley & Sons, New York, 1966 edition (p. 497)
[4] https://en.wikipedia.org/wiki/Music
[5] https://www.merriam-webster.com/dictionary/music
[6] https://www.osha.gov/noise
[7] Giancoli, D., "Physics – Principles with Applications", Pearson Higher Ed, New York, 2014 Edition, p. 328
[8] https://www.merriam-webster.com/dictionary/noise
[9] Ibid
[10] https://pubmed.ncbi.nlm.nih.gov/16201210/
[11] Giancoli, D., "Physics – Principles with Applications", Pearson Higher Ed, New York, 2014 Edition, p. 331

Alexander Graham Bell, or much more commonly, a decibel (dB). The sound level is defined as: $\beta\ (in\ dB) = 10\ log\left(^{I}/_{I_0}\right)$ where I_0 is $10^{-12}\ ^{W}/_{m^2}$."

Sound (like other pressure waves) is an additive process and, like with a musical instrument, what the human ear hears is the combination and sum of the individual waves being generated; the physics term is superposition of the individual waves. The net effect is that the intensity of each individual wave is algebraically summed to find the resulting intensity.[12]

While noise energy can be expressed as a metric unit with an exponent, a logarithmic scale has been developed to refer to the sound energy intensity more easily. A leading employment testing and employee wellness service provider for Occupational Safety and Health Administration (OSHA) [13] defines:

> "the Decibel A scale (dBA) is a logarithmic system of measuring sound as the human ear experiences it. The scale assigns a weight to the decibel value of sound based on the sensitivity of the ear at a particular frequency."[14]

Depending on the usage of the sound level measurements, sound level decibels are reported in several frequency-weighting scales: A, C, and Z are the most common types. [15]

- A-weighting [dB(A)] – The A-weighted frequency provides readings that conform to a notional human hearing response. It is defined in various international standards such as ANSI S1.4.[16] 'A' Weighted is the most commonly used and covers the full frequency range of 20Hz all the way up to high frequency 20 kHz. The human ear is most sensitive to sound frequencies between 500 Hz and 6 kHz (especially around 4 kHz) whilst at lower and higher frequencies the human ear is not very sensitive. The 'A' weighting adjusts the sound pressure level readings to reflect the sensitivity of the human ear and is, therefore, mandated all over the world for hearing damage risk measurements.
- C-weighting [dB(C)] – The C-weighted frequency looks more at the effect of low-frequency sounds on the human ear compared with the A-weighting and is essentially flat or linear between 31.5Hz and 8kHz.
- Z-Weighting [dB(Z)]– (Z-frequency-weighting). Z-weighted is the flat frequency response of 8Hz to 20kHz (+/- 1.5dB). This is the actual noise that is made with no weighting at all for the human ear (Z for zero). Often used in octave band analysis and for determining environmental noise.

When the frequency bands use a doubling of the central frequency for each band, this is referred to as an octave.[17] [18] Further details on the comparison between dB(A) and dB(Z) scales is described in ANSI S1.11. [19]

[12] Giancoli, D., "Physics – Principles with Applications", Pearson Higher Ed, New York, 2014 Edition, Section 19-8.
[13] https://www.workplacetesting.com/definition/4081/decibel-a-scale-dba
[14] **Note**: Several OSHA related documents have similarly worded definitions of dB(A), however, this definition was chosen because of the clarity. Those documents include: 29 CFR 1904, 29 CFR 1910.95, et al.
[15] https://pulsarinstruments.com/news/understanding-a-c-z-noise-frequency-weightings/ (quoted with annotations)
[16] https://ia600209.us.archive.org/25/items/gov.law.ansi.s1.4.1983/ansi.s1.4.1983.pdf
[17] https://en.wikipedia.org/wiki/Octave
[18] https://en.wikipedia.org/wiki/Octave_band
[19] ANSI S1.11: Specification for Octave, Half-Octave, and Third Octave Band Filter Sets" (PDF). p. 13

Typically, ordinances limiting noise use the dB(A) scale.[20] There are a small number of entities which use the dB(Z) scale which includes the Town of Warrenton (Chapter 9).[21]

C. Sound/Noise Sources

All data centers contain mechanical systems that produce noise. The following mechanical systems and devices are the primary sources of noise from data centers being operated/planned for Northern Virginia:

- Fans:
  - Fan blades produce sound due to the interaction of the fan blades with the air. The leading edge of the fan blades are striking the air and the trailing edges of the blades will reduce the air pressure and provide a condition much like boiling water. Depending on the design and quality of the blades, the amount of noise will be randomly produced in various frequencies.
  - Air movement itself is a noise producer as it mixes and interacts with its path constrictions. Constrictions include the fan housing, exhaust/inlet structure, and gates/louvers on the fan for weather protection/isolation.
  - The fan motors are mechanical devices and will produce their own sound as devices with moving parts.
  - Examples of noise producing fans in data centers include fans which exhaust air from the roof or top of each floor, intake fans on the sides of the buildings, fans used in evaporative cooling systems, and fans used with cooling and operating diesel generators.
- Cooling systems:
  - Cooling systems can include compressors for intermediate cooling systems, evaporative cooling 'towers', and other heat exchangers with multiple fluids involved.
  - This includes not only the cooling systems for the 'data halls,' but also the HVAC systems for the office areas and elevator/mechanical equipment on the roof.
- Diesel-Electric Generators
  - These backup generators are very large diesel engines and their internal combustion engines produce large amounts of noise which emanate from the body of the engine and from the exhaust of the engine. These diesel engines are several times the size of engines used in commercial trucks on our highways.

Additionally, when evaluating the total noise associated with the environments around data centers, analyses should include 'background' noise produced from the surrounding roads. These noise sources include:

- Vehicle motors
- Vehicle tire 'friction' on the pavement
- Other intermittent road noises including horns and 'jack-brakes' on trucks, which are not included in these analyses.

Other environmental noise producers, such as factories, concert venues, non-data center light industry, schools, and natural environmental noises, have not been included in the study described in this paper. For a total noise analysis, they should be included, but are beyond the capabilities of the author and very site specific. Please note that when the "total noise" is measured by a professional measurement, such as

---

[20] Ordinances using dB(A) including: HUD (24 CFR 51), OSHA, County Codes for Fauquier (Chapter 13.3), Fairfax (Chapter 108.1), King George (Section 10-8), Loudoun (Chapter 654.02), Prince William (Ordinance #14), and Stafford (Chapter 16), and City of Manassas (Chapters 14 and 58)

[21] https://warrentonva.gov/DocumentCenter/View/219/Article-9---Supplemental-Regulations-PDF

by the Police after a complaint is filed, these noises will be included. So, they are important to consider, just beyond this study's scope.

D. Sound/Noise Energy Transmission and Modeling

Textbooks describe sound energy as waves of energy which, if unimpeded, will spread out evenly in all directions from a source.[22] These textbooks further break the transmission of sound energy into two basic types, and the modeling of these two types of waves is described below.

- A spherical wave (aka: point source) travels outwardly in a spherical shape. A data center is a relatively small noise source (less than 1,000 feet in any direction) and will be modeled as a point source.
- A plane wave (aka: line source) travels outwardly in a single direction and remains as a plane/cylinder. Roads are long lines that go in straight lines from the limit of the energy wave in one direction to the other so they will be modeled as line sources.

All pressure waves are influenced by reflection, refraction, dispersion, and attenuation. The previously cited physics textbooks provide details about how this occurs. For this study, only a brief explanation is provided.

- Reflection is caused when the wave strikes (or impinges) on something that will cause the wave to change direction. For sound waves from data centers, examples include: the ground, a wall, or an atmospheric change (such as a thermocline). Reflections do not change the intensity of the specific wave-front, but rather just change the direction of the wave's movement.
- Refraction is caused when the wave passes between (channeled) reflection sources, such as between two buildings. At the exit from the refraction channel, the wave appears to begin again as a new point source having the total energy that entered the channel.
- Dispersion is caused as the wave spreads outward from the source in an ever-increasing size, the energy in the wave spreads across the new larger wavefront.
- Attenuation is a process where the sound energy (recall it is a pressure wave) is absorbed in the medium. An example would be passing through a forest or raindrops, the leaves/raindrops absorb some of the energy.

In a perfect system, the energy in a pressure wave (such as a sound/noise wave) would travel outwardly in all directions subject to the four factors defined above.

1. Spherical Waves – Point Source Modeling

- Since each data center produces sound from a large collection of sources which are relatively close together compared to the distances that the sound will travel, the noise from data centers is calculated as a singular (point source) spherical wave without any loss in modeling quality. Since noise energy waves are additive, the total intensity of a data center noise will be calculated as the sum of each individual sound generator.
- Spherical wave intensities decrease by a factor of $1/_{r^2}$ [23] when they have no reflection, refraction, dispersion, or medium changes along their path. The variable "r" is defined as the ratio of the previous distance to the new distance. For example, going from 1 meter to 2 meters (doubling the distance), the ratio would be $1/_{2^2}$ or $1/_4$ -- the noise intensity at 2 meters is 1/4th of the intensity at 1 meter away.

[22] Ibid 3 throughout Chapter 19 and Ibid 7 throughout Chapter 12
[23] Giancoli, D., "Physics – Principles with Applications", Pearson Higher Ed, New York, 2014 Edition, p. 310.

- Reflection will limit the spread of the energy wave, keeping it confined between the ground and the clouds (roughly estimated as 1,000-5,000 feet above the ground). This effect will prevent the wave from expanding and, as a result, decrease the dispersion of the wave, keeping it more concentrated. For this study, the concentrating effect of the sound waves will be calculated as: $1/_{r^{1.5}}$.
- Refraction is not considered in this study. Since the effect will, for the most part, be limited to house heights of less than 50 feet which is small compared to the reflection height.
- Attenuation of the energy waves in the human audible frequencies is not considered as a major factor and hence is not included in this study. The Great Oak neighborhood in Manassas, VA has 600-1,200 feet of old growth deciduous forest/trees between the closest homes and the data center buildings. There has been little change in the noise intensities between when the trees are 'in-leaf' and are leafless.
- Finally, due to the relatively short distances examined, the atmosphere is assumed to be constant in temperature and humidity, and as a result, will be assumed to be a constant with little effect.
- Sound/noise energy for data centers is also a function of the building size. The building size determines the amount of power used in the data halls. The heat to be removed is a function of the electrical thermal losses (aka: i^2R losses where the variables "i" is the electrical current used and "R" is the resistivity in the devices). So, for this study, the size of the building is assumed directly proportional to the power used and, as a result, the electrical thermal losses which must be removed. For example: doubling the floor space in a data center doubles the noise energy intensity (not the dB).
- The actual noise levels of all data centers is not known because some of the buildings were not fully operational or not even built/planned as of the study. In cases like this, a modeling technique of using a nominal reference can be employed where a representative reference is developed which can be scaled to different sizes and locations. The nominal data center used was taken as a rough average size of the more recent data centers – approximately 330,000 sq ft of floorspace. A distance of 500 feet from the noise generation part of the building was used because it was easy to program.

2. Planar Waves – Line/Road Source Modeling

- Road noises are a function of the traffic volume and speed of the traffic, and geometry relative to the direction of wave travel.
- Planer wave intensities decrease by a factor of $1/_r$ when they have no reflection, refraction, dispersion, or medium changes along their path. For example, going from 1 meter to 2 meters (doubling the distance), the noise energy would be $1/_2$ of the intensity at 2 meters as it was at 1 meter away.
- Since the road noise is well below the level of the sounds generated as spherical waves and will directly interact with the ground, a factor of less attenuation than $1/_r$ should be used. However, determination of this new r-ratio is beyond the scope of this study and will be greatly influenced by ground-level items, such as sound walls along I-66. A conservative approach was used, and no correction was included in this study.
- Road noise is the primary component in the "current" or "measured" noise levels in readings taken that are referred to in the study.[24] The remaining noise energy would come from other environmental sound producers which are described in the final bullet of Section I.C on page 9.

[24] Rochat J.L., Acoustics Today, Winter 2016, vol 12 issue 4, beginning on page 38.

E. Modeling

1. Reference sound intensities

- Originally, in Summer 2022, noise level readings were taken at four data center sites of the generated noise using an application on the author's iPhone 12 called "Decibel Meter"[25]. The sites included:
  - Tanner Way (Amazon)
  - Airman Avenue (Maneucher Ventures)
  - Godwin Drive (QTS)
  - Data Center site about 1 mile north of US Route 50 along Loudoun County Parkway (unknown owner)
- When the readings for these four sites were corrected to the nominal data center described above, the readings were remarkably similar, varying by less than 20% in noise intensity. To determine the noise level for the nominal data center, once the four energy readings were averaged and converted to dB(A), the nominal data center noise level was 65.0 dB(A). Since then, readings have been compared to predicted noise readings in the Great Oak neighborhood and it is believed that the 65.0 dB(A) nominal level is conservative by about 0.5-2.0 dB(A).
- In a review of Smart Phone applications that take sound measurement readings,[26] the app National Institute of Occupational Safety and Health (NIOSH) called "NIOSH-SM" (SM is an abbreviation for Sound Meter) was determined to be the top-rated application. This app is used by OSHA in their work throughout the USA. Benchmarks were done between the "Decibel Meter" app and the "NIOSH-SM" app and readings were found to be very similar. The major difference was that the "NIOSH-SM" app provides readings to the 10th of a decibel where the "Decibel Meter" app does not. If the "NIOSH-SM" app had been used for the initial nominal data center determination, then the nominal data center noise level would have been a bit higher (perhaps by as much as ½ dB(A)), which means that the nominal data center of 65.0 dB(A) is a conservative estimate.
- To model road noise, data from various sources was used.
  - The most accurate road noise used in the modeling was from on-site noise readings at various locations. At the locations where readings were taken, interpolations were used between locations.
  - For locations where on-site road noise readings were not taken, secondary data sources such as the Virginia Department of Transportation (VDOT) studies contained in the CPA 2021-00004 Traffic Addendum and VDOT websites, were used to estimate road noise based on traffic velocity and volume. Additionally, noise levels provided by the US Department of Transportation (DOT) were also used in determining noise intensity relationships.
  - For this study, the first step was to determine a standard road noise from a combination of readings and the US DOT and VDOT websites.[27] Then, other road noise intensities can be modeled from the standard.

---

[25] **Note**: In June 2022, the readings using "Decibel Meter" were compared to readings from the Prince William County Police Department in the Great Oak Neighborhood in Manassas (PW County). Readings between the 2 devices were well within +/- 0.5 dB(A). Due to the length of time used for the readings, this is considered a very close comparison. Additionally, this validates the use of the iPhone 12 as the noise reading instrument with the given error band.

[26] https://canadianaudiologist.ca/feature-4/

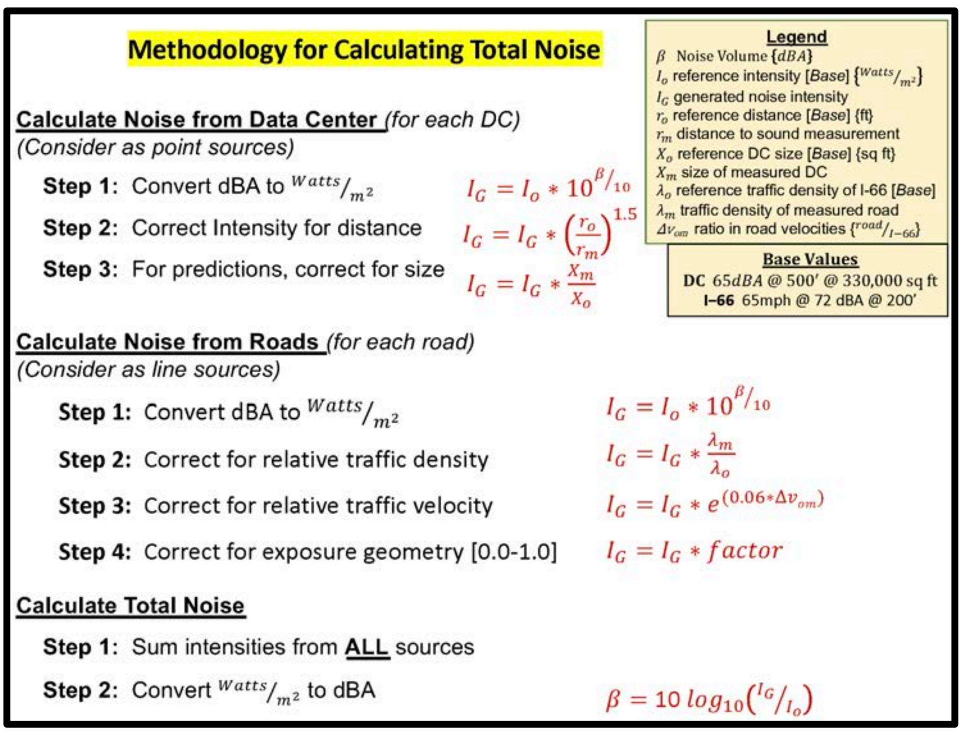
[27] https://www.researchgate.net/figure/Typical-Highway-Noise-Levels_fig1_228381219, et al

- I-66 road noise at the University Park and Ride in Gainesville was used as 72 dB(A) ,taken at 100 feet from the edge of the road. Reading taken.
- After review of various VDOT sources, it was determined that noise is best modeled as a linear function of the traffic volume. Additionally, the traffic speed was analyzed and a curve fitting function of: $I_G = I_G * e^{(0.06*\Delta vom)}$ was derived and used. **Note**: Δvom is defined in Figure 1.

- Additionally, for the noise intensity analysis for the Town of Warrenton's (ToW) proposed data center, road noises were provided as a part of the Amazon Web Service noise analysis which was provided to the ToW.[28] So, for the ToW analysis, the average of the above modeling and the AWS report were averaged in the models.
- Finally, to correct for sections of road which are either not perpendicular to the direction of noise travel or did not fully cover the range from 'horizon -to-horizon', a proportional factor was used.

Figure 1 shows the equations used in the modeling process.

Figure 1: Modeling Total Noise Equations



2. Other Factors used in the modeling

- Another factor considered was the number of stories in the building. To correct for building height, the total noise intensity was treated as a function of the building's floor space footprint multiplied by the number of floors. It is assumed that since the total heat to be removed is proportional to the floor space and, when adding a second floor, the amount of floorspace is doubled from the building footprint.
- A combination of existing and proposed buildings was included in the models. Since the shape and orientation of the buildings is not known, a common method of representation of the

---

[28] '*Walsh, Collucci, Lubeley & Walsh letter dated 9/9/2002 Exhibits 4 & 5*'

buildings was needed. Since all data centers (and when schools were included in the models) are quasi-rectangular shaped buildings, a simplification of calculating the distance from the edge of the building to the location for the analysis, the buildings were modeled as being circular. (The circular objects modeling trick is commonly used in basic modeling.) This assumption introduces errors to shorten distances on the center of the building and lengthen the distances on the corners. The result will be canceling errors. The net error was inside the statistical errors for the analysis, especially when a number of buildings were modeled, and their results summed.

3. Modeling Code

- The results presented in the following sections were done with a combination of spreadsheets in Microsoft Excel and in a computer program written using the MATLAB™ language. All models used were written and validated by the author.
- Validation of the computer codes (Excel and MATLAB) noise estimates was performed a VERY close comparison was found (within 1/3 dB(A)). Additionally, the MATLAB code output was compared (throughout the 2nd half of 2022) against measured noise levels in the Great Oak neighborhood and the predicted noise levels were slightly less than actual readings. Again, showing that the modeling is conservative by a fraction of a dB(A).

II. Neighborhood Noise Assessments

The sections in this Chapter are the results of 'small area studies' that have been performed to predict the noise levels within that area. Unless otherwise noted, each of the data analyses was done by the author of this study.

Copyright Warning:

- All graphical and tabular results are copyrighted by the author and may not be reproduced or used without the express written consent of the author. The HOAs listed have the consent of the author without requesting additional release authority.
- Analyses have used either the Excel spreadsheet or the MATLAB™ computer code that was written by the author. All code is the property of the author who is solely responsible for its development and use.
- Items that were not developed by the author may be copyrighted by their developer and should be contacted prior to use.

Each of the below analyses used:

- The geographical information systems (GIS) publicly available from Prince William County (PWC), Fauquier County, City of Manassas, Town of Warrenton, or King George County to determine locations of all data centers. Google Earth was used for locations not mapped in the publicly available GIS systems. Where locations could not be determined using the governmental GIS systems, Google Earth was used to determine the locations. All of these systems are publicly available without charge.
- Locations of all data centers and data center sites for PWC are listed on the list of data centers map produced by the author under separate cover. Data center locations for Warrenton and King George County are taken from official documents provided by the town/county.
- Locations for measurements/predictions were selected by the author (et al.) to represent a cross section of the HOA(s), public and private schools, and selected public safety facilities. Their

positions were determined using GIS or Google Earth systems. Each section provides a listing of the locations for reference.

- All data centers were modeled using the ‘nominal data center’ described in the previous chapter of: 330,000 sq ft at 500 feet distance making 65 dB(A) of sound/noise. Town of Warrenton data center noise is expressed in dB(A) and dB(Z). A description is provided in that section.
- The locations of the data centers, which are either operational or currently under construction, use the actual building location in the model code. Buildings which are still in the planning/development stages have their locations estimated based on currently best available data. If site plans were not available, then sizes of buildings were estimated and evenly distributed around the parcel.
- For the PWDG, the data centers specified in the three Rezoning (REZ) Packages were used for sizing and estimating the locations of the buildings. Note that the three REZs specify a total of approximately 21 million square feet of data center floorspace while the CPA 2022-00004 specified 27.6 million square feet. This difference results in a lowering of the total floorspace and underestimating the noise by a factor of about 22%, which will reduce the predicted noise levels by about 1.5dB(A) in the locations with the highest noise intensities.

Each of the following analyses are presented in roughly the same format:

- List of locations where readings were taken. Included are notes on which sites had actual readings taken showing current noise levels.
- All readings were taken in mid-afternoon on a weekday.
- Roads included in analysis and source of parameters/data
- List of different types of analyses and conditions in results
- Comparison to any actual operational data center readings
- Graphical results

A. Small Area Study: Heritage Hunt HOA, Gainesville, VA

1. Locations Analyzed

Table 4: Heritage Hunt Locations

Location		Current Noise Level dB(A)	Reading or Interpolated
HH Clubhouse	Portico	50.5	Reading
HH Marsh Mansion	BBQ grill	53.4	Interpolated
HH Front Gate	Sec Bldg	64.3	Reading
HH Pickleball Courts	Center	48.1	Reading
Adirondack & Fieldstone	Intersection	52.0	Interpolated
Affirmed Place	North End	53.6	Reading
Alderwood Way	South Bend	45.6	Reading
Avington Place & Tuscarora	Intersection	51.8	Reading
Barley Field Place	Cul-de-Sac	51.3	Reading
Box Elder Loop	Center	46.2	Reading
Charismatic & Majestic Prince	Intersection	54.6	Reading
Cinch Lane	Center	49.6	Reading
Culverhouse Ct	East end	53.3	Reading
Cumberstone & Current	Intersection	53.0	Reading

Location		Current Noise Level dB(A)	Reading or Interpolated
13348 Fieldstone	Driveway	51.5	Reading
HH Blvd & Heritage Valley	Intersection	54.7	Reading
Kentucky Derby Ct	Cul-de-Sac	56.3	Reading
Open Valley Way	Center	56.5	Reading
6305 Pasture View	Driveway	51.9	Reading
Piney Grove Way & Cavaletti	Intersection	51.3	Reading
Ryton Ridge Way Cul-de-sac	Cul-de-Sac	50.7	Reading
Saddle & Derby Run	Intersection	47.1	Reading
Tred Avon Place	Cul-de-Sac	50.7	Reading
Hole 1	Green	58.6	Reading
Hole 2	Green	55.4	Interpolated
Hole 3	Green	54.8	Interpolated
Hole 4	Green	53.2	Interpolated
Hole 5	Green	51.3	Interpolated
Hole 6	Green	51.3	Interpolated
Hole 7	Green	52.0	Interpolated
Hole 8	Green	54.3	Interpolated
Hole 9	Green	55.4	Interpolated
Hole 10	Green	51.3	Interpolated
Hole 11	Green	49.3	Interpolated
Hole 12	Green	52.6	Interpolated
Hole 13	Green	47.8	Interpolated
Hole 14	Green	48.5	Interpolated
Hole 15	Green	53.4	Interpolated
Hole 16	Green	54.8	Interpolated
Hole 17	Green	54.8	Interpolated
Hole 18	Green	54.3	Interpolated
Driving Range	Center	54.1	Reading
Maintenance Facility	Building	57.8	Reading

2. Roads included

Table 5: Heritage Hunt Road Analysis

Road		Volume Relative to I-66	Average Speed (mph)	Geometry Factor Used
I-66		1	65	
US 29: Though MNBP		0.100	50	*
US 29: C-R Forest South		0.570	55	*
Pageland Lane	2022	0.082	35	
	2035	0.420	55	
VA 234 N of US-29		0.133	45	
VA 234 PW Pkwy S of I-66		0.416	50	*
Heathcote Blvd		0.232	45	
Catharpin Rd		0.033	45	
VA 55		0.082	45	*

*Note: * indicates 'Geometry Factor' was used and included in 'Volume Factor' calculation. Basic physics theory calculates the noise energy in a line source with an integration for the source being a straight line that is perpendicular to the shortest distance from the source to the analysis location and exists from horizon to horizon. The 'Geometry Factor' was used to correct the integral for the alignment.*

3. Analyses

Table 6: Heritage Hunt Predicted Noise Intensities

Location		Current Noise dB(A)	Noise with all PWDG DCs dB(A)	Noise Energy Multiplier *	Closest Data Center (feet)
HH Clubhouse	Portico	50.5	68.7	66.8	3,424
HH Marsh Mansion	BBQ grill	53.4	69.6	41.8	2,680
HH Front Gate	Sec Bldg	64.3	70.7	4.4	2,440
HH Pickleball Courts	Center	48.1	69.9	155.0	2,380
Adirondack & Fieldstone	Intersection	52.0	71.3	86.2	1,440
Affirmed Place	North End	53.6	68.7	33.0	2,700
Alderwood Way	South Bend	45.6	69.3	243.6	2,340
Avington Place & Tuscarora	Intersection	51.8	67.8	40.6	4,220
Barley Field Place	Cul-de-Sac	51.3	66.8	36.1	4,740
Box Elder Loop	Center	46.2	68.9	188.5	3,020
Charismatic & Majestic Prince	Intersection	54.6	67.2	18.5	4,980
Cinch Lane	Center	49.6	67.7	65.5	3,520
Culverhouse Ct	East end	53.3	72.3	81.0	1,090
Cumberstone & Current	Intersection	53.0	69.3	43.4	2,250
13348 Fieldstone	Driveway	51.5	71.7	108.2	980
HH Blvd & Heritage Valley	Intersection	54.7	68.4	23.6	3,505
Kentucky Derby Ct	Cul-de-Sac	56.3	67.8	14.1	2,260
Open Valley Way	Center	56.5	69.2	18.8	3,070
6305 Pasture View	Driveway	51.9	69.6	69.6	2,285
Piney Grove Way & Cavaletti	Intersection	51.3	67.0	37.8	3,680
Ryton Ridge Way Cul-de-sac	Cul-de-Sac	50.7	69.4	75.4	3,035
Saddle & Derby Run	Intersection	47.1	70.4	221.3	3,805
Tred Avon Place	Cul-de-Sac	50.7	69.4	75.7	1,590
Driving Range	Center	54.1	68.4	27.3	3,140
Maintenance Facility	Building	57.8	67.3	8.9	4,505

Notes:

(1) The column "Noise Energy Multiplier" indicates the multiple of the noise energy $\left(W/_{m^2}\right)$ between current and fully built-out as a ratio of the current and after buildout energy levels. For example, a multiplier of "2.0" would have twice the energy in the sound waves at that location after DCs are built out. Doubling the energy is 3 dB(A). A 10 dB(A) increase would be a multiplier of 10. A 100 dB(A) increase would be a multiplier of 100.

(2) Figure 2 is a "Choropleth" type of chart. A choropleth chart shows a range of intensities as a color overlay. The boundaries between the colors is a line of equal intensity called an "isopleth". A choropleth chart is commonly used in weather predictions to show temperature variations or rainfall amounts across an area.

Figure 2: Heritage Hunt Noise Choropleth

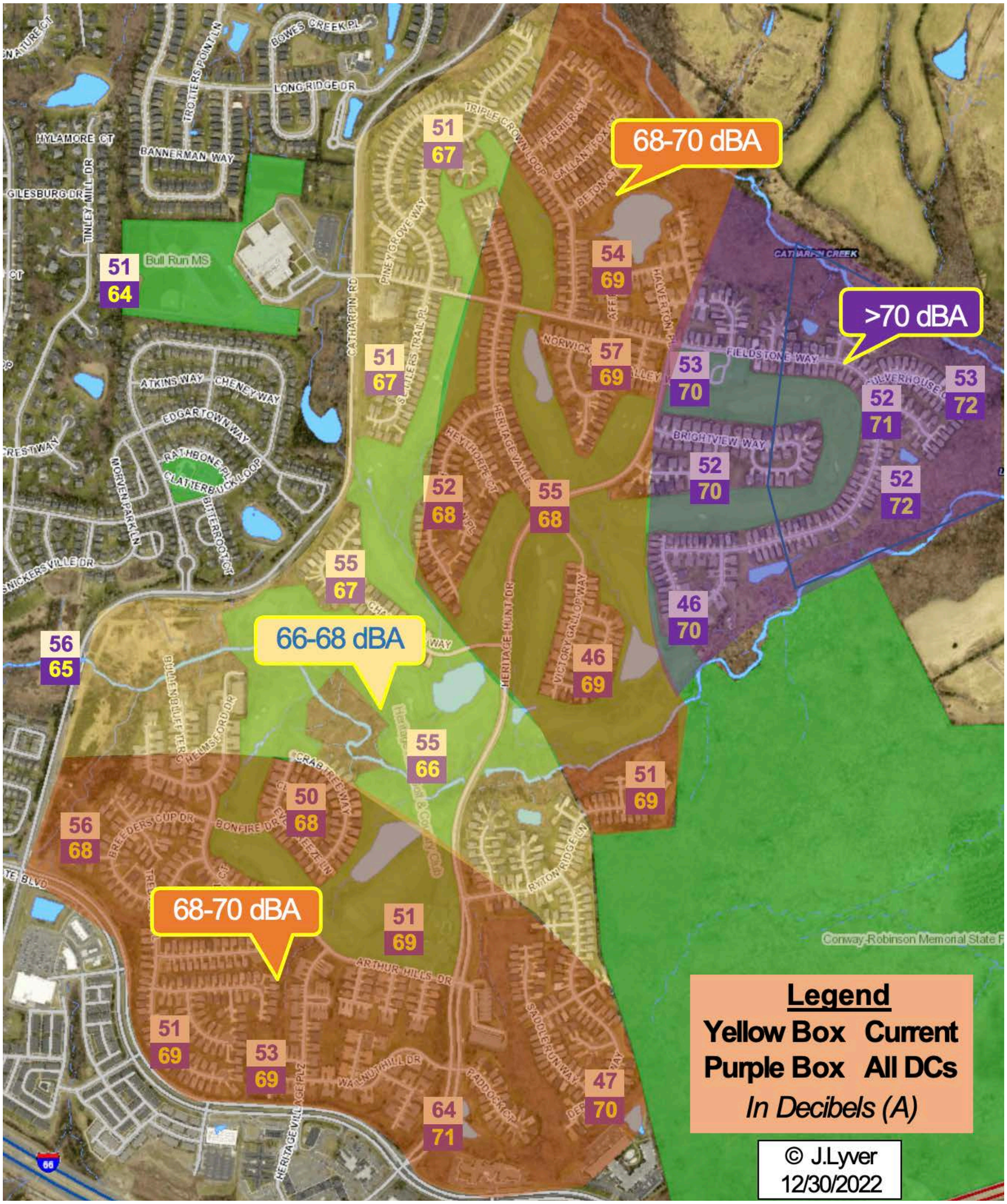
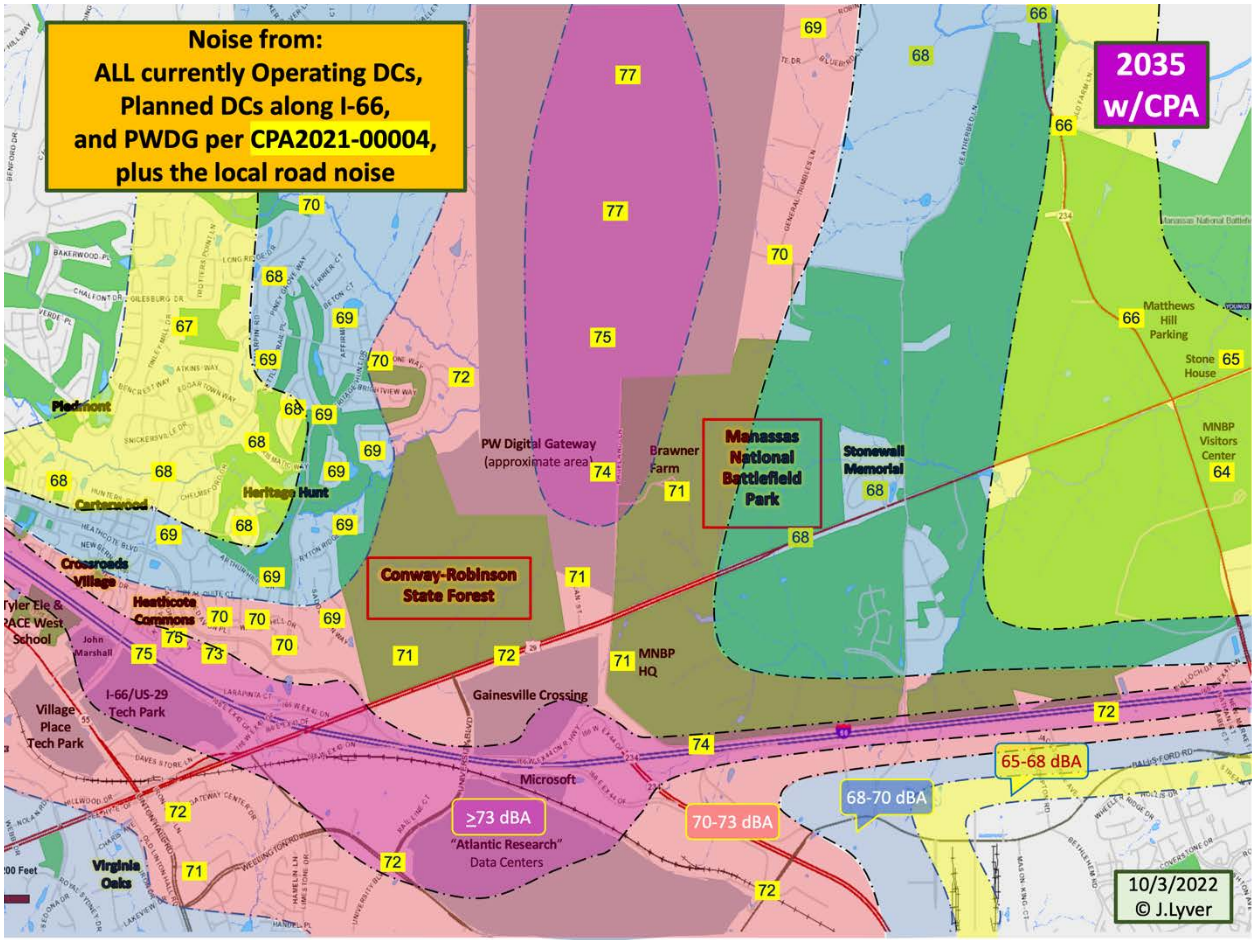


Figure 3: Heritage Hunt Wider-Area Noise Choropleth



4. **Comments and Comparison** (Current [2022] and after PWDG Build-out)
   - **All areas within Heritage Hunt will exceed the PWC Noise Ordinance #14 [29] for daytime and nighttime maximum noise levels. Even the "quietest" area of Heritage Hunt will be over 7 dB(A) above the daytime noise limits (and over 12 dB(A) the nighttime noise limits).**
   - Loudest area in Heritage Hunt will be in the northeastern corner where the noise level will be approximately equal to the I-66 road noise taken at 100 feet from I-66.
   - Noise in the northeastern section of Heritage Hunt will be from the PWDG. Noise in the southern section of Heritage Hunt will be from the data centers located along I-66 between the Haymarket town line and the VA-234 / PW Parkway interchange.

[29] https://library.municode.com/va/prince_william_county/codes/code_of_ordinances?nodeId=CH14NO_S14-7MEPR

B. Small Area Study: Oak Valley and Virginia Oaks, Catharpin, VA

1. Locations Analyzed

Table 7: Oak Valley and Virginia Oaks Locations

Location		Current Noise Level dB(A)	Reading or Interpolated
Catharpin Ball Field on Sudley Rd	Center of Fields	56.0	Reading
4606 Sanders Lane	House	56.4	Interpolated
4510-4512 Old Field Drive	Street	47.4	Reading
4580 Sudley Rd	Near house	48.6	Reading
4610 Sudley Rd	Near house	57.5	Reading
5409-5417 Ancestry Rd	Street	54.6	Reading
13508-13516 Heritage Farms Dr	Street	54.6	Reading

2. Roads included

See Table 5. Most of current noise level is from Catharpin Road and Sudley Road.

3. Analyses

Table 8: Oak Valley and Virginia Oaks Predicted Noise Intensities

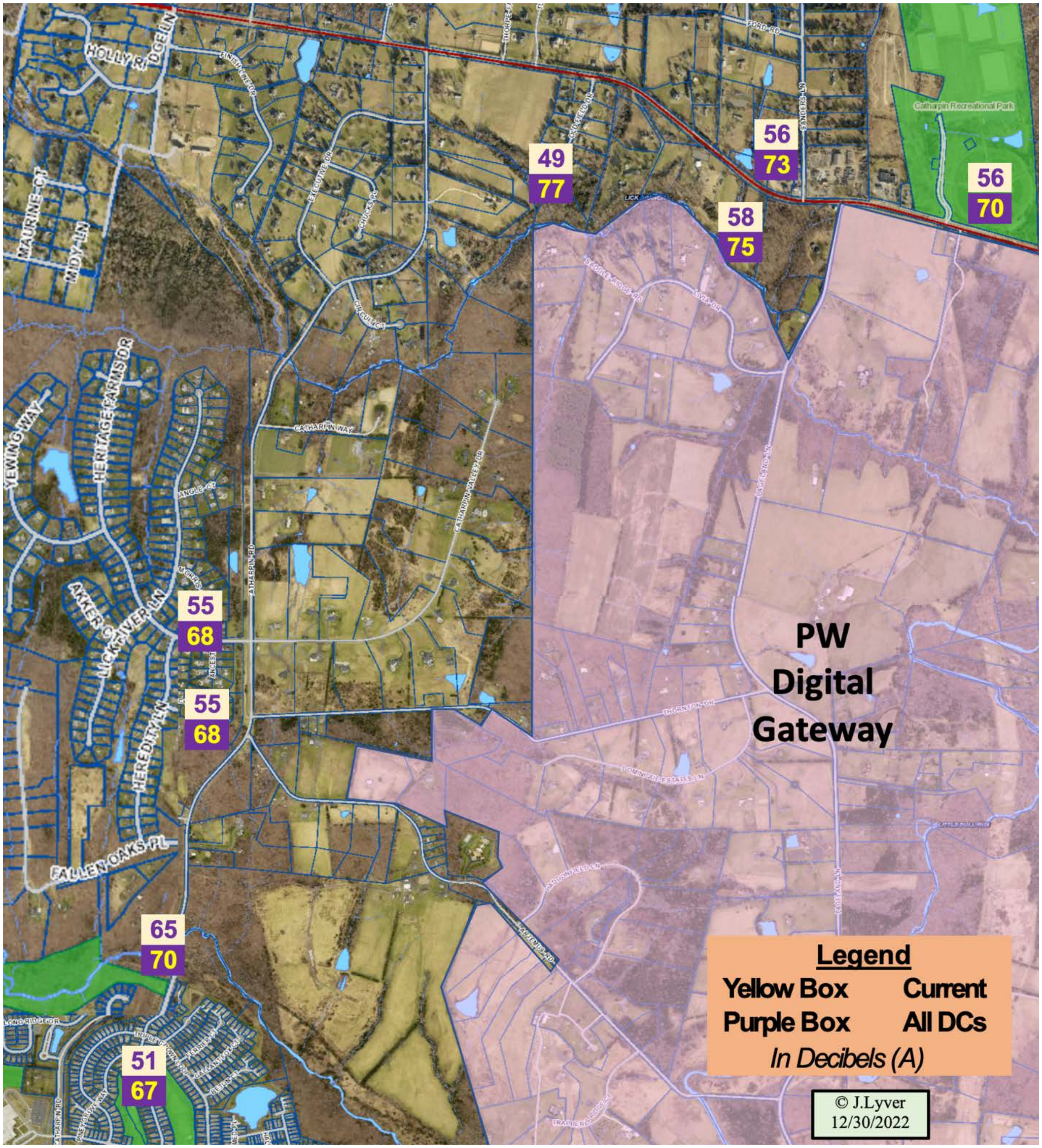
Location		Current Noise dB(A)	Noise with all PWDG DCs dB(A)	Noise Energy Multiplier *	Closest Data Center (feet)
Catharpin Ball Field on Sudley Rd	Center of Fields	56.0	69.7	23.4	1,470
4606 Sanders Lane	House	56.0	72.6	46.2	644
4510-4512 Old Field Dr	Street	47.4	72.2	308.6	574
4580 Sudley Rd	Near house	48.6	77.2	746.8	180
4610 Sudley Rd	Near house	57.5	75.3	61.6	290
5409-5417 Ancestry Rd	Street	54.6	68.4	24.1	3,000
13508-13516 Heritage Farms Dr	Street	54.6	68.2	23.1	3,260

***Note**: See Table 6 Note (1) for explanation of * for the 'Noise Energy Multiplier' column.*

4. Comments and Comparison

- **All areas within area will exceed the PWC Noise Ordinance #14 for daytime and nighttime maximum noise levels. Even the "quietest" area of Oak Valley and Virginia Oaks will be over 9 dB(A) above the daytime noise limits (and over 17 ½ dB(A) the nighttime noise limits).**
- Since the study area lies on the western and northern edge of the study area, all noise will be from the PWDG.
- Locations lying between the locations directly analyzed and the PWDG will have even higher noise levels. Estimates of the noise level along Pageland Lane between Thornton Lane and Livia Court will exceed 80 dB(A).
- By using REZ data center maximum square footage, predicted readings may be as much as 1.5 dB(A) higher

Figure 4: Oak Valley and Virginia Oaks Area Predicted Noise Intensities



C. Small Area Study: Greenhill Crossing, Gainesville and Haymarket, VA

1. Locations Analyzed

Table 9: Greenhill Crossing HOA & Haymarket Locations

Location		Current Noise Level dB(A)	Reading or Interpolated
Abberley Loop	North of lake	55.8	Reading
Bull Run Middle School	Track	50.8	Reading
Cannondale Way	East End	66.0	Interpolated
Carterwood & Falsmere	Intersection	44.1	Reading
Catharpin & Heathcote	Intersection	64.8	Reading
Catharpin Road	Little Bull Run	59.2	Reading
El Vaquero West	Northeast Parking	58.2	Reading
Greenville Crossing Clubhouse	South side	57.1	Reading
Haymarket Children's Academy	South Side	56.0	Reading
Kona Drive	East End	67.5	Interpolated
Landseer Circle	Monument	49.9	Reading
Legends & Newberry	Intersection	48.2	Reading
Piedmont Entrance	Circle	61.8	Reading
PWC Fire Station 4	Front Parking	54.5	Reading
Sheringham	At Bike Path	50.3	Reading
St. Paul Street	1st cross street	53.4	Reading
Tyler Elementary School	Front Entrance	54.5	Reading

***Note**: Additional Heritage Hunt location also included*

2. Roads included

See Table 5. Most of current noise level is from Heathcote Blvd and I-66 (with Sound Wall).

3. Analyses

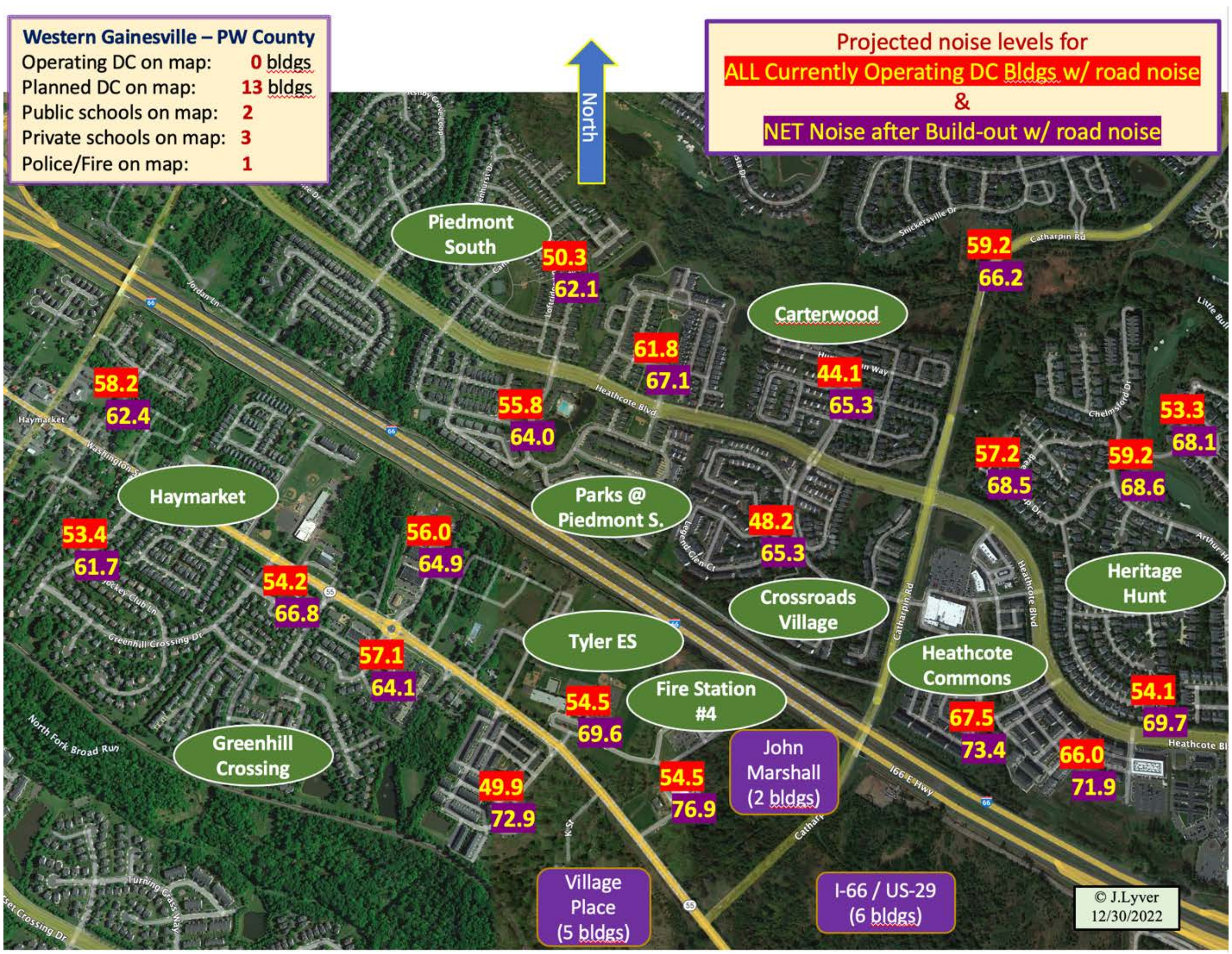
Table 10: Greenhill Crossing HOA & Haymarket Predicted Noise Intensities

Location		Current Noise Level dB(A)	Noise with all PWDG DCs dB(A)	Noise Energy Multiplier *	Closest Data Center (feet)
Abberley Loop	North of lake	55.8	64.0	6.7	2,980
Bull Run Middle School	Track	50.8	64.7	24.8	4,500
Cannondale Way	East End	66.0	71.9	3.9	910
Carterwood & Falsmere	Intersection	44.1	65.3	132.6	2,630
Catharpin & Heathcote	Intersection	64.8	69.2	2.8	2,150
Catharpin Road	Little Bull Run	59.2	66.2	5.0	4,225
El Vaquero West	Northeast Parking	58.2	62.4	2.6	4,660
Greenville Crossing Clubhouse	South side	57.1	64.1	5.0	2,570
Haymarket Children's Academy	South Side	56.0	64.9	7.7	2,150
Kona Drive	East End	67.5	73.4	3.8	328
Landseer Circle	Monument	49.9	72.9	201.6	195
Legends & Newberry	Intersection	48.2	65.3	73.5	1,670

Location		Current Noise Level dB(A)	Noise with all PWDG DCs dB(A)	Noise Energy Multiplier *	Closest Data Center (feet)
Piedmont Entrance	Circle	61.8	67.1	3.4	4,650
PWC Fire Station 4	Front Parking	54.5	76.9	177.1	735
Sheringham	At Bike Path	50.3	62.1	15.4	3,940
St. Paul Street	1st cross street	53.4	61.7	6.7	4,000
Tyler Elementary School	Front Entrance	54.5	69.6	27.5	690

Note: *See Table 6 Note (1) for explanation of * for the 'Noise Energy Multiplier' column.*

Figure 5: Greenhill Crossing HOA and Haymarket Area Predicted Noise Intensities



4. **Comments and Comparison**

- **All locations within this area will exceed the PWC Noise Ordinance #14 for daytime and nighttime maximum noise levels. Even the "quietest" area will be almost 6 dB(A) above the daytime noise limits (and almost 11 dB(A) the nighttime noise limits).**
- Since the small study area lies on the western and northern edge of the greater study area, the majority of the noise will be from the data centers along the I-66 Gainesville Corridor.

D. Small Area Study: Manassas National Battlefield Park (MNBP) Area

This small area may also be designated as the Manassas Battlefield Historic District area.

1. Locations Analyzed

Table 11: MNBP Locations

Location		Current Noise Level dB(A)	Reading or Interpolated
Conway-Robinson State Park	Entrance Loop	62.8	Interpolated
Stonewall Cemetery	North End Circle	58.9	Interpolated
MNBP – HQ	Building	61.6	Interpolated
MNBP – Brawner Farm	Parking Center	58.5	Interpolated
MNBP – Visitor Center	Front Parking	58.5	Interpolated
MNBP – Stone House	Building	60.6	Interpolated
MNBP – Mathew Hill Parking	Center	59.5	Interpolated
Sudley Road & Poplar Hill Rd	Intersection	59.3	Interpolated
Sudley Road & Little Bull Run	Bridge	59.1	Interpolated
Gen Trimble	SW Corner	55.4	Interpolated
Robin & Bluebird Lane	Intersection	54.1	Interpolated
Bobwhite Dr	Cul-de-Sac	54.1	Interpolated
Lolan St	North End	60.1	Interpolated

2. Roads included

See Table 5.

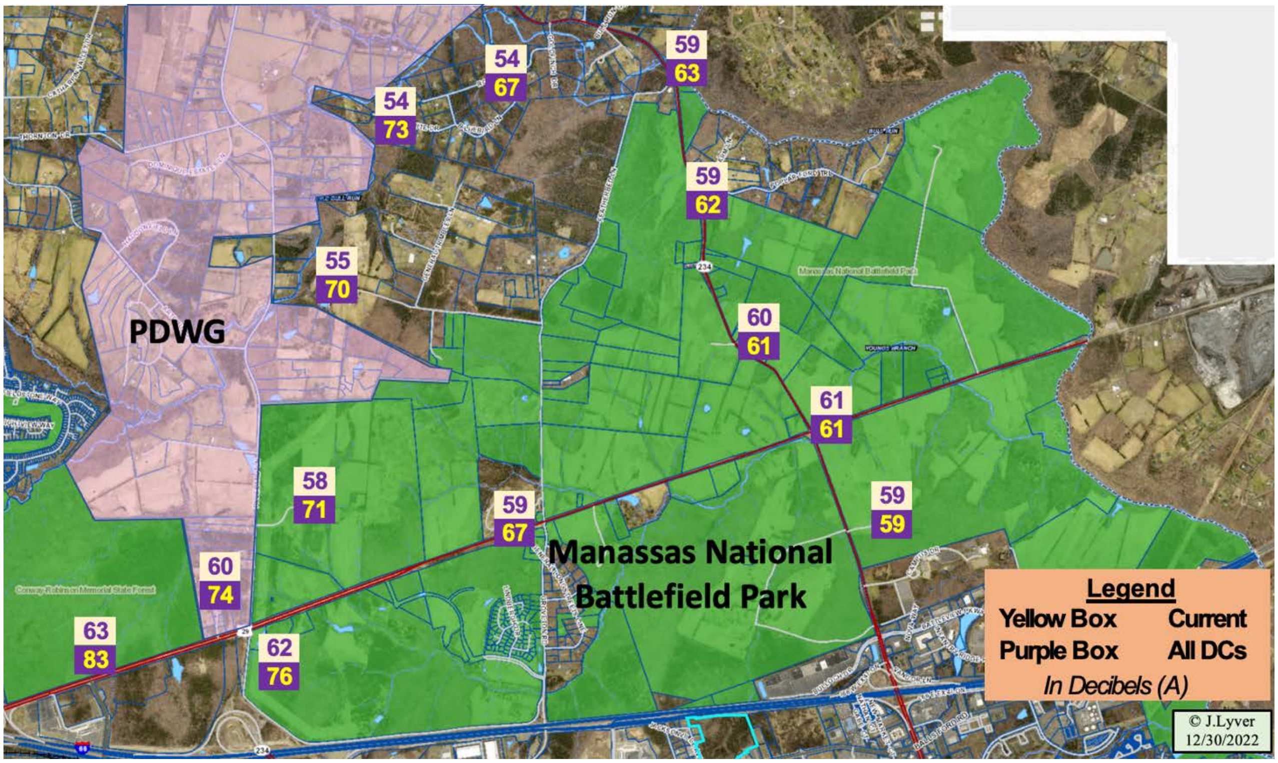
3. Analyses

Table 12: MNBP Area Predicted Noise Intensities

Location		Current Noise dB(A)	Noise with all PWDG DCs dB(A)	Noise Energy Multiplier *	Closest Data Center (feet)
Conway-Robinson State Park	Entrance Loop	62.8	82.7	99.9	980
Stonewall Cemetery	North End Circle	58.9	66.6	5.9	5,180
MNBP – HQ	Building	61.6	75.8	26.7	1,553
MNBP – Brawner Farm	Parking Center	58.5	71.0	18.0	1,625
MNBP – Visitor Center	Front Parking	58.5	58.8	1.1	> 1 mile
MNBP – Stone House	Building	60.6	60.6	1.0	> 1 mile
MNBP – Mathew Hill Parking	Center	59.5	60.9	1.4	> 1 mile
Sudley Road & Poplar Hill Rd	Intersection	59.3	61.9	1.8	> 1 mile
Sudley Road & Little Bull Run	Bridge	59.1	62.9	2.4	> 1 mile
Gen Trimble	SW Corner	55.4	70.0	28.6	1,800
Robin & Bluebird Lane	Intersection	54.1	67.3	21.0	4,350
Bobwhite Dr	Cul-de-Sac	54.1	73.3	82.8	750
Lolan St	North End	60.1	73.7	23.3	1,890

***Note**: See Table 6 Note (1) for explanation of * for the 'Noise Energy Multiplier' column.*

Figure 6: MNBP Area Predicted Noise Intensities



4. **Comments and Comparison**

- **Approximately 90% of the MNBP Area will exceed the PWC Noise Ordinance #14 for daytime and nighttime maximum noise levels. Even the "quietest" area will be at the limit for daytime noise.**
- Loudest area in MNBP will be in the western edge (Brawner Farm area) of the MNBP where the noise level will be approximately equal to the I-66 road noise taken at 100 feet from I-66.
- Noise in the northwestern section of MNBP will be from the PWDG.
- Noise in the southern section of MNBP will be from the data centers located along I-66 between Haymarket Town line and the VA-234 / PW Parkway interchange.
- Two of the closest data centers to the MNBP are located at the VA-234 North and I-66 interchange. They are small data centers and may not be currently operating.
- Should the US-29 road through the middle of the MNBP be closed, there will be a slight decrease in the total noise near US-29 – perhaps a single dB(A) reduction which will not make up the increase in ambient noise due to the PWDG.

E. Small Area Study: Great Oak HOA, Manassas, VA

1. Locations Analyzed

Table 13: Great Oak Locations

Location		Current Noise Level dB(A) *	Reading or Interpolated
10201 Winded Elm	Driveway	61.9	Reading
10220 Winged Elm	Driveway	64.0	Reading
10236 Winged Elm	Driveway	64.3	Reading
10077 Coffee Tree	Driveway	61.0	Reading
10377 Plum Lane	Driveway	58.5	Reading
LDS Church Property	Center	63.8	Interpolated
George C. Round Ele School	West Side	60.6	Interpolated
Kings Landing Property	Center	61.5	Interpolated
Harvest Place	Cul-de-Sac	60.8	Interpolated
The Landing - Ratliff Trail	NE Corner	59.6	Interpolated
The Landing – Buchannan Loop	E Corner	61.2	Interpolated
The Landing – Hopkins & Spieden	Intersection	58.8	Interpolated

2. Roads included

Roads included in readings and interpolations. No additional analysis performed on added Road noise.

3. Analyses

Table 14: Great Oak Area Predicted Noise Intensities

Location		Current Noise from Tanner Way DCs ONLY dB(A)	Noise with all Tanner Way and Brickyard Way DCs dB(A)	Total Noise from all DCs dB(A)	Noise Energy Multiplier *	Closest Data Center (feet)
10201 Winded Elm	Driveway	61.9	65.4	67.4	3.5	1,320
10220 Winged Elm	Driveway	64.0	66.2	68.6	2.9	960
10236 Winged Elm	Driveway	64.3	66.5	68.8	2.8	920
10077 Coffee Tree	Driveway	61.0	65.2	67.0	4.0	1,600
10377 Plum Lane	Driveway	58.5	64.6	66.1	5.8	2,400
LDS Church Property	Center	63.8	66.1	68.4	2.9	850
George C. Round Ele School	West Side	60.6	64.8	66.6	4.0	1,540
Kings Landing Property	Center	61.5	65.1	67.1	3.7	1,250
Harvest Place	Cul-de-Sac	60.8	65.1	66.8	4.0	1,250
The Landing - Ratliff Trail	NE Corner	59.9	69.5	70.1	11.4	860
The Landing – Buchannan Loop	E Corner	61.2	72.5	73.0	15.1	490
The Landing – Hopkins & Spieden	Intersection	58.8	68.6	69.4	11.4	1,100

***Note**: See Table 6 Note (1) for explanation of * for the 'Noise Energy Multiplier' column.*

Figure 7: Great Oak HOA Predicted Noise Intensities

4. Comments and Comparison

- **For ONLY Tanner Way data centers, all areas within the Great Oak small study area exceed the PWC Noise Ordinance #14 for nighttime maximum noise levels. All except the furthest buildings will exceed the daytime noise limits.**
- **When the Brickyard Way data centers are operational, the quietest area on the above map will exceed the daytime noise limit by over 6 dB(A) and the nighttime noise limit by over 11 dB(A).**

F. Small Area Study: Amberleigh Station HOA, Bristow, VA

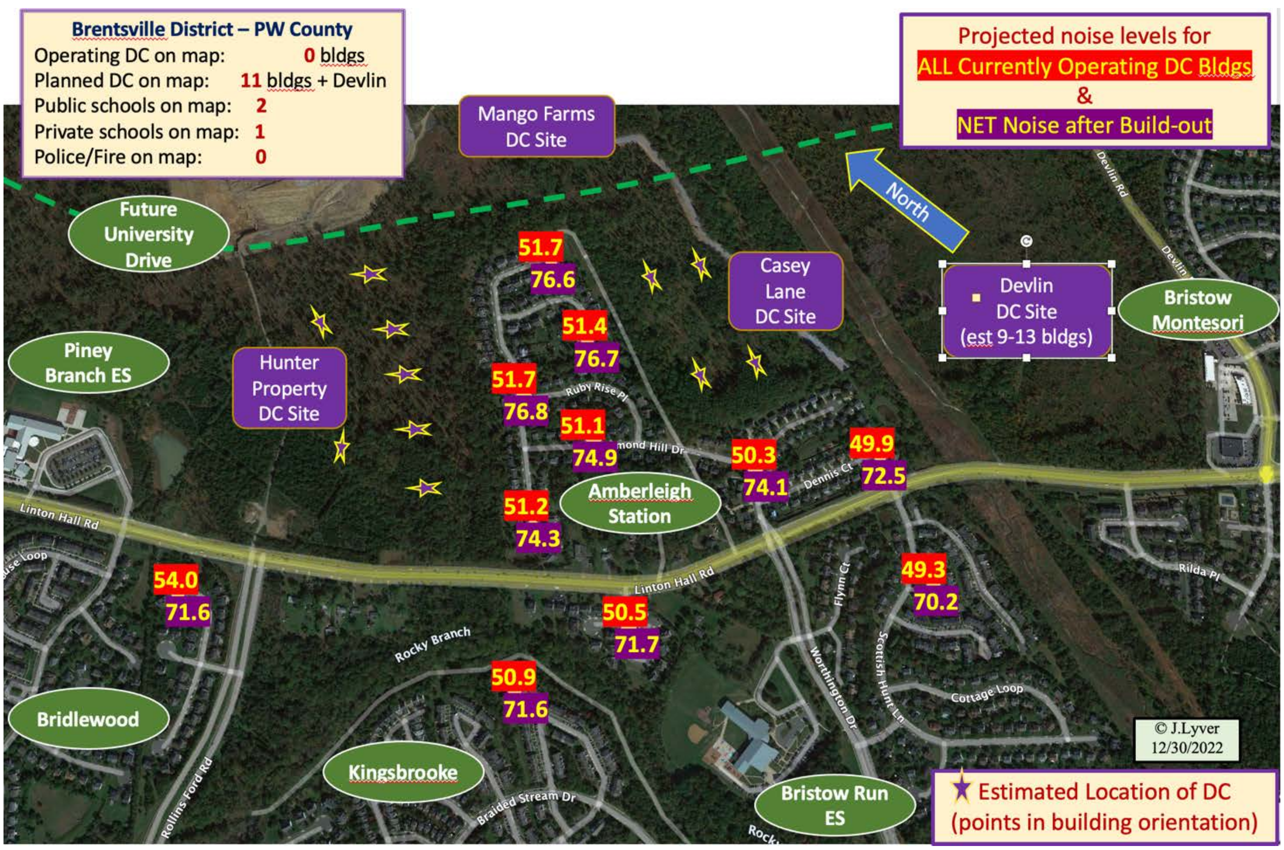
For the Amberleigh Station HOA Small Area Study, only predictions of the current noise from currently operating data centers and the total noise in the area after the Hunter-Devlin Parcel was considered. There were no current noise readings taken or estimated.

Table 15: Amberleigh Station HOA Locations

Location		Currently Operating DCs dB(A)	Total Noise with all DCs dB(A)	Noise Energy Multiplier *	Closest Data Center (feet)
Sapphire Ridge Pl	NE Cul-de-Sac	51.7	76.6	318.1	335
Sapphire & Ruby Rise	Intersection	51.7	76.8	336.6	345
Changing Leaf Terrace	Cul-de-Sac	51.4	76.7	349.0	420

Location		Currently Operating DCs dB(A)	Total Noise with all DCs dB(A)	Noise Energy Multiplier *	Closest Data Center (feet)
8747 Diamond Hill Dr	Street	51.1	74.9	242.3	720
Sapphire Ridge Pl	SW Cul-de-Sac	51.2	74.3	208.7	480
Bourne & Diamond Hill	Intersection	50.3	74.1	242.7	615
Dennis Ct	Cul-de-Sac	49.9	72.5	188.3	940
9077 Slate Stone Loop	Street	49.3	70.2	124.3	1,790
13313 Carmella Ct	Street	50.5	71.7	135.6	1,370
Moat Crossing Pl	North End	50.9	71.6	119.2	980
Chipper Ct	Cul-de-Sac	54.0	71.6	58.0	1,360

Figure 8: Amberleigh Station HOA Predicted Noise Intensities



Comments and Comparison (Current [2022] and after Hunter Site Build-out)

- **All areas within Amberleigh Station will exceed the PWC Noise Ordinance #14 for daytime and nighttime maximum noise levels. Even the "quietest" area of Amberleigh Station will be over 7 dB(A) above the daytime noise limits (and over 12 ½ dB(A) the nighttime noise limits).**

G. Small Area Study: Warrenton, VA

The small area study for Warrenton is an analysis of the proposed Amazon Web Services (AWS) Company that was submitted as a Special Use Permit (SUP) application in mid-2022 to be built within the Town of Warrenton (ToW).

The ToW Noise Ordinance[30] provides limits on the amount of noise energy that can be emitted from a parcel within the ToW. The ToW Noise Ordinance provides limits in dB(Z) limits per frequency octave as opposed to dB(A) energy levels. This modeling described and used throughout this report was done in dB(A), so calculations were first done in dB(A) and then converted to dB(Z). This is discussed in subsection 3 below.

1. Assumptions and Considerations

The analysis in this small area study for Warrenton is based on the following:

- The Study is strictly limited to predicting the noise generated by the proposed Amazon data center in the "Special Use Permit (SUP) 2022-0003, Amazon Data Center".[31]
- Proposed DC planned to be approximately 220,000 square feet.
- Since the SUP does not contain specifics on the technologies or systems to be used in the thermal control systems in the design of the proposed DC, the analyses in this Study are using the assumption that this DC will use similar systems as other Amazon DCs in the Northern Virginia Area.
- In September 2022, a 'Noise Study' was submitted for AWS as a required portion of the SUP. [32]
- The ToW Zoning Administrator (ZA) has provided a detailed analysis of the applicability of the ToW Noise Ordinance to the proposed DC in a letter dated December 16, 2022.[33] The following is a summary of the applicability in reference 33:
    - Only the noise generated within the proposed DC parcel will be evaluated for conformance. While resulting total noise will affect residents, only the noise generated within the parcel will be considered.
    - ToW Noise Ordinance Table 9-1, Columns 1 and 3 will be used to set the maximum noise limits. Column 2 on this table does not apply.
    - Three corrections to the Table 9-1 limits which are specified in Table 9-2 will be used which include:
        - -5 dBZ corrections on each frequency band due to being adjacent to residential areas
        - -5 dBZ corrections on each frequency band for operations between 10pm and 7am
        - -5 dBZ corrections on each frequency band for presence of a 'hum' in the sound generated. ***Note****: This correction will only be applied should the proposed DC be declared by the ToW to have a 'hum' characteristic. See Part 2 for more details on this correction.*
    - Per reference 33, the locations for measuring conformance to the ToW Noise Ordinance will be taken at the property boundary of the proposed DC parcel. Readings beyond the parcel

[30] https://warrentonva.gov/DocumentCenter/View/219/Article-9---Supplemental-Regulations-PDF
[31] Town of Warrenton electronic public files: https://mccmeetingspublic.blob.core.usgovcloudapi.net/warrntonva-meet-0e8d7229b2524aa58449d694673aaaa2/ITEM-Attachment-001-0cbfc2e7199340fd86a1f107ac47e6eb.pdf
[32] *Walsh, Collucci, Lubeley & Walsh letter dated 9/9/2002 Exhibits 4 & 5'*
[33] Walton, R., Town of Warrenton Zoning Administrator, Letter to Foote, J., of Walsh, Collucci, Lubeley & Walsh, dated December 16, 2022

boundary may be used in initiating reviews of the noise levels; however, will not be directly used in determining conformance.

***Note**: The original SUP contained a 240,000 square foot substation within the proposed DC parcel adjacent to Blackwell Road. In the October 28, 2022, updated SUP Plans, the Substation was removed from the site drawings; however, nowhere was it definitively written that the substation is removed from the project by either the developer or Dominion Power. For modeling completeness, a substation was included in the Parts 1 & 2 analyses; however, the noise energy from a substation has NOT been included in the displayed calculation results.*

2. Amazon Provided Noise Study Analysis

In October 2022, the author reviewed the AWS noise study with assistance from other ToW residents. The results of the review were presented at a 'ToW Town Hall' on October 26, 2022, as shown in Figure 9. On October 28, AWS' representatives withdrew the Noise Study. On November 9, 2022, the analysis results were presented to the ToW Planning Commission at their Public Hearing on the SUP showing that their SUP was now incomplete. The following week, the ToW PC suspended action on the SUP application.

Figure 9: Engineering Review AWS' Noise Study

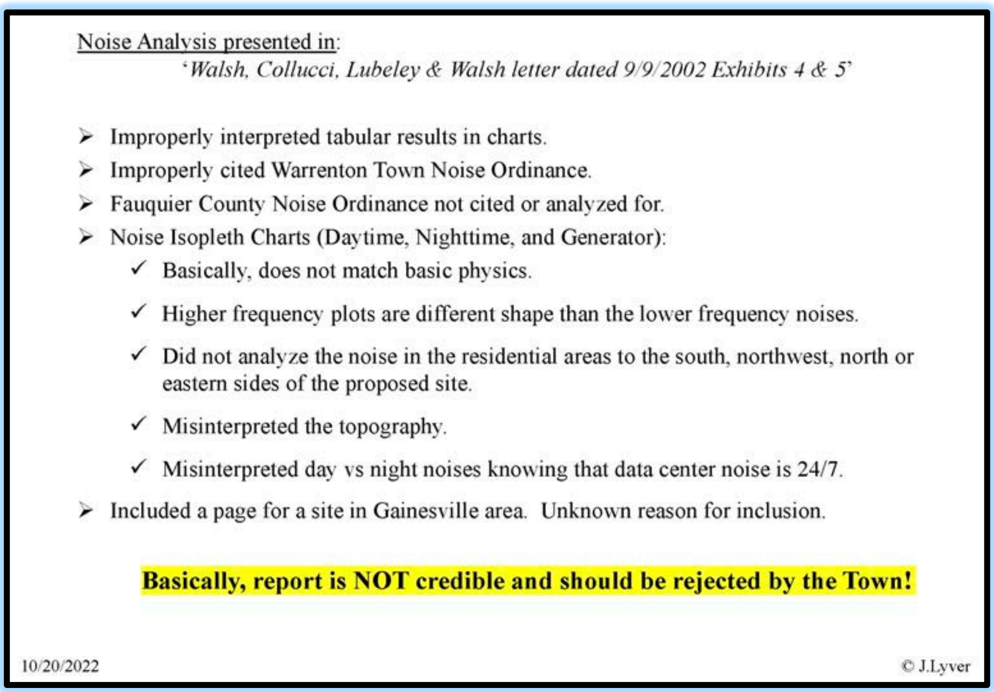


Figure 10: Review of AWS ToW Noise Study

Warrenton SUP Submission

- Town of Warrenton Zoning Ordinance **REQUIRES** in:

  Section: 11-3.10 Special Use Permits and Waivers

  Sub-Section: 11-3.10.2 Application.

  Item #8: ***"Noise impact and abatement studies to determine potential impact on adjoining properties and neighborhoods."***

- Noise Analysis presented in:

  'Walsh, Collucci, Lubeley & Walsh letter dated 9/9/2022 Exhibits 4 & 5'

  "6) Noise generation.

  A summary of the very extensive noise study that was performed is attached to this letter together with the entire study, which contains the technical background, are attached to this letter as Exhibits 4 and 5."

- Noise Analysis WITHDRAWN in:

  'Walsh, Collucci, Lubeley & Walsh letter dated 10/28/2022 – Table Item #3'

  "The Applicant is aware of the concerns over noise, and legitimate response to the "noise study" initially submitted. As we advised the Planning Commission, that "study" was only a preliminary draft that did not include descriptive information or complete data. Unfortunately, neither the Applicant nor this firm were told this, and thought it to be the "report."

11/9/2022 © J.Lyver

3. Total Warrenton Noise Analysis

The Warrenton noise study used a special version of the noise modeling done previously in this Study. Since the ToW Noise Ordinance specifies noise limits in dB(Z), calculations were done in dB(A) and then converted to dB(Z). Table 16 shows the ratio of total energy used in the conversion from dB(A) to dB(Z) as a function of fraction of total energy for each frequency bands listed in the 3rd column of the Noise Ordinance's Table 9-1. Table 16 was derived from the AWS provided in the September 2022 Noise Study.

For the analysis, 25 locations were selected within 1 mile of the proposed data center to identify noise levels in nearby neighborhoods and other locations. Figure 11 shows the 25 locations of the locations where the analyses were performed. Figure 12 shows the residential areas within ½ mile and shows that locations 1-12, 20 and 21 lie within the ToW boundary, locations 13-18 lie outside the ToW boundary and within Fauquier County (FC) and location 19 straddles the ToW boundary with FC. The street addresses for the 25 locations are provided with Table 17.

Note: *The* Table 17 *column "Ambient" represents the noise from the local roads. The VAData1/2/3 DCs are included in the "AWS DC" column.*

Table 16: Noise Energy Distribution

DC	Road	Hz
35.17%	0.53%	63
31.95%	2.19%	125
12.55%	3.27%	250
7.65%	16.92%	500
8.93%	52.02%	1,000
3.01%	21.81%	2,000
0.72%	2.86%	4,000
0.02%	0.40%	8,000

Figure 11: Mapping of Analysis Locations

Total noise includes sounds/noise from: The proposed data center, local roads (US-17, US-29, US-211, and Blackwell Road,) the 3 operating data centers located at the Warrenton Training Center (WTC) (VaData1, VaData2, and VaData3 [when VaData3 is operational]), and any electrical transmission and transforming noise. The total noise prediction are shown in Table 17, Figure 13, and Figure 14.

Figure 12: Residences Within 1/2 Mile of the Proposed Data Center

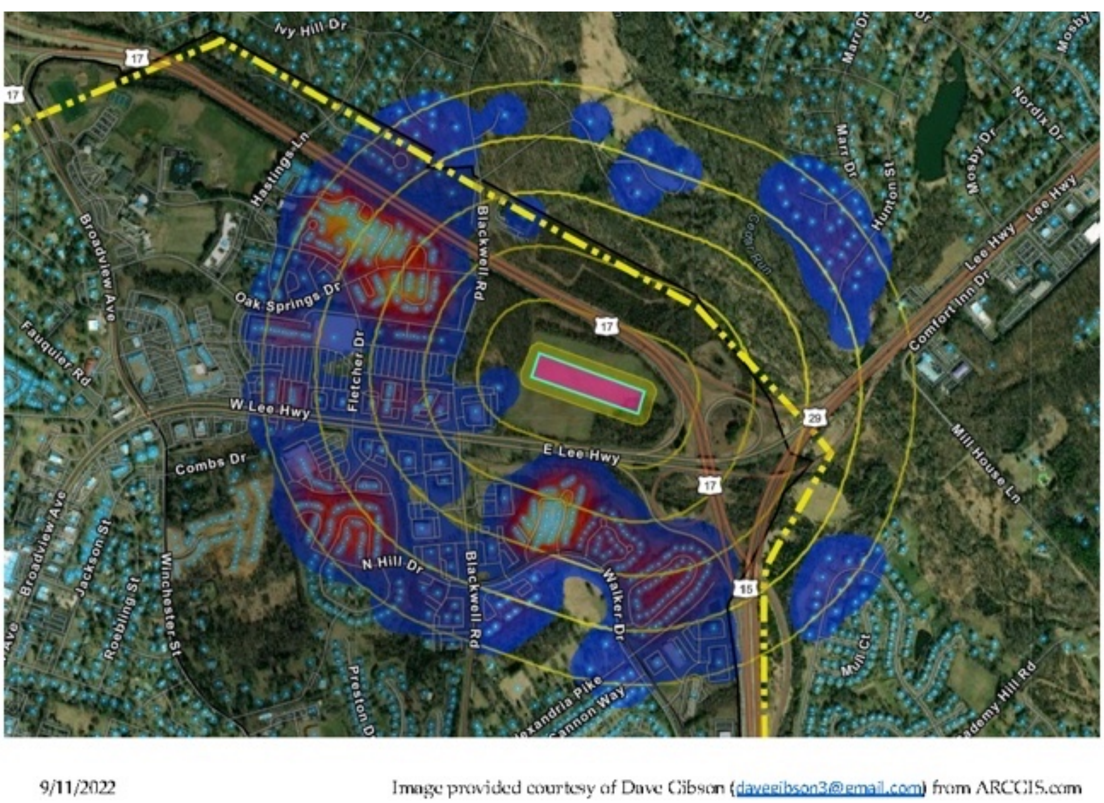


Table 17: Predicted Total Noise after DC Buildout

AWS DC	AWS SubSt	Ambient	WTC DCs
ON	off	ON	ON

Locations of sites to analyse		non-DC dBA	AWS DC dBA	Total dBA	Total dBZ 63 Hz	Total dBZ 125 Hz	Total dBZ 250 Hz	Total dBZ 500 Hz	Total dBZ 1,000 Hz	Total dBZ 2,000 Hz	Total dBZ 4,000 Hz	Total dBZ 8,000 Hz
1	725 Arbor Ct	52.1	59.5	60.2	54.9	54.6	50.6	49.8	52.1	47.9	40.4	29.3
2	21 Pepper Tree Ct	56.5	58.6	60.7	54.1	53.8	50.2	51.1	54.7	50.7	42.5	32.8
3	751 Cherry Tree Ln	54.1	56.4	58.4	51.9	51.6	48.0	48.9	52.4	48.4	40.2	30.5
4	721 Acron Ct	52.5	56.8	58.2	52.3	51.9	48.2	48.3	51.3	47.3	39.3	29.1
5	761 Gen Wallace Ct	52.5	55.3	57.2	50.8	50.5	46.9	47.5	50.9	46.9	38.8	28.9
6	141 W. Lee Hwy	52.9	56.0	57.7	51.5	51.2	47.5	48.0	51.3	47.3	39.2	29.3
7	222 North View Circle	55.3	55.9	58.6	51.4	51.2	47.7	49.4	53.2	49.3	40.9	31.5
8	492 Blackwell Rd	52.6	58.7	59.6	54.1	53.8	49.9	49.4	52.0	47.9	40.2	29.5
9	530 Highland Towne Ln	56.2	63.1	63.9	58.6	58.2	54.3	53.5	56.0	51.8	44.2	33.2
10	102 Dorsett Ln	56.0	67.2	67.5	62.7	62.3	58.3	56.7	58.3	53.9	46.9	34.4
11	514 Camden Cir	57.4	62.4	63.6	57.9	57.5	53.7	53.6	56.5	52.4	44.5	34.1
12	534 Estate Ave	53.8	56.5	58.3	52.0	51.7	48.0	48.7	52.1	48.1	40.0	30.2
13	7648 Moven Dr	57.1	53.6	58.7	49.2	49.2	46.6	50.2	54.6	50.7	42.1	33.2
14	7482 Argyll Ct	56.3	52.4	57.7	48.0	48.1	45.5	49.3	53.7	49.9	41.2	32.3
15	7379 Comfort Inn Dr	55.5	52.2	57.2	47.8	47.9	45.1	48.6	53.0	49.2	40.6	31.6
16	7350 Hunton St	56.3	54.3	58.4	49.9	49.8	46.8	49.7	53.9	50.0	41.5	32.4
17	7320 Marr Dr	52.4	53.0	55.8	48.6	48.3	44.9	46.5	50.4	46.5	38.1	28.7
18	6539 Hidden Hollow Ln	52.3	59.0	59.8	54.4	54.1	50.2	49.5	52.0	47.8	40.2	29.3
19	Parcel 6985-60-5718-500	52.3	69.7	69.8	65.2	64.8	60.8	58.8	59.7	55.1	48.6	34.5
20	33 Woodlands Way	52.0	60.9	61.4	56.4	56.0	52.0	50.8	52.8	48.6	41.3	29.6
21	800 Blackwell Rd	52.5	57.9	59.0	53.4	53.1	49.2	48.9	51.7	47.6	39.8	29.3
22	400 Willow Court	57.0	51.5	58.0	47.2	47.5	45.3	49.8	54.3	50.5	41.8	33.0
23	7292 Mosby Drive	58.8	59.4	59.4	54.9	54.7	51.2	52.9	56.7	52.8	44.4	35.0
24	297 Winchester Street	49.4	51.3	53.5	46.8	46.5	42.9	44.0	47.6	43.6	35.4	25.8
25	6432 Whites Mill Lane	51.9	50.3	54.2	45.9	45.8	42.7	45.4	49.5	45.7	37.1	28.0

Figure 13: ToW AWS DC Predicted Noise Intensities

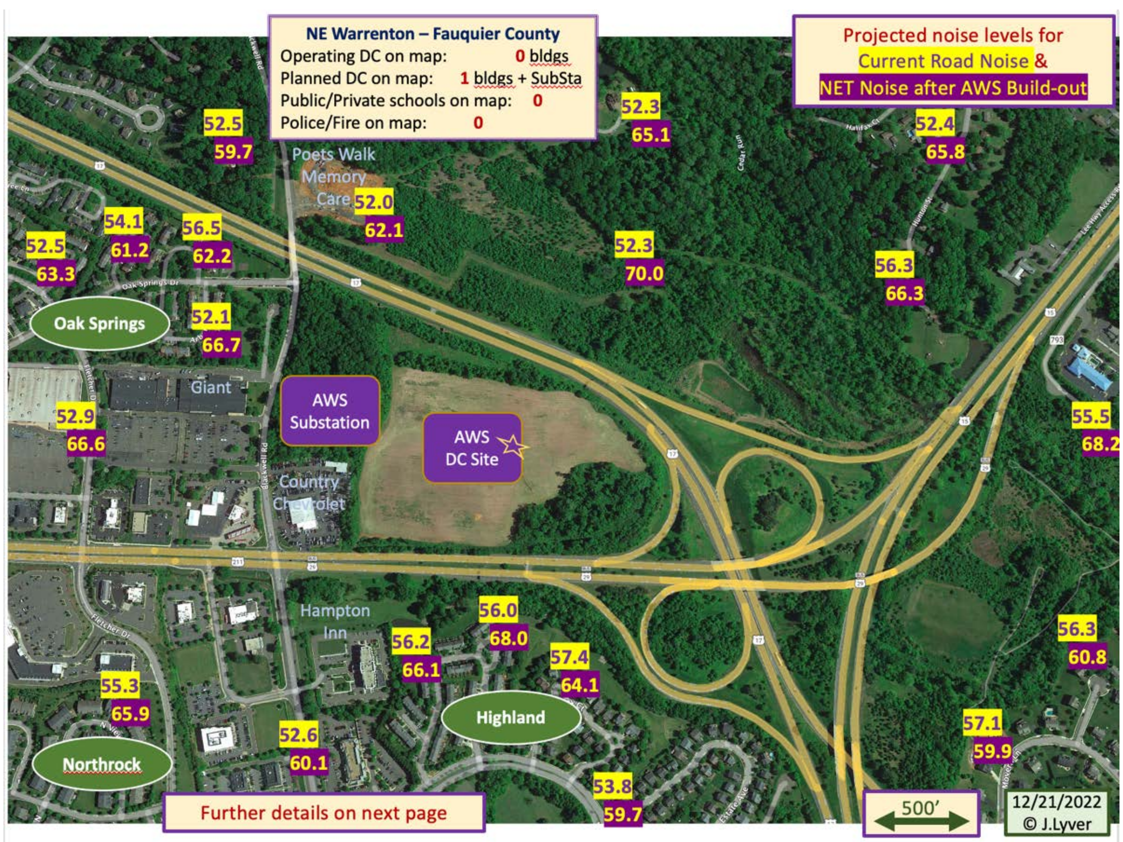
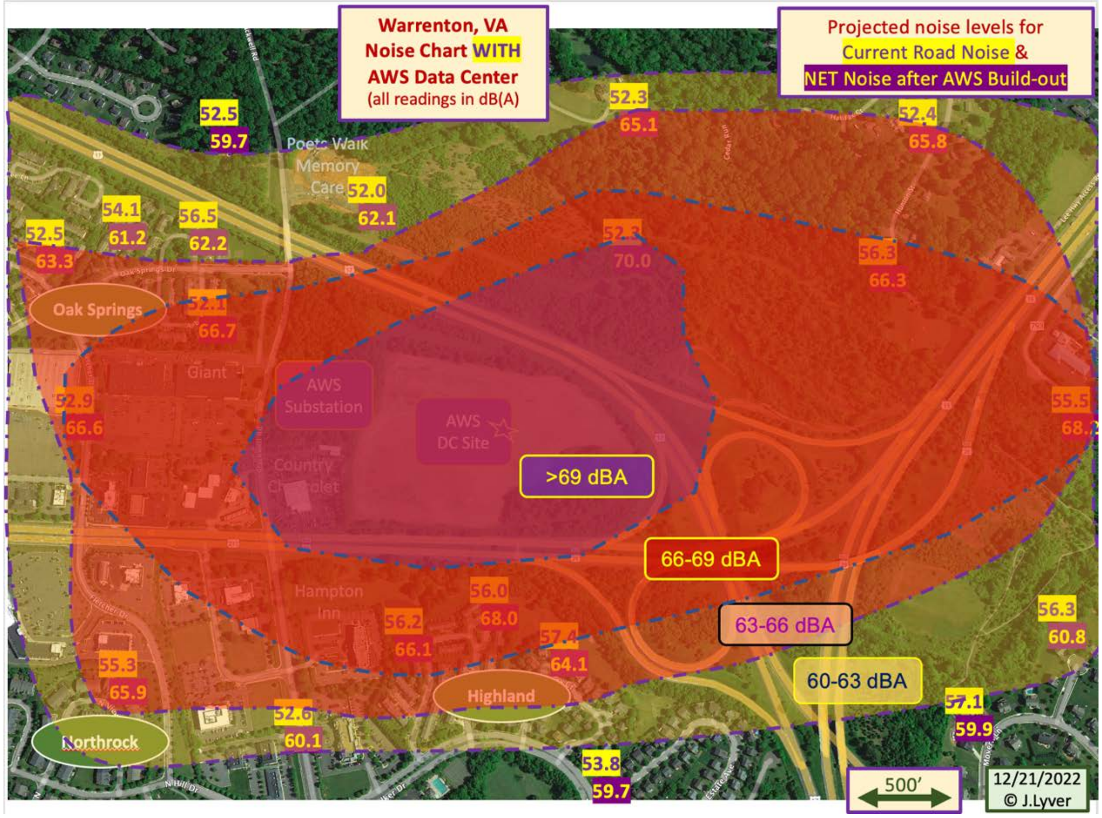


Figure 14: ToW AWS DC Predicted Noise Intensity Choropleth



4. Conclusion of Total Warrenton Noise Analysis

This Study clearly shows that noise levels in the area surrounding the proposed DC will exceed the noise limits specified in the ToW Noise Ordinance. While this exceedance will NOT trigger an automatic violation of the Ordinance, it will be justification for the residents of the effected neighborhoods to file a complaint with the ToW for excessive noise due to the proposed DC. This should trigger a ToW measurement of the noise levels which may/will result in a legal violation of the Ordinance by the proposed DC operator/owner.

5. Warrenton Noise Ordinance vs Data Center

In the letter from the Town of Warrenton (ToW) Zoning Administrator (ZA), Mr. Rob Walton, of December 16, 2022,[34] stated how the ToW will interpret/apply the noise ordinance limits shown in the Noise Ordinance. Below is a summary of the interpretation from the ToW ZA letter:

- ToW Noise Ordinance Section 9-14, Table 9-1, Columns 1 & 3 noise limits will apply 24/7.[35]
- ONLY sound emanating from the inside the parcel will be counted in evaluation of a violation to the ToW Noise Ordinance.
- Sound pressure levels will only be measured at the proposed DC parcel property line.
- To comply at all points along the entire property boundary must be in conformance with the noise ordinance.

---

[34] Ibid 33
[35] Ibid 30

- A -5 dB(Z) correction applies at all points around the property boundary since the data center parcel borders a residential area.
- An additional -5dB(Z) correction applies for all operations from 10pm until 7am.
- If the proposed DC exhibits a "tone" or "hum" type of sound generated from the DC, an additional -5dB(Z) correction will apply. This 3rd correction ("tone" / "hum") may not apply if the DC Operator/owner can "prove" it does not apply based on the referenced ANSI standards, per the Town of Warrenton 12/16/22 Zoning Determination Letter. (Reference 33)

Table 18: ToW Noise Ordinance Table 9-1 limits

(Limits with various corrections in dB(Z))

	-5 dB(Z)	-10dB(Z)	-15 dB(Z)
Frequency Band (Hz)	Daytime no-hum	Day w/hum & Night no-hum	Nighttime w/hum
63	67	62	57
125	65	60	55
250	60	55	50
500	54	49	44
1,000	50	45	40
2,000	46	41	36
4,000	42	37	32
8,000	39	34	29

Since the ToW ZA has stated in reference 33 that the readings will be taken around the parcel boundary to determine site conformance to the ToW Noise Ordinance, a standard set of locations should be determined and codified to ensure consistent readings and conformance determination. The Figure 11 shows proposed locations around the property boundary where the noise can/could be used for standardized noise measurements. The distances on the chart indicate the distance from the location to the closest wall of the proposed DC.

Since noise meters only read total noise, a standard set of noise energy level readings must be taken and codified at the standard measurement locations PRIOR to the first day of the proposed DC becoming operational. Then, to determine the noise emanating from inside the proposed DC parcel, the ambient pre-operational noise readings can be subtracted from the post operational reading to determine the noise generated by the proposed DC as shown in Equation 1.

$$[DC\ Parcel\ Noise] = [Total\ Noise] - [Ambient\ Noise] \qquad \text{Equation 1}$$

Table 19 shows the predicted noise energy levels at the parcel boundary for the noise generated from the proposed DC site (includes DC and other noise generators on the parcel) at the locations shown on Figure 11.

Table 19: Predicted Noise Energy at Proposed Measurement Locations

	Feet	dBA		dBZ 63Hz	125 Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz
A	480	63.5	A	59.0	58.6	54.5	52.3	53.0	48.3	42.1	27.0
B	430	64.2	B	59.7	59.3	55.2	53.1	53.7	49.0	42.8	27.7
C	250	67.8	C	63.2	62.8	58.7	56.6	57.3	52.5	46.3	31.3
D	265	67.4	D	62.8	62.4	58.4	56.2	56.9	52.2	45.9	30.9
E	160	70.7	E	66.1	65.7	61.6	59.5	60.2	55.5	49.2	34.2
F	400	64.7	F	60.2	59.7	55.7	53.5	54.2	49.5	43.3	28.2
G	425	64.3	G	59.8	59.3	55.3	53.1	53.8	49.1	42.9	27.8
H	715	60.9	H	56.4	56.0	51.9	49.7	50.4	45.7	39.5	24.4
I	370	65.2	I	60.7	60.2	56.2	54.0	54.7	50.0	43.8	28.7

***Note**: Noise predicted for proposed DC **ONLY**.*

Table 19 shows the noise energy reaching the property boundaries for the 25 locations selected. OF those locations, noise will exceed the FC Noise Ordinance limit for location #19 – GPIN 6985-60-5718-500. Additionally, the area in 'orange' on Figure 14 located north of US 17 (Bypass) and east of US-29/15 which are outside the ToW boundary would also exceed the FC Noise Ordinance limit. Also, depending on how the Section 13.5-3(b) (see above) is interpreted, other locations may be in violation.

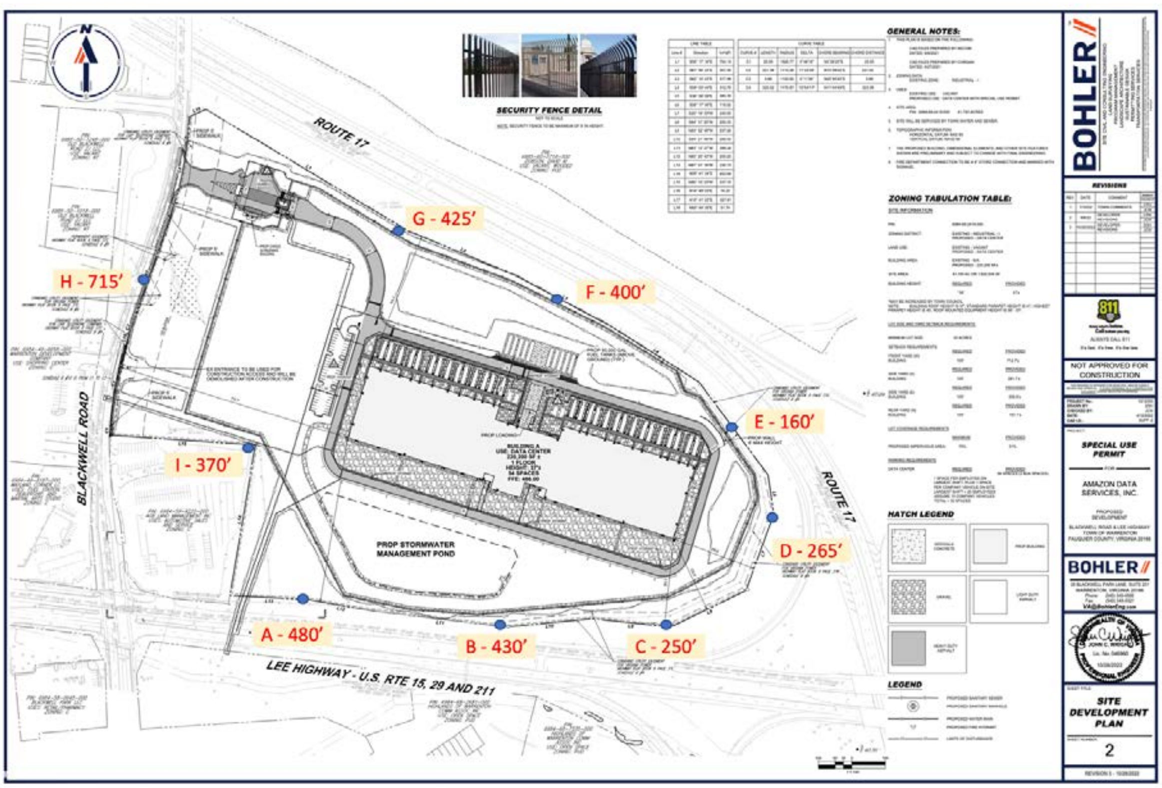
Comparing the noise energy predictions in Table 19 against the Noise Ordinance limits shown Table 18. Table 20 shows the predicted exceedances (aka: violations) of the ToW Noise Ordinance with -5 dB(Z), -10 dB(Z), and -15dB(Z) corrections applied.

The left part of Table 21 shows the number of dB(Z) that the readings at locations shown in Figure 15 will exceed the -15dB(Z) corrected limits specified in the ToW Noise Ordinance. In the right part of Table 21, the percent of noise energy reduction that will be needed to meet the ToW Noise Ordinance.

For example: Table 21 shows that Location A would have to reduce the generated noise level in the 63Hz frequency band by 2.0 dB(Z) which would result in 63% of the original energy to be in conformance with the -15dB(Z) noise limit in the ToW Noise Ordinance.

Note on Table 21 that the largest reduction in noise energy would be for Location E in the 1,000 Hz frequency band where the reduction will have to decrease to less than 1% of the original noise level.

Figure 15: Proposed DC Site with Proposed Noise Measurement Locations [36]



[36] https://mccmeetingspublic.blob.core.usgovcloudapi.net/warrntonva-meet-0e8d7229b2524aa58449d694673aaaa2/ITEM-Attachment-001-0cbfc2e7199340fd86a1f107ac47e6eb.pdf

Table 20: Predicted Exceedance of the ToW Noise Ordinance Limits at the Parcel Boundary

	-5 dB(Z) Correction - Daytime w/ no hum							
	63Hz	125 Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz
A	.	.	.	.	V	V	V	.
B	.	.	.	.	V	V	V	.
C	.	.	.	V	V	V	V	.
D	.	.	.	V	V	V	V	.
E	.	V	V	V	V	V	V	.
F	.	.	.	.	V	V	V	.
G	.	.	.	.	V	V	V	.
H	.	.	.	.	V	.	.	.
I	.	.	.	V	V	V	V	.

	-10 dB(Z) Correction - Daytime w/hum and Nightime no hum							
	63Hz	125 Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz
A	.	.	.	V	V	V	V	.
B	.	.	V	V	V	V	V	.
C	V	V	V	V	V	V	V	.
D	V	V	V	V	V	V	V	.
E	V	V	V	V	V	V	V	V
F	.	.	V	V	V	V	V	.
G	.	.	V	V	V	V	V	.
H	.	.	.	V	V	V	V	.
I	.	V	V	V	V	V	V	.

	-15 dB(Z) Correction - Nighttime w/hum							
	63Hz	125 Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz
A	V	V	V	V	V	V	V	.
B	V	V	V	V	V	V	V	.
C	V	V	V	V	V	V	V	V
D	V	V	V	V	V	V	V	V
E	V	V	V	V	V	V	V	V
F	V	V	V	V	V	V	V	.
G	V	V	V	V	V	V	V	.
H	.	V	V	V	V	V	V	.
I	V	V	V	V	V	V	V	.

Table 21: Predicted Exceedance Level Amounts with -15dB(Z) Correction Applied

	Predicted Noise levels in excess of the Noise Limit with a -15dBZ correction							
	63Hz	125 Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz
A	2.0	3.6	4.5	8.3	13.0	12.3	10.1	-
B	2.7	4.3	5.2	9.1	13.7	13.0	10.8	-
C	6.2	7.8	8.7	12.6	17.3	16.5	14.3	2.3
D	5.8	7.4	8.4	12.2	16.9	16.2	13.9	1.9
E	9.1	10.7	11.6	15.5	20.2	19.5	17.2	5.2
F	3.2	4.7	5.7	9.5	14.2	13.5	11.3	-
G	2.8	4.3	5.3	9.1	13.8	13.1	10.9	-
H	-	1.0	1.9	5.7	10.4	9.7	7.5	-
I	3.7	5.2	6.2	10.0	14.7	14.0	11.8	-

	Percent of predicted noise energyto comply with Noise Limit -15dBZ correction							
	63Hz	125 Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz
A	63%	44%	35%	15%	5%	6%	10%	-
B	54%	37%	30%	12%	4%	5%	8%	-
C	24%	16%	13%	5%	2%	2%	4%	59%
D	26%	18%	14%	6%	2%	2%	4%	65%
E	12%	8%	7%	3%	1%	1%	2%	30%
F	48%	33%	27%	11%	4%	4%	7%	-
G	53%	37%	30%	12%	4%	5%	8%	-
H	-	80%	65%	27%	9%	11%	18%	-
I	43%	30%	24%	10%	3%	4%	7%	-

6. Fauquier County Noise Ordinance Violations

The proposed DC site lies completely within the boundaries of the ToW. However, the noise generated on the proposed DC site will affect the residents of Fauquier County (FC) living outside the ToW limits. The FC Noise Ordinance – Chapter 13.5[37] would most likely apply to provide these residents with relief. While the FC Noise Ordinance does not contain a simple table of maximum values like the ToW Noise Ordinance does, below is a paraphrase of the applicable paragraphs from the FC Noise Ordinance:

7. Warrenton Study Conclusion

The analysis shows that the data center will need a significant reduction in the noise that other Amazon and Amazon-like data centers currently generate. It is doubtful as to whether Amazon will be able to achieve this level of noise energy reduction.

[37] https://library.municode.com/va/fauquier_county/codes/code_of_ordinances?nodeId=COOR_CH13.5NO#

Additionally, it is a concern that the ambient noise surrounding the proposed DC will have on residents will be significant and will result in increased noise related health effects.

H. Small Area Study: King George County, VA

Also, in mid-2022, the proposed SUP application was submitted to the King George County, VA, Planning Office to allow construction of a set of data centers along VA Route 3 in King George County about 15 miles east of Fredericksburg, VA. The following analysis was performed to predict the noise levels for the residents near the proposed stie.

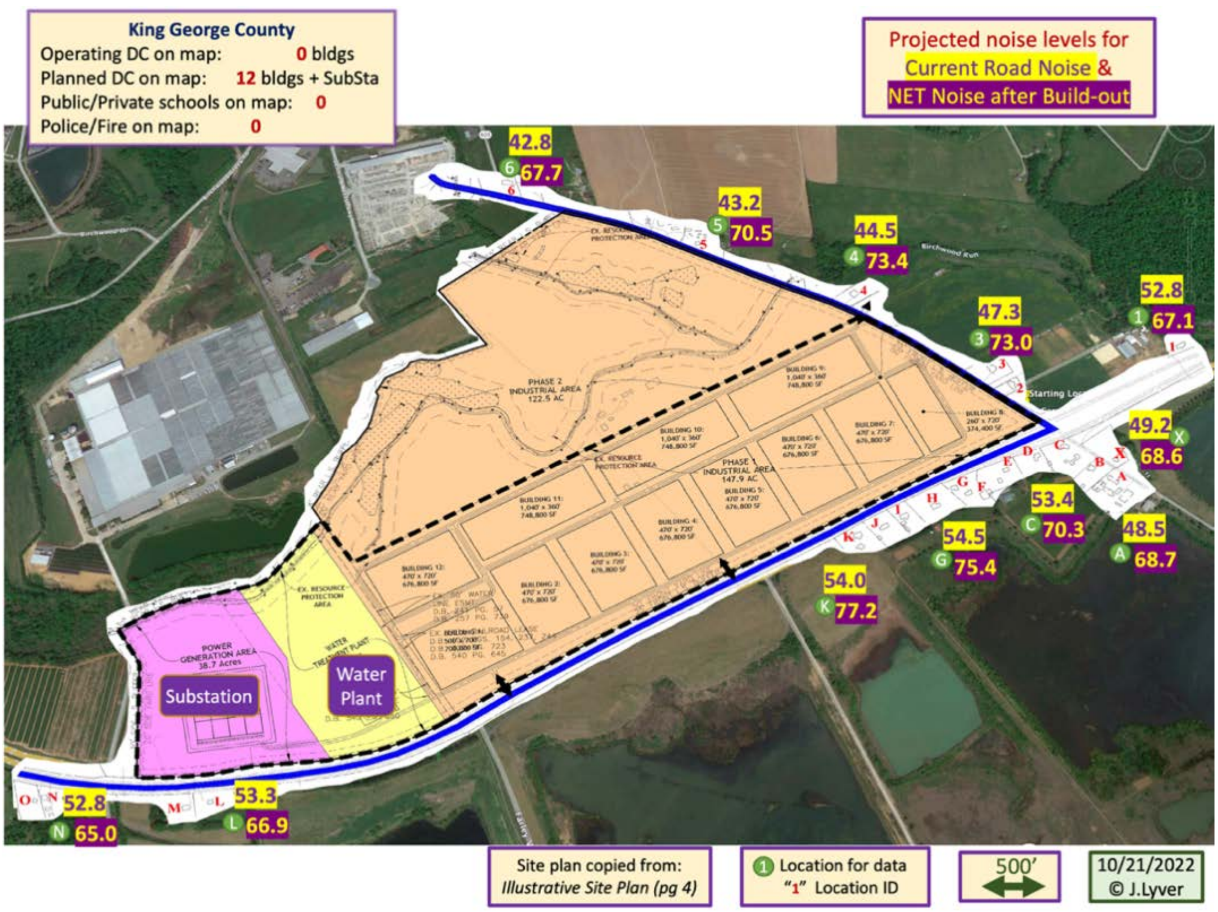
It was noted that the King George County data center levels would exceed the County Noise Ordinance at every location by several dB(A).

Table 22: Predicted King George County Noise Levels

10/21/2022
© J.Lyver

Location #	Addresses of Sites to Analyze	Road dBA	DC dBA	Total dBA
1	4089 Kings Hwy	52.8	67.0	67.1
2	11511 Bloomsbury Rd	48.4	72.3	72.4
3	11497 Bloomsbury Rd	47.3	73.0	73.0
4	11371 Bloomsbury Rd	44.5	73.4	73.4
5	11253 Bloomsburg Rd	43.2	70.5	70.5
6	11103 Bloomsburg Rd	42.8	67.7	67.7
A	11620 Lagrange Ln	48.5	68.7	68.7
B	11598 Lagrange Ln	49.3	69.2	69.2
C	11580 Lagrange Ln	53.4	70.2	70.3
D	3524 Kings Hwy	53.4	71.2	71.3
E	3498 Kings Hwy	52.9	72.6	72.6
F	behind 3456 KingsHwy	50.7	73.1	73.1
G	3456 Kings Hwy	54.5	75.3	75.4
H	3442 Kings Hwy	52.2	75.5	75.5
I	3412 Kings Hwy	53.0	76.2	76.2
J	3396 Kings Hwy	52.8	76.4	76.4
K	3370 Kings Hwy	54.0	77.2	77.2
L	2340 Kings Hwy	53.3	66.7	66.9
M	2318 Kings Hwy	52.5	66.3	66.5
N	2216 Kings Hwy	52.8	64.7	65.0
O	2204 Kings Hwy	51.0	64.6	64.8
X	11611 LaGrange Ln	49.2	68.5	68.6

Figure 16: King George County Site Predicted Noise Levels



III. Noise Analyses for Schools and Public Safety Facilities

A. School Analyses

All analyses were done using the same MATLAB™ code written by the author that calculated the noise intensity in the previous chapter. Differences in the analysis techniques include:

- Schools were included on the list if they are located within 1 mile from the Data Center Opportunity Zone Overlay District (DCOZOD)
- Preschools were not included on this list which offered education levels up through kindergarten.
- Only the noise generated from data centers was calculated. Road or ambient noise was not included.
- Sizes of schools were estimated from Google Earth measurements. The previous section used point locations.
- Distances were measured from the circumference of a postulated circular data center to the circumference of a postulated circular school. Basically, this was taking the distance between the data center and the school and subtracting the radii of the data center and the school when modeled as circular buildings.

Results are presented in 3 groups with similar breakouts of information: Public Schools, Private schools, and Higher Education Schools.

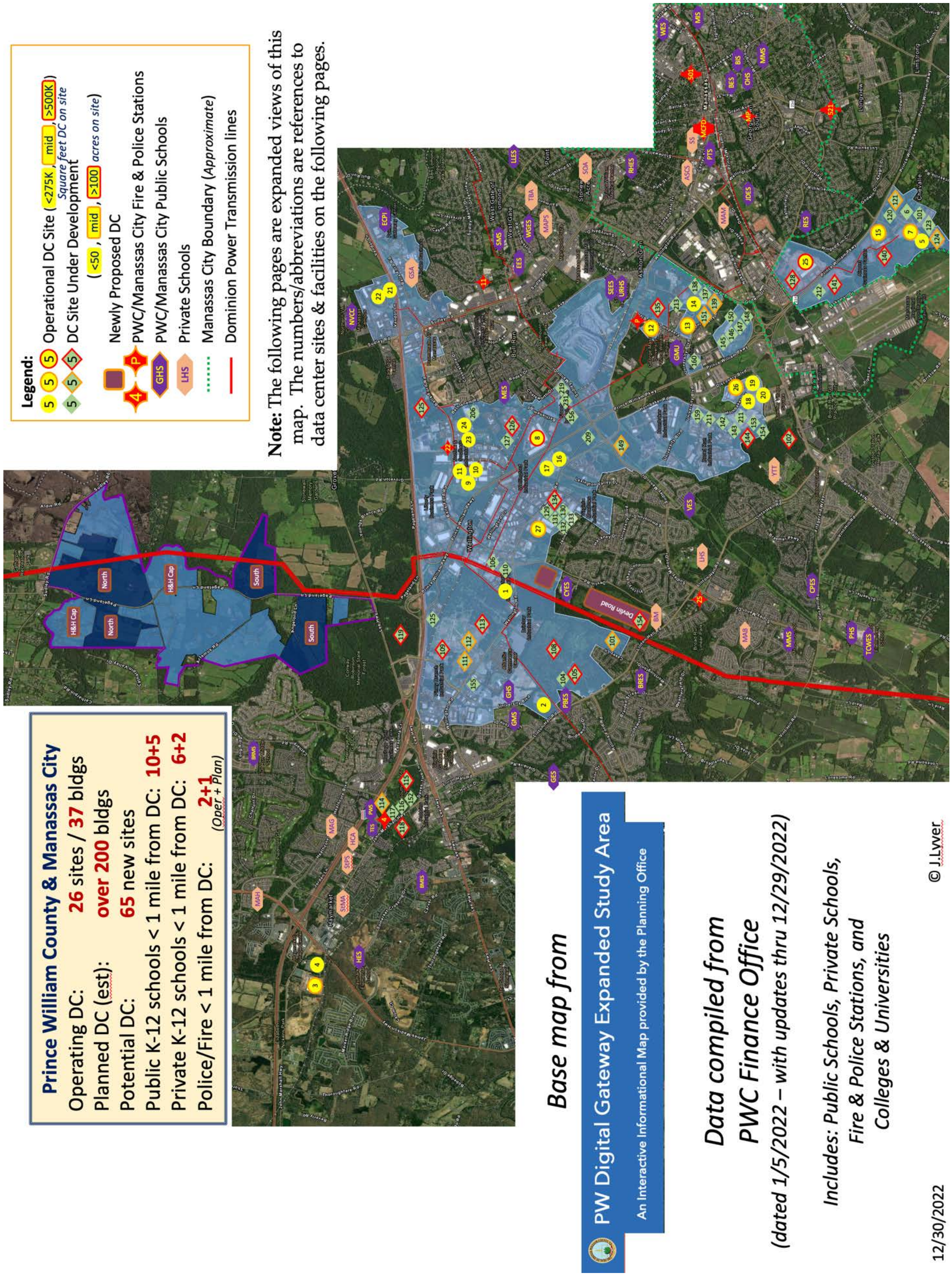
The importance of knowing the noise level outside the school is to analyze the recommended noise limit inside the classroom (35 dB(A)) for 'permanent classrooms'.[38] Part II of reference 38 provides information for 'temporary' classrooms. The referenced ANSI Standard is used across the U.S.A for limiting noise in a classroom to ensure that the noise does not affect student learning environment. This noise level is measured during the time when students would be present but are NOT present and includes all noise sources from both internal and external sources. Internal noise sources include HVAC systems and other mechanical systems. External noise sources include road noise, nearby facilities. In this study ONLY the noise from operating and planned data centers has been included, so ALL noise levels would be noticeably higher when other external noise sources like roads, and other industrial facilities are included.

Figure 17 provides an overview map of all of the operating DCs, planned DC sites, public schools, private schools with 1st grade and higher education levels, colleges, universities, and public safety facilities within the vicinity of the DCOZOD. This figure is from the document: "*Maps of Data Center Development in Prince William County, VA*"[39] by the author of this study. That document also contains detailed information on data center and data center sites to include address, size, and owner. In the following tables, the column "Map Abbrev" refers to the icon for the school or public safety facility on the figure.

[38] ANSI/ASA S12.60-2010/Part 1

[39] Lyver, J., "Maps of Data Center Development in Prince William County, VA", dated 12/30/2022. Document may be obtained by request to the author at JLyver4@Comcast.NET

Figure 17: Map of Operating and Planned DCs, Schools and Public Safety Facilities



1. Public Schools

Table 23: Public Schools - Noise from Currently Operating DCs

School District	Education Level	School Name	Closest DC (feet)	Current dB(A)	# DCs <1 mile	# DCs <2 miles	Map Abbrev [40]
Manassas City Public Schools (MCPS)	Elementary Schools (ES)	Jeannie Davis ES	4,949	56.2	1	10	JDES
		George C Round ES	1,584	61.8	5	14	RES
Prince William Public Schools (PWCS)	ES	Buckland Mills ES	6,717	49.7	0	3	BMES
		Bristow Run ES	5,664	49.7	0	4	BRES
		Cedar Point ES	10,773	*	0	0	CPES
		Chris Yung ES	3,017	56.6	3	15	CYES
		Ellis ES	3,118	57.2	4	12	EES
		Glenkirk ES	6,571	46.6	0	1	GES
		Haymarket ES	2,766	55.7	3	3	HES
		George P. Mullen ES	2,499	59.8	12	18	MES
		Piney Branch ES	831	60.2	1	4	PBES
		Sinclair ES	5,521	53.4	0	11	SES
		Tyler ES	8,048	48.5	0	3	TES
		Victory ES	6,354	56.3	0	16	VES
	Middle Schools (MS)	Gainesville MS	1,419	56.6	1	2	GMS
	High Schools (HS)	Gainesville HS	1,689	56.0	1	4	GHS
		Patriot HS	14,206	*	0	0	PHS
		Unity-Reed HS	2,626	58.5	4	16	URHS
	Non-Traditional Schools (NT)	PACE West	9,086	47.8	0	3	PWS

***Note**: * indicated no operating DCs within 2 miles*

[40] Map Abbreviation referred to is contained in the "Data Center Maps" document by J.Lyver. Copies may be obtained by request from JLyver4@Comcast.NET

Table 24: Public Schools – Additional Noise from Planned DCs

School District	Education Level	School Name	Closest DC (feet)	Planned dB(A) being ADDED	# DCs <1 mile	# DCs <2 miles	Map Abbrev
MCPS	ES	Jeannie Davis ES	5,245	63.8	1	16	JDES
		George C Round ES	2,368	67.9	4	20	RES
PWCS	ES	Buckland Mills ES	3,941	62.9	2	4	BMES
		Bristow Run ES	2,057	76.1	4	15	BRES
		Cedar Point ES	8,096	62.8	0	6	CPES
		Chris Yung ES	2,932	81.1	13	28	CYES
		Ellis ES	2,704	64.8	5	22	EES
		Glenkirk ES	6,860	68.0	0	4	GES
		Haymarket ES	8,046	57.5	0	4	HES
		George P. Mullen ES	1,470	69.6	6	19	MES
		Piney Branch ES	311	79.4	4	20	PBES
		Sinclair ES	8,540	57.6	0	6	SES
		Tyler ES	677	70.2	4	4	TES
		Victory ES	4,314	70.1	5	27	VES
	MS	Gainesville MS	2,158	77.1	5	18	GMS
	HS	Gainesville HS	2,111	78.6	7	24	GHS
		Patriot HS	11,626	*	0	0	PHS
		Unity-Reed HS	2,105	65.9	6	24	URHS
	NT	PACE West	166	74.9	4	8	PWS

Note*: * indicated no planned DCs within 2 miles*

Table 25: Public Schools – Total Noise from Operating and Planned DCs

School District	Education Level	School Name	Map Abbrev *	Total Noise Intensity dB(A)
MCPS	ES	Jeannie Davis ES	JDES	64.5
		George C Round ES	RES	68.9
PWCS	ES	Buckland Mills ES	BMES	63.1
		Bristow Run ES	BRES	76.1
		Cedar Point ES	CPES	62.8
		Chris Yung ES	CYES	81.1
		Ellis ES	EES	65.5
		Glenkirk ES	GES	68.1
		Haymarket ES	HES	59.7
		George P. Mullen ES	MES	70.1
		Piney Branch ES	PBES	79.5
		Sinclair ES	SES	59.0
		Tyler ES	TES	70.3
		Victory ES	VES	70.3
	MS	Gainesville MS	GMS	77.1
	HS	Gainesville HS	GHS	78.7
		Patriot HS	PHS	0.0
		Unity-Reed HS	URHS	66.6
	NT	PACE West	PWS	74.9

Table 26: Public Schools – Summary of Distances to Operating and Planned DCs

School	Inside or Outside the DCOZOD?	Nearby Data Center Sites
(MCPS) George C. Round ES	Outside	~1/3 mile from 4 operating DC bldgs & ~ 1/2 mile from 1 planned DC site & ~ 2/3 mile from 1 operating DC Bldg & 1 planned DC site & ~1/2 mile from 2 planned DC sites
(MCPS) Jeannie Davis ES	Outside	~ 1 mile from 4 operating DCs
Buckland Mills ES	Outside	<1 mile from 2 planned DC sites
Bristow Run ES	Outside	~1/2 mile from 2 planned DC sites & ~1 mile from 2 planned DC sites
Chris Yung ES	Outside – borders DCOZOD	Borders planned DC site (Devlin Rd) & ~1/2 mile from operating 2 DC bldgs & 3 planned DC site & ~2/3 mile from 1 operating DC bldg & 2 planned DC sites & ~3/4 mile from 4 planned DC sites & ~1 mile from 2 planned DC sites
Ellis ES	Outside – borders DCOZOD	~1/2 mile from 2 operating DC bldgs & 1 planned DC site & < 1 mile from 2 operating DC bldgs & 2 planned DC sites
Gainesville HS	**INSIDE**	<1/3 mile from 1 operating DC bldg & <1/2 mile from 2 planned DC sites & ~ 2/3 mile from 2 planned DC sites & ~3/4 mile from 1 operating DC bldg & 2 planned DC sites
Gainesville MS	Outside – borders DCOZOD	<1/4 mile from 1 operating DC bldg & < 1/2 mile from 1 planned DC site <1 mile form 4 planned DC sites
Haymarket ES	Outside	~1/2 mile from 3 operating DC bldgs
Mullins ES	Outside – borders DCOZOD	~1/4 mile from 1 planned DC site & ~1/3 mile from 1 planned DC site & ~1/2 mile from 6 operating DC bldgs & <3/4 mile from 1 planned DC site & <1 mile from 5 operating DC bldgs &
PACE West	Outside	Borders 2 planned DC sites & <1/4 mile from 2 planned DC sites & <1/3 mile from 1 planned DC site
Piney Branch ES	Outside – borders DCOZOD	~ Borders 1 operating DC bldg & 1 planned DC site & <1/3 mile from 1 planned DC site & 1/2mile from 1 planned DC site & 2/3 mile from 1 planned DC site
Tyler ES	Outside	<1/4 mile from 3 planned DC sites & <1/3 mile from 1 planned DC site & ~1/2 mile from 2 planned DC sites
Unity-Reed HS	Outside – borders DCOZOD	~1/2 mile from 2 operating DC bldgs & 1 planned DC site & ~2/3 mile from 1 planned DC site & ~ 1 mile from 2 operating DC bldgs & 3 planned DC sites
Victory ES	Outside	~ 3/4 mile from 1 planned DC site & ~1 mile from 3 planned DC sites

Notes: *- Some listed data center sites may contain multiple buildings*
- "Borders" indicates < 1000' to DC bldg or DC site

- *"DC site" refers to a land parcel with an unknown number of DC buildings planned*
- *"~" indicates 'approximately' and "<" indicates 'less than'*

2. Private Schools

Table 27: Private Schools - Noise from Currently Operating DCs

Jurisdiction	Education Level	School Name	Closest DC (feet)	Current dB(A)	# DCs <1 mile	# DCs <2 miles	Map Abbrev
Private Schools in Manassas City (P-MC)	ES	Minneland Academy - Manassas	7,145	54.2	0	7	MAM
Private Schools in Prince William County (P-PWC)	ES	Bristow Montessori	7,882	50.9	0	6	BM
		Good Sheppard Academy	1,114	58.9	2	6	GSA
		Haymarket Christian Academy	6,616	49.7	0	3	HCA
		Minneland Academy - Gainesville	758	60.7	1	2	MAG
		Minneland Academy - Heathcote	3,935	53.0	3	3	MAH
		St Michael's Academy	3,003	54.3	3	3	StMA
		St Paul's School	3,003	54.3	3	3	StPS
	NT	Youth for Tomorrow	4,326	55.1	4	6	YFT

Table 28: Private Schools – Additional Noise from Planned DCs

Jurisdiction	Education Level	School Name	Closest DC (feet)	Planned dB(A) being Added	# DCs <1 mile	# DCs <2 miles	Map Abbrev
P-MC	ES	Minneland Academy - Manassas	6,739	62.0	0	8	MAM
P-PWC	ES	Bristow Montessori	2,458	74.8	2	16	BM
		Good Sheppard Academy	9,283	55.6	0	3	GSA
		Haymarket Christian Academy	2,273	65.5	4	4	HCA
		Minneland Academy - Gainesville	1,181	76.8	4	17	MAG
		Minneland Academy - Heathcote	8,548	57.4	0	4	MAH
		St Michael's Academy	5,233	61.3	1	4	StMA
		St Paul's School	5,233	61.3	1	4	StPS
	NT	Youth for Tomorrow	1,670	71.6	7	16	YFT

Table 29: Private Schools – Total Noise from Operating and Planned DCs

Jurisdiction	Education Level	School Name	Map Abbrev	Total Noise Intensity dB(A)
P-MC	ES	Minneland Academy - Manassas	MAM	62.6
P-PWC	ES	Bristow Montessori	BM	74.9
		Good Sheppard Academy	GSA	60.5
		Haymarket Christian Academy	HCA	65.6
		Minneland Academy - Gainesville	MAG	76.9
		Minneland Academy - Heathcote	MAH	58.8
		St Michael's Academy	StMA	62.1
		St Paul's School	StPS	62.1
	NT	Youth for Tomorrow	YFT	71.7

Table 30: Private Schools – Summary of Distances to Operating and Planned DCs

School	Inside or Outside the DCOZOD?	Nearby Data Center Sites
Bristow Montessori	Outside	Borders 1 planned Devlin Road site & ~1/2 mile from 1 planned DC site & ~ 1 mile for planned DC site
Good Shephard Academy	**INSIDE**	<1/4 mile from 2 operating DC bldgs
Haymarket Christian Academy	Outside	< 2/3 miles from 2 planned DC sites & ~ 3/4 mile from 2 planned DC sites
Minneland Academy (Gainesville)	Outside	Borders 1 operating DC Bldg & 1/4 mile from 1 planned DC site & 1/2 mile from 1 planned DC site & ~3/4 mile from 1 planned DC site
Minneland Academy (Haymarket)	Outside	<3/4 mile from 3 operating DC Bldgs
St Michael's Academy & St Paul's School	Outside	~3/4 mile from 3 operating DC bldgs
Youth for Tomorrow	Outside	Borders 1 planned DC site & <1/3 mile from 1 planned DC site & ~2/3 mile from 3 planned DC sites & <1mile from 4 operating DC bldgs

3. Higher Education

Table 31: Higher Education - Noise from Currently Operating DCs

School Name	Closest DC (feet)	Current dB(A)	# DCs <1 mile	# DCs <2 mile	Map Abbrev
NoVa Community College – Manassas Campus	1,890	56.2	2	5	NVCC
ECPI University	4,099	51.1	2	2	ECPI
George Mason University – SciTech Campus	892	64.7	8	19	GMU

Table 32: Higher Education – Additional Noise from Planned DCs

School Name	Closest DC (feet)	Planned dB(A) being Added	# DCs <1 mile	# DCs <2 miles	Map Abbrev
NoVa Community College – Manassas Campus	10,950	46.6	0	1	NVCC
ECPI University	14,303	*	0	0	ECPI
George Mason University – SciTech Campus	1,548	70.3	1	28	GMU

Table 33: Higher Education – Total Noise from Operating and Planned DCs

School Name	Map Abbrev	Total Noise Intensity dB(A)
NoVa Community College - Manassas Campus	NVCC	56.6
ECPI University	ECPI	51.1
George Mason University - SciTech Campus	GMU	71.3

Table 34: Higher Education – Summary of Distances to Operating and Planned DCs

Facility	Inside or Outside the DCOZOD?	Nearby Data Center Sites
ECPI University	**INSIDE**	<3/4 mile from 2 operating DC bldgs
NoVa Community College - Manassas Campus	Outside	~1/2 mile from 2 operating DC bldgs
George Mason University – SciTech Campus	Outside – borders DCOZOD	Borders 1 operating DC bldg <1/4 mile from 2 operating DC bldgs & < 1/3 mile from 2 planned DC sites & <1/2 mile from 1 operating DC bldg & 6 planned DC sites & ~2/3 mile from 1 planned DC site & ~ 3/4 mile from 1 planned DC site & <1 mile form 3 operating DC bldgs

B. Public Safety Facilities

All analyses were done using the same MATLAB™ code written by the author that calculated the noise intensity in the previous chapter. Analyses for public safety facilities was done identically to the School analyses described in the previous section.

There are no Public Safety Facilities in the City of Manassas that were within 1 mile of the DCOZOD

Table 35: Public Safety Facilities - Noise from Currently Operating DCs

Jurisdiction	Department	Name	Closest DC (feet)	Current dB(A)	# DCs <1 mile	# DCs <2 miles	Map Abbrev *
PWC	Fire Department	Fire Station 11	5887	53.4	0	11	FS-11
		Fire Station 22	811	62.8	10	17	FS-22
		Fire Station 25	9520	45.5	0	2	FS-25
		Fire Station 4	9099	47.8	0	3	FS-4
	Police Department	PWC Western District Station	471	65.7	4	19	P

Table 36: Public Safety Facilities - Additional Noise from Planned DCs

Jurisdiction	Department	Name	Closest DC (feet)	Planned dB(A) being Added	# DCs <1 mile	# DCs <2 mile	Map Abbrev *
PWC	Fire Department	Fire Station 11	8252	58.0	0	7	FS-11
		Fire Station 22	3473	71.8	3	20	FS-22
		Fire Station 25	4864	71.5	1	17	FS-25
		Fire Station 4	136	76.3	4	7	FS-4
	Police Department	PWC Western District Station	727	70.0	8	27	P

Table 37: Public Safety Facilities - Total Noise from Operating and Planned DCs

Jurisdiction	Department	Name	Map Abbrev *	Total Noise Intensity dB(A)
PWC	Fire Department	Fire Station 11	FS-11	59.3
		Fire Station 22	FS-22	72.3
		Fire Station 25	FS-25	71.5
		Fire Station 4	FS-4	76.3
	Police Department	PWC Western District Station	P	71.3

Table 38: Public Safety Facilities – Summary of Distances to Operating and Planned DCs

Facility	Inside or Outside the DCOZOD?	Nearby Data Center Sites
PWC Police Station (Western District)	Outside – borders DCOZOD	Borders 2 operating DC bldg & 1 planned DC site & ~ 1/2 mile from 1 operating DC Bldg & ~2/3 mile from 1 operating DC Bldg & 3 planned DC site & ~1 mile from 2 planned DC site
PWC Fire Station #4	Outside	Borders 4 planned DC sites & < 1/4 mile from 1 planned DC site & ~ 1/3 mile from 1 planned DC site
PWC Fire Station #22	**INSIDE**	Borders 3 operating DC bldg & ~1/3 mile from 3 operating DC bldgs & < 1/2 mile from 1 planned DC site & ~2/3 mile from 2 planned DC sites & ~1 mile from 3 operating DC bldgs

IV. Summary and Recommendations

A. Summary

1. Prince William County government is not fulfilling its obligations to residents by developing reliable noise projections for proposed data center rezoning proposals before approving those proposals.
2. Within northern Virginia, there are widely varying noise ordinance specifications between counties and locales which afford residents widely varying protections from 24/7 data center noise levels.
3. County government staffs lack sufficient expertise for crafting thorough-going noise ordinances without loopholes which industrial and commercial activities can exploit to circumvent the intent of noise ordinances.

B. Recommendations

1. Prince William County (PWC) government needs to take seriously its obligations to protect its residents from intrusive noise levels.
2. PWC needs to develop reliable and validated noise analysis methodologies and measurement capabilities for proposed data center rezoning proposals before approving those proposals.
3. Until PWC has this secured these noise modeling and measurement capabilities, the county should impose a moratorium upon all further data center rezoning proposals.
4. PWC needs to modernize its dated noise ordinances for digital-era industrial activities. PWC should survey statewide and nationwide noise ordinances and develop a best practice noise ordinance which affords PWC residents the protection from 24/7 data center noise levels which they deserve.
5. Further, PWC needs to craft a thorough-going noise ordinances which eliminate loopholes which industrial and commercial activities can exploit to circumvent the intent of noise ordinances.
6. PWC government needs to invest in its staff and develop greater in-house noise modeling and measurement expertise.
7. ToW needs to establish a standardized set of locations to take readings around the proposed DC and needs to formally record a baseline set of readings for those locations.

Appendix: Health Effects Attributed to Increased Noise Levels

The following analysis was assembled by Dr. Ally Stoeger (Chair of the Health and Safety Committee, HOA Roundtable of PWC) and is gratefully used with her permission.

<u>Persistent 24/7 Data Center Noise in the community can cause:</u>

- **Chronic Sleep Deprivation**
- **Anxiety and Depression due to combination of noise and lack of control when residents realize this noise even permeates their homes**
- **Difficulty with Concentration**
- **Increases stress related conditions such as:**
  - **gastrointestinal problems**
  - **auto-immune diseases**
  - **hypertension and cardiovascular disease**
- **Increased health risk as residents avoid outdoor exercise**

Chronic sleep deprivation affects both your brain and body and can cause:

- **Anxiety, depression, mood swings, suicidal thoughts**
- **Memory and concentration**
- **For children it can decrease growth hormones**
- **Vehicular and Workplace accidents**
- **Impacts insulin release and increases risk of diabetes**
- **Less interest in exercise due to fatigue**
- **Hypertension, cardiovascular health, and stroke:**
  June 2022: American Heart Association updated the cardiovascular checklist by adding the importance of 7 – 9 hours sleep

PERSISTENT 24/7 NOISE, AS WELL AS SLEEP DEPRIVATION DUE TO NOISE, CAN IMPACT MENTAL AND PHYSICAL HEALTH AND DRAMATICALLY LOWER QUALITY OF LIFE.

Appendix II: Reference Tables

Table 39: Typical Noise Levels

Typical Noise Levels	
45-50 dBA	Quiet Suburb˜ & Moderate Rainfall˜
50-60 dBA	Modern Built in Dishwasher ˜
55 dBA	Coffee percolator ˜
59 dBA	2001 Volvo @ idle @ 5′ *
60 dBA	Restaurant with regular conversation ˜ Modern garbage disposal @ 5′ * Sewing Machine @ 5′ ˜
65-70 dBA	Restaurant which is too loud for conversation ˜ Average 1990′s Dishwasher ˜
72 dBA	I-66 @ 300' * (to median strip)
74 dBA	Dyson Vacuum Cleaner @ 5′ *, Hairdryer @ 1′ ˜ Battery powered Leaf Blower @ 5′ * *(Hearing damage begins)*
80 dBA	Food Blender ˜, 1990′s garbage disposal ˜, Typical alarm clock˜, coffee grinder ˜
81 dBA	Push Gasoline Lawn Mower @ 5′ *
85 dBA	Train whistle @ 500' ˜, Passing diesel semi-Truck ˜

Note: *indicates measured noise and ˜ indicates internet reference noise
Distance indicated is between generator and measurement

Table 40: PWC Noise Ordinance Section 14-4 Table

MAXIMUM PERMISSIBLE SOUND PRESSURE LEVELS

Zoning District Classification	Maximum dBA Daytime	Maximum dBA Nighttime
Residential	60	55
Mixed Use District	60	55
Commercial	65	60
Office	65	60
Industrial	79	72

Page intentionally left blank