

**Association of Environmental Engineering and Science Professors (AEESP)
Final Report for the Foundation Grant**

**Where Does Data Come From? Introducing rural students
to environmental sciences through hands-on deployment and
data interpretation of local noise measurements**

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Overview:

This project began in January of 2025 and ended in November of 2025. The project aimed to foster enthusiasm towards investigating one's environment and inspire students to pursue a career in Environmental Sciences and Engineering. The specific theme of this project focused on showcasing noise pollution through classroom demonstrations, sensor deployment, and data interpretation in hands-on activities. Rural students in mid-Missouri were the target of this outreach, and two different high school groups participated.

Specifically, the project was implemented at Jefferson City High School (JCHS) and North Callaway High School (NCHS). JCHS is located in an urban area of Missouri: Jefferson City. Jefferson City has a population of approximately 42,565 people [1]. NCHS is located in a rural area of Missouri where the nearest town, Auxvasse, has a population of about 1,385 people [1]. The student participants at JCHS included five students who were either actively enrolled in the AP Environmental Science course or previously completed the course. The students who participated at NCHS included 12 students who were enrolled in an introductory biology course. Discussions with the high school coordinators mentioned that the JCHS were likely going to college after graduation while the students at NCHS were not necessarily college-bound.

Figure 1 Aerial Satellite with Measurement Locations in Yellow (JCHS left, NCHS right).



Each high school was visited once by the team from Westminster College, which included the Principal Investigator (PI) and one undergraduate student. Three objectives were planned for the visits, as defined below.

1. Define and describe characteristics of noise pollution including magnitude and frequency.
2. Plan and deploy a sound level meter according to a defined data objective.
3. Use Microsoft Excel or Google Sheets to quantify and visualize the total noise profile across time.

Unfortunately, the software component of the activity (i.e., Objective #3) was omitted due to time constraints. However, the spot measurements were still interpreted through discussion and interpretation of the statistics.

A final objective (i.e., Objective #4) for the project included disseminating the results of the project to learning resources such as the National Science Teaching Association for other educators to replicate the investigation; and present at the next AEEESP conference. This objective is on-going.

Background & Motivation:

This project aimed to foster enthusiasm towards investigating one's environment and inspire students to pursue a career in Environmental Sciences and Engineering. While planning, deployment, collection, and interpretation of environmental data are steps crucial to all environmental subjects, this project focused on noise pollution – a pollutant that impacts both rural and urban areas [2]. In addition, the hands-on nature of the project hoped to provide transparency and understanding on how data is 'made' in order to build confidence in conclusions presented by scientists and engineers.

Implementation:

The main piece of equipment used in this project included the Sound Level Meter (821ENV-D) by PCB Piezotronics (shown in Figure 1). This sound level meter (SLM) is a Class 1 meter meaning it meets high quality standards in its measurements. The device is able to measure one-third octave frequencies and the associated magnitude in various weighted decibels across time. After equipment was ordered, arrived, and tested at Westminster College, local high schools were contacted regarding scheduling of an outreach event. High schools were given multiple options for outreach events: a 1-day visit with less software activities, or a 2-day visit where the second day focused exclusively on robust analysis of the frequency and decibel timeseries. Both high schools that participated preferred the 1-day visit due to scheduling constraints.

Upon arrival at the high schools, the Westminster team was introduced briefly, but without providing any background information about our interests in the Environmental Science or Engineering fields. This omission was intentional as a pre-survey was administered to students after the introductions. The Westminster team wanted students' interests about Environmental Science & Engineering, noise pollution, and software skills prior to any outreach intervention. A copy of the pre and post survey statements are included in the supplemental materials. Results of the survey are detailed in the "Outcomes" section of this report. After completion of the surveys, environmental science and engineering was briefly discussed, including the team's personal passions and pathways into the field, and students were given an informational handout about the fields – also provided in the supplemental materials. The team then introduced the concepts of magnitude and frequency of noise pollution by playing an audio recording. The singular recording

Figure 2 SLM with Live Display



included a constant chorus of insect stridulations with occasional, loud aircraft flyovers. The team and students discussed what people heard and then replayed the recording after highlighting differences between perceived frequencies and magnitudes alongside spatial factors impacting the recording.

After discussion ended, students were informed that they would be conducting their own measurements around campus. Students were handed a measurement campaign worksheet to help guide their hands-on investigations around their campus but allowed complete freedom and ownership in the design process. The guided handout is provided in supplemental materials. Once the individual students were completed with their handout, the students held a forum to decide upon one measurement campaign according to a central question (e.g., data objective) they wanted to investigate. JCHS students decided to investigate the following: a roadway intersection on the edge of campus, alongside a busy hill on campus, and within their campus's enclosed courtyard. They wanted to find the loudest and quietest places around campus. The JCHS measurements were conducted on a Saturday morning when the main student population was not in session. NCHS wanted to investigate which indoor areas were the loudest and quietest inside the building and decided to investigate: the library, the band room, the weightlifting room, and then an outdoor measurement near the highway. The NCHS measurements were completed when school was in session. The students were very meticulous about being sure to schedule the route such that the measurements were completed when band and weights classes were in session.

After students finalized the group's measurement route, the group proceeded to take timed, two minute measurements at each location using the SLM. Students completed a field notes packet at each location to mimic scientists and engineers in the field – handout is provided in supplemental materials. The packet focused on simple metrics such as maximum, minimum, and average decibel level and documenting any dominant frequency. Other field notes were documented such as arrival and departure time and observations. Small discussions were held at each measurement site as well once the two minute measurements were completed.

Upon completion of the measurement campaign, the team documented the values of each location on a central-viewed whiteboard. Students were then asked open-answer questions such as “What was the most surprising measurement we took today and why?”. The Westminster team offered guided questions to help stimulate the discussion and interpretation of the data, but let the high school students drive the conversation. The Westminster team also asked students what they would do differently in the future using the SLM, or what could be done in the students' lives to improve their noise environment at school or their hearing in hobbies such as hunting. After wrapping up discussions and any additional questions, the post-survey was administered to the students. Specific details on the measurement results, the survey data, and the discussion will be documented in the “Outcomes” section of this report.

Despite not having the time to complete the Microsoft Excel/Google Sheets activities with the students, the project was still implemented successfully. In addition, the JCHS expressed a keen

interest in continuing the partnership with Westminster College including scheduling a future Microsoft Excel investigation of the temporal pattern of their measurements; and repeating the outreach in subsequent years.

Outcomes and Results:

The pre and post-surveys were administered in such a way that results were anonymous but still paired. Five statements were presented to the students and students responded to the statements using a numerical scale of 1 to 5 with 1 being strongly disagree and 5 being strongly agree. The five statements were as such:

1. I often notice the noises and/or sounds around me.
2. I understand what properties determine a location's soundscape.
3. I have considered pursuing a career in science, math, technology, or engineering.
4. I have considered pursuing a career, taking a course, and/or participating in a club about the environment.
5. I feel confident using Excel software on my own to calculate a minimum, maximum, and average of a dataset.

Table 1 shows the average pre and post values for each statement alongside the difference in those averages for each statement (i.e., Post – Pre). It is notable that the JCHS students were students enrolled in AP Environmental Science, which is an optional class. As such, we are not surprised by the large (≥ 4.0) pre-survey scores for statements #3 and #4 since these students have already expressed an interest in the environment simply by enrolling in the optional AP Environmental Science course. Differences in NCHS were minor but did show a positive trend towards more interest in noise and environmental science and engineering clubs/courses. However, neither improvement or deprecation in statement #3 “I have considered pursuing a career in science, technology, math, or engineering” was disheartening.

Statement 2: “I understand what properties determine a location's soundscape” had the largest increase in interest for across both student populations. Noise is a pollutant that people can experience easily without additional testing. Therefore, I suspect the hands-on demonstration with the SLM alongside the experiential side of noise pollution contributing to this large increase in both populations.

		S1	S2	S3	S4	S5
JCHS	Post (average)	3.6	4.2	4.6	4.6	3.0
	Pre (average)	3.8	2.0	4.0	4.6	2.4
	Difference:	-0.2	2.2	0.6	0.0	0.6
NCHS	Post (average)	4.4	3.8	2.8	3.3	2.9
	Pre (average)	4.3	2.5	2.8	2.9	2.7
	Difference:	0.1	1.3	0.0	0.4	0.2

Table 1 Aggregated Averages for Each Statement by School

In Table 2, any statement where a student marked a larger value in their post-survey was counted. The statements were worded in such a way that a positive increase in value from pre-survey to post-survey indicates an improvement in interest or confidence.

Number of students whose post survey result increased .					
	S1	S2	S3	S4	S5
JCHS (out of 5)	0	5	3	0	2
NCHS (out of 12)	4	10	3	3	3
Number of students whose post survey result decreased .					
	S1	S2	S3	S4	S5
JCHS (out of 5)	1	0	0	0	0
NCHS (out of 12)	1	0	1	0	0

Table 2 Counts of the number of students where the post survey either increased or decreased, respectively.

Despite minor increases in most statement’s averages, a count of the number of *individual* responses that increased in score showed more promising outcomes of the outreach intervention. Table 2 shows that at least three students out of the 12 participants at NCHS reported increased affinity in *all* statements. This data shows that the outreach did have an impact on the individual level for some participants.

Notable discussions with the groups include the following: NCHS students were very surprised that the band room was just as loud as the weight room (Figure 3). However, we noted a lower minimum in the band room indicating periods of intermittent silence or quieter soundscapes. Students perceived the weightroom as much louder in general due to both music being played on speakers, loud weight dropping noises, and the presence of an echo. Students at NCHS were also curious about doing further investigations near the local forest behind their school to try to quantify any insect noise.

Students at JCHS wanted to further investigate indoor noise as they noted that the hallways at their school seemed very loud at times. They also wanted to actively use the courtyard more in order to have a quieter soundscape in which to enjoy their lunch (Figure 4). Students at JCHS were very interested in diving deeper into the data using Microsoft Excel and/or Google Sheets, and future events are currently being planned.

Figure 3 Students taking Field Notes in the Weightroom of NCHS



Figure 4 Students at JCHS Waiting for the Courtyard Measurement



Conclusions and Future Work:

The project was successful in educating rural students about noise pollution and giving them hands-on experience planning and executing a measurement campaign. Survey data showed an increase in knowledge about a location's soundscape and some increased interest in Environmental Science & Engineering. While the project did not reach hundreds of students, the focus on small community learning and advancing scientific knowledge follows alongside the mission of Westminster College's individualized approach to learning. Likewise, this project also inspired an undergraduate student at Westminster College to create her own measurement outreach project.

Future work from this project includes repeating the outreach event in subsequent years at the high schools; and creating a Spring semester event where students use Microsoft Excel/Google Sheets to analyze the data in more depth. Resources such as datasets for the project are currently being compiled to share with other educators who desire to showcase the properties of noise pollution to their students.

Future communications of this project include presenting the findings at the Innovation and Teaching Learning Conference and Missouri University of Science & Technology in March 2026. The work will also be submitted for presenting at the next AEESP conference.

Acknowledgement:

This project was supported by the Association of Environmental Engineering and Science Professors through the Early Career PI Foundation Grant. The grant provided the funding that allowed the purchase of the SLM and all supporting materials such as the printed handouts. The project would not have been possible without this generous award. It has allowed me to continue my research in noise pollution, incorporate noise pollution measurements in my curriculum, and has established a community partner with JCHS to continue Environmental Science & Engineering outreach.

I want to thank and acknowledge the coordinators at the local high schools who gave me their time and effort in planning and approving these outreach events.

Lastly, I'd like to thank special teams at Westminster College including the printing office and the Ethics in Research Committee who reviewed and approved my surveys and human-based research procedures.

References

1. Census Report, <https://censusreporter.org/profiles/> . Accessed December 29, 2025.
2. Burden of disease from environmental noise Quantification of healthy life years lost in Europe. WHO Regional Office for Europe. 2011

Supplemental Materials:

Pre Survey (post-survey is identical)	1 page
Environmental Science & Engineering Handout	2 pages
Measurement Planning Packet	3 pages
Field Notes Packet, <i>abbreviated</i>	2 pages

Outreach Pre Survey

To accurately pair up 'before' and 'after' survey results, please fill out the "favorite" questions with the same answers for each survey. For example, if you put "Monkey" and "Orange", please put "Monkey" and "Orange" again on the next survey. This allows me to match up results accurately and anonymously.

Favorite Animal: _____ Favorite Color: _____

Instructions: For each statement below, please circle one value that describes how much you agree or disagree with the statement. Please use honest and current feelings when answering each statement. Please assess all statements.

I often notice the noises and/or sounds around me.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

I understand what properties determine a location's soundscape.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

I have considered pursuing a career in science, math, technology, or engineering.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

I have considered perusing a career, taking a course, and/or participating in a club about the environment.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

I feel confident using Excel software on my own to calculate a minimum, maximum, and average of a dataset.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

What is Environmental Science & Engineering?

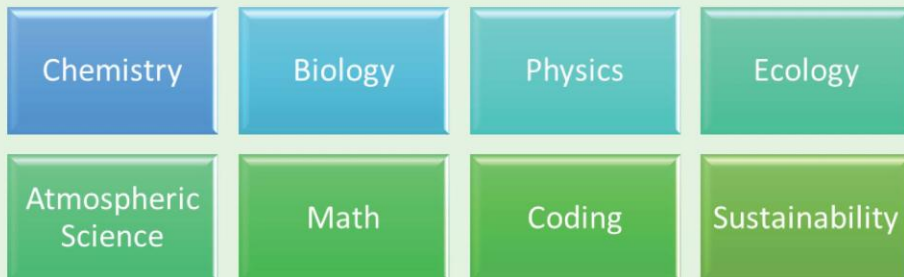
- It is the study of **environmental systems** including:
 - How systems impact human health & society,
 - How humans impact environmental systems (both living & non-living systems), &
 - What technology is needed to remediate harmful pollutants.

From the **smallest microbes & pollutants** to **gigantic global systems**, environmental scientists & engineers can specialize in diverse topics!



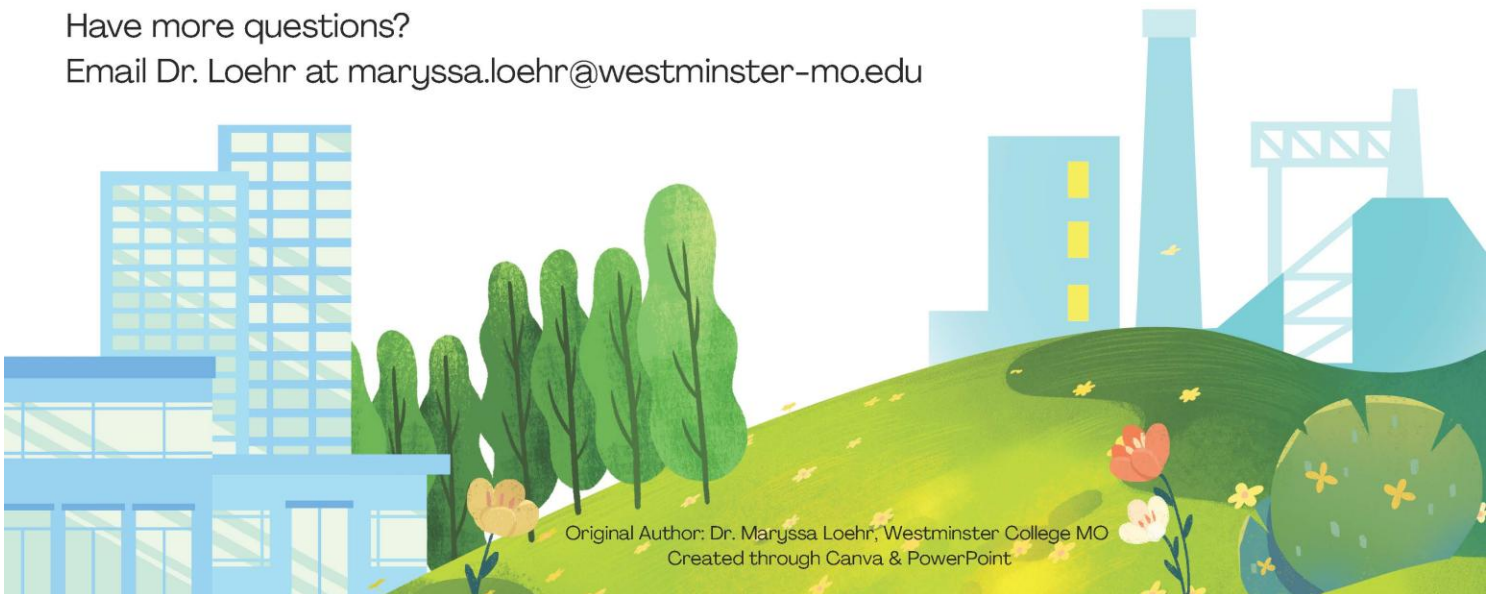
What kind of courses do Environmental Science & Engineering majors take in college?

Majors typically start by taking chemistry, biology, and math. Then, they proceed to specialize in focus areas like ecology, atmospheric sciences, energy, or other topics.



Have more questions?

Email Dr. Loehr at maryssa.loehr@westminster-mo.edu



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Created through Canva & PowerPoint

Environmental pollutants exist in various media (e.g., water, air, soil, food), which makes measuring and analyzing their impacts challenging!



Noise
Pollution



Water
Pollutants



Biological
Pollutants



Atmospheric
Pollutants



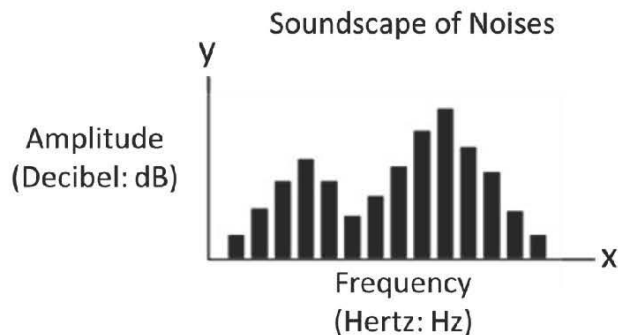
Heat
Stress



Light
Pollution

What is environmental noise pollution?

- Environmental noise pollution is any unwanted or excessive sound that can cause negative impacts to human health, wildlife, or perception of soundscapes.

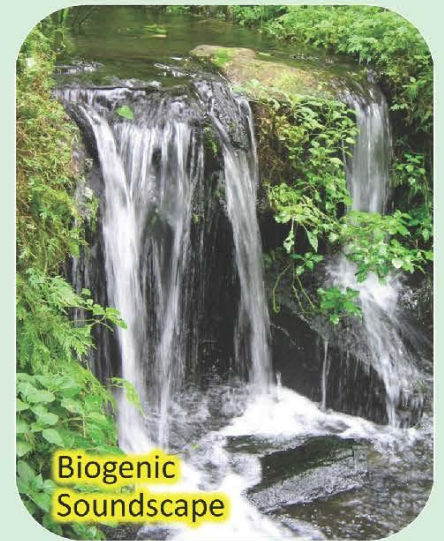
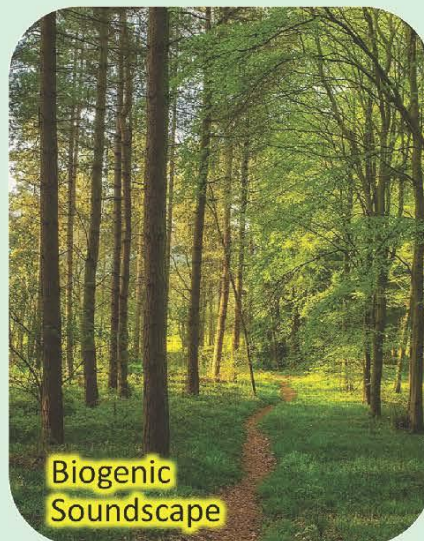


Sound is a combination of both amplitude (i.e., loudness) and frequency (i.e., pitch).



Some noise can be irritating (e.g., traffic), while other environmental noises are considered soothing (e.g., bird song).

A place's "soundscape" can be influenced by many factors: human created (anthropogenic) &/or non-human (biogenic) sources.



Measurement Planning through the Scientific Method

The Scientific Method steps:

1. Make observations of the concept and ask questions about how and why that concept might happen.
2. Form a hypothesis, for example: if [x happens] then the result will be [...] because of [this... mechanism].
3. Run an experiment and gather data. If able, repeat data collection for best results.
4. Analyze the data to draw conclusions about your hypothesis, for example: does your data support your hypothesis, deny your hypothesis, or is more data needed because you can't come to a conclusion?
5. Share your results with others – even results that don't support your original hypothesis!
6. Repeat and revise to verify your theory, data, and results!

Fill out this worksheet individually and ask for help if you need it.

Think about the noise around your school. Have you ever noticed noise while on campus? If not, make some guesses about noise around your campus. Document your observations and thoughts here:

What kind of questions do you have about the noise around your school's campus? Use the map below to help inspire you.

Which of these statements is most like your questions? Circle the letter that is most similar.

- a) I want to know what the noise level is at many different locations around campus.
- b) I want to find out where the loudest and quietest places around campus are located.
- c) I wonder what types of noises are around my school, such as human-made (i.e., anthropogenic) versus natural noises (i.e., biogenic noise).

Campus Satellite Map:



Group's measurement goal will be statement letter: A B C Other

After the group decides on a measurement goal from the statements above, create a hypothesis regarding that statement here. If you are unsure, take your best guess!

- Remember, try to use an if-then statement alongside a reason for *why* you think this result will happen.
-

Experimental Design

Let's plan our measurements. Today will be spending approximately 6 minutes at each location with a maximum of 4 locations. These short-term measurements are called "Spot Measurements" as they capture a singular set of conditions like weather, location, and time. We will document observations and then collect 2-minutes of sound amplitude and frequency.

Based on the group's measurement goal, mark locations on the map below that are easy to access and will help us gather applicable data to our goal. We will finalize our locations as a group.

What order should we go to our locations in to be efficient with our field time?



Measurement Collection

After seeing the demonstration with Dr. Loehr regarding the sound level meter, proceed with Dr. Loehr to our first location. Bring your possessions if the classroom will be unlocked, and have your field notes handout ready to collect data.

Analyzing Data, Reflecting, and Making Conclusions

After completing the Excel/Google Sheets activity, use your data to discuss the following questions with Dr. Loehr:

1. Which location, if any, surprised you with its data? What was the surprise?
2. How does your data results confirm, deny, or neither confirm nor deny your hypothesis?
3. How could we improve our measurements to better investigate our measurement goal and hypothesis?
4. What could be improved around campus to improve the soundscape for your community?
5. What additional investigations could help us understand the campus noise environment better?

Thank you for sharing your time with Dr. Loehr! I hope you have learned a little about Environmental Science & Engineering as well as the fascinating world of environmental noise.

Please take the post-survey and use your same color and animal combination.

How to take Field Notes as a Scientist or Engineer:

1. Prepare for field work thoroughly: wear closed shoes, sunscreen, sun glasses, wear a hat, bug spray, protective clothing, bring food and water, bring a pen/pencil, and **especially** *tell someone where, when, and for how long you'll be in the field.*
2. Check the weather to prepare for or change field measurements. I use “accuweather.com” live radar for potential storms and “wunderground.com” hourly data for temperature and wind values.
3. Always have safety first. If a site/location is unsafe to traverse, then do **not** proceed with measurements. If you feel unsafe, then do **not** proceed with measurements. If the weather is going to be unsafe, do **not** proceed.
4. Avoid contact with vegetation to reduce chances of insect bites and poison ivy (pictured here):



Avoid touching vegetation, it could be Poison Ivy like this here!
To remember poison ivy:
“Leaves of 3, leave it be.”

5. Always report the time to the nearest second and include “AM/PM”. For example: 6:17:29 pm. Some teams use military time such as 18:17:29 instead of AM/PM.
6. When taking observations pay attention to your sight, sound, and smell. Record anything noticeable. Avoid tasting things. :)
7. Be truthful: if you make a mistake then document what the mistake was. If anything goes wrong, document it and share with your team.

Noise Monitoring Field Notes

Scientist's Name: _____ Date: _____

Location Name: _____ Time of Arrival: _____

Observations: _____

Were photos taken of the location? Yes No

Start Time of Measurements: _____ End time: _____

Average LAeq: _____ Min LAeq: _____ Max LAeq: _____

Most Prominent Frequency: _____

Departure Time: _____

Notes:

Location Name: _____ Time of Arrival: _____

Observations: _____

Were photos taken of the location? Yes No

Start Time of Measurements: _____ End time: _____

Average LAeq: _____ Min LAeq: _____ Max LAeq: _____

Most Prominent Frequency: _____

Departure Time: _____

Notes: