ABSTRACT

INDOOR AIR QUALITY AND ENVIRONMENTAL CONSULTING: MY INTERNSHIP EXPERIENCE AS AN AIR MONITOR FOR NOVA ENVIRONMENTAL, INC.

by Julia Lynn Hamilton

This report summarizes my duties as an Environmental Consultant at Nova Environmental, Inc. in Ann Arbor, Michigan. My main responsibilities included monitoring the air quality on construction sites where asbestos removal was taking place. If airborne, asbestos fibers can be very dangerous to human health and are known to be linked to lung diseases and cancers. Due to this, asbestos containing materials need to be removed from buildings before construction or renovations occur. Several steps need to be taken to ensure that asbestos is removed safely at a job site. When on a construction site, there are several laws and regulations in place regarding asbestos removal as well as worker safety. This internship experience and my time at the Master of Environmental Science program through the Institute for the Environment and Sustainability at Miami University are described in the report.

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by

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List of Acronyms

ACM – Asbestos Containing Material

AHERA – Asbestos Hazard Emergency Response Act

CAA – Clean Air Act

CERCLA – Comprehensive Emergency Response, Compensation and Liability Act

DEQ – Department of Environmental Quality

EPA – Environmental Protection Agency

HEPA – High Efficiency Particulate Air

IES – Institute for the Environment and Sustainability

MEn – Master of Environmental Science

NESHAP – National Emission Standards for Hazardous Air Pollutants

OSHA – Occupational Safety and Health Administration

PCM – Phase Contrast Microscopy

PEL – Permissible Exposure Limit

TEM – Transmission Electron Microscopy

TSCA – Toxic Substances Control Act of 1990

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This report could not have been completed without the help of my major advisor, Dr. Sarah Dumyahn. Her expansive knowledge about environmental law was very helpful when writing the sections of the report about environmental laws and regulations and how they applied to asbestos. I learned many new things thanks to her guidance through this whole process. I also want to thank my other two committee members, Robbyn Abbitt and Dr. Catherine Almquist for carefully reviewing my report as well and continuing to support me through the whole internship report and defense process. Additionally, I would like to thank both Dr. Suzanne Zazycki and Dr. Jonathan Levy for supporting me and the other students in our MEn program at Miami University, and guiding me through the journey of graduate school.

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I would also like to thank my family: my parents and my brother, for sticking by my side during this whole process of graduate school and my internship. Without them I would not be where I was today! Lastly, I would like to thank my boyfriend, Adit Mehta, for keeping me sane throughout this whole process and supporting me through thick and thin.

Chapter 1: Introduction

To satisfy my professional experience for the Master of Environmental Science (M.En.) degree in the Institute for the Environment and Sustainability (IES) at Miami University, I worked a total of five months at Nova Environmental, Inc. as an Environmental Consultant. I worked during two different time periods: May to August 2017 and February to April 2018. My primary role within Nova was performing air monitoring and inspections at asbestos removal sites. This report highlights my responsibilities in this position as well as laws and regulations associated with this type of work. Additionally, I will provide a reflection on my experience in the M.En. program in IES.

1.1 Nova Environmental, Inc.

Nova Environmental, Inc. is a small environmental consulting firm consisting of fifteen full-time employees located in Ann Arbor, Michigan (Figure 1). Nova was founded in 1988 by Kary Amin and Barry Smith to address the issue of indoor air pollution, focusing on mold, lead, and asbestos. Nova's main clients are commercial or institutional entities that own large buildings such as schools, hospitals, churches, and other community buildings and less often small private residences. Nova's largest clientele, especially during the summer months, are school districts, also referred to as local education agencies, in the southeastern Michigan area. It is estimated that approximately 44,000 buildings in the United States still contain some type of asbestos, with hundreds of the buildings undergoing renovations each year ("Asbestos School Hazard Abatement Reauthorization Act (ASHARA) of 1990," n.d.). Asbestos needs to be removed from the area and disposed of before beginning construction to prevent the particles from being breathed in by construction workers and other people entering the buildings.

Figure 1. Nova Environmental, Inc. Office Building (Hamilton, 2018).

Nova offers five services in terms of asbestos: inspections, project design, project management and air monitoring, operation and maintenance program development, and asbestos consultation. Inspections can occur before, during, or after a construction project. These inspections are done to test if building materials may contain asbestos and will need to be removed before a construction project begins. Additionally, inspections can be conducted after construction projects are completed to show that the area is clear of asbestos and will not need to be worried about in future construction projects or renovations. When designing projects, Nova records if there is asbestos in a building, and if so how much and where it is, and determines the order in which it needs to be removed. These projects are designed carefully to remove the asbestos in the timeliest manner possible, and be the most convenient for other companies working in that building.

Nova's third service, project management and air monitoring, is what is done on the job site during the asbestos removal. This is what I did primarily throughout the time at my internship. This includes monitoring asbestos abatement companies before, during, and after removal of asbestos containing materials (ACMs). An ACM is defined as a material containing one percent or more of asbestos within it ("Asbestos Containing Materials (ACM) and Demolition," n.d.). The project management includes several different steps. One step is to ensure the setup of the area where the ACMs are being removed is done correctly, to maximize the isolation of the space. This ensures that no asbestos can leak out of the isolated area and into other parts of the building. During removal, the air is monitored to protect the asbestos abatement workers. Additionally, the air right outside the isolated enclosure is usually monitored to make sure no asbestos fibers are leaking out and to protect any other people that may be inside the building during removal. After the removal is finished, the air is tested to ensure that the area and the air are now clear of asbestos.

Another service that Nova provides to companies in regard to asbestos is operation and maintenance program development. This service mostly refers to training and seminars that Nova provides to construction companies in southeastern Michigan. Construction companies are required to be educated in asbestos awareness in order to make sure that the employees can recognize ACMs. Additionally, these construction companies are also required to learn the dangers of asbestos and the importance of halting any and all construction projects if they happen to come across an ACM. Lastly, Nova provides asbestos consultation. This service is similar to Operation and Maintenance Program Development. However, this service is a training or informational session provided to civilians. Civilians usually include employees that work at schools, hospitals, and other community buildings that may contain ACMs and may need to be removed sometime in the future.

Along with these asbestos services, Nova offers other services with pollution. These services include the following:

- Lead Services
- Chemical Monitoring
- Indoor Air Quality Assessments
- Mold Services
- Safety Program Development

- Less Commonly Outdoor Air, Soil and Water Testing

Within Nova, there is a hierarchy of employees and their responsibilities (Figure 2). Sitting on top is the president, with the Vice President and two other employees who have equal decision making power. Below them is where all the other employees fall including myself, any other temporary or seasonal hires, and a few full time employees who work exclusively in the field.

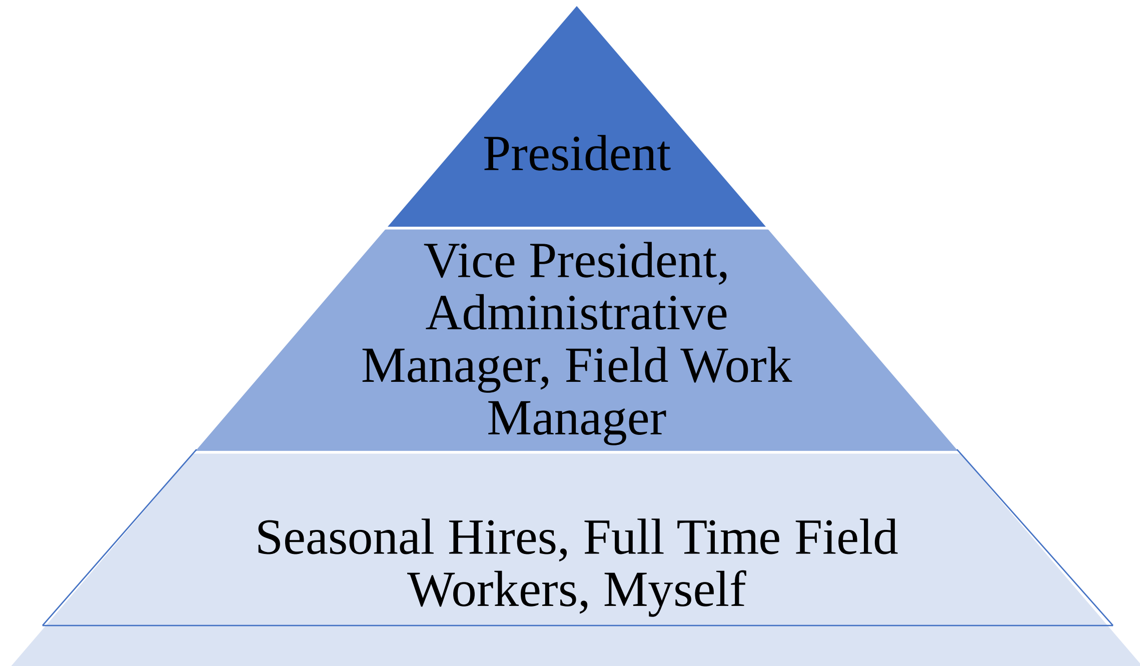

Figure 2. Nova Environmental, Inc. Employee Hierarchy.

When hired at Nova, one has to attend a two-week training session with the administrative manager, Meghan McCarthy. During this training, the new hires learn several different topics. These topics include but are not limited to:

- Duties and Responsibilities of the Job
- History of Asbestos
- Dangers of Asbestos
- Asbestos in Buildings, Specifically Schools
- Laws Associated with Asbestos
- How to Perform Asbestos Concentration Calculations
- OSHA and Asbestos

After this training is complete, the employees are certified with Nova's in-house. We also become OSHA 10 certified for one year, which is a certification that teaches employees about the importance of safety in the work place and the responsibility of employers to protect their workers. After this point, my supervisor was Lisa Whitton, who serves as the Vice President of

Nova. As previously mentioned, Lisa has the second highest amount of responsibility in the company after the president. I directly reported to her, asked her any questions, sent her my paperwork at the end of a job, and got occasional visits from her on job sites if she wanted to monitor the progress of a job. However, the majority of the time I was by myself in the field.

Nova Environmental, Inc.'s mission is simple: "provide clients with expert environmental consultation that allows for regulatory compliance while understanding the importance of staff and public relations" (Nova Environmental, Inc., 2014). Nova has a great mission and it aligns with my goals to work for environmental health and public safety.

1.2 My Role at Nova

At Nova, I worked as an Environmental Consultant dealing with the company's asbestos projects in the southeastern Michigan area (Figure 3). My internship focused on providing project management and air monitoring service for asbestos removal projects. My role consists of being on site at construction projects during ACM removal to ensure worker safety and air quality regulations were met. Many aspects of asbestos, including the laws regarding worker safety and air quality regulations are described in Chapter 2.

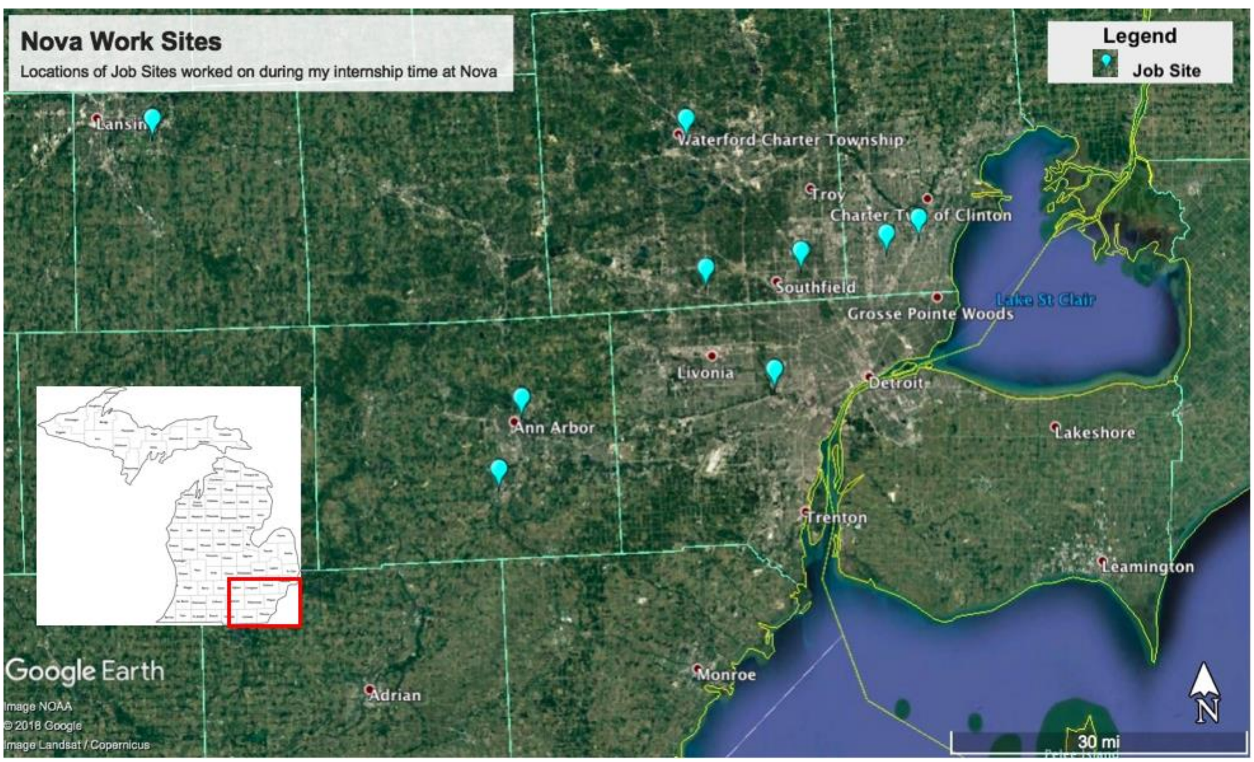

Figure 3. Nova Job Site Locations (Google Earth).

For each project I monitored the air quality. The description of my role at project sites is described in detail in Chapter 3, but the following is an overview of the main steps. Before the asbestos removal begins, isolated enclosures need to be constructed to prevent asbestos from leaking into other areas of a building. When the area is constructed, I remain on-site and monitor the air quality throughout the removal process of the ACMs. I do this by monitoring the air in and around the isolated enclosure using two different types of air pumps. The low volume or personal air pump is calibrated on site by me before air monitoring. The high-volume air pumps are calibrated by Nova employees in the office prior to allowing the pump to go out into the field. The air is monitored outside to ensure that no asbestos fibers are exiting the enclosure. After the removal is done, I run air tests to determine whether or not the area is clear of asbestos. It is also my responsibility to document test results and monitoring for Nova and the State of Michigan's Department of Environmental Quality (DEQ). Additionally, I calculated the asbestos air concentrations at the beginning, middle and end of each project, which then are reported back to the client.

Chapter 2: Introduction

In environmental consulting for air quality, there are many aspects of asbestos that are important to understand. For instance, the uses and types of products that asbestos is found in can aid in identifying and sampling for asbestos. Additionally, the impacts that asbestos has on human health is important to know in order to stay safe when handling the material. Because of the negative human health impacts asbestos can have, many laws are in place to help regulate the uses of asbestos. In this section, these laws along with the different agencies they fall under are explained in further detail.

2.1 Asbestos and Human Health Impacts

Asbestos is a naturally occurring mineral that is used in fireproofing, insulation, and other construction materials (Tossavainen, 2004). There are many positive attributes about asbestos: it has high strength and wear characteristics, it is very flexible, it has good insulation properties, and is very resistant to physical and chemical change (Lyon, 2012). These characteristics make asbestos a great building material. There are three main types of asbestos used in construction materials: chrysotile, amosite, and crocidolite, with the most common type by far being chrysotile (Kusiorowski et al., 2012). There are three additional types of asbestos that also are regulated: anthophyllite, tremolite, and actinolite (Mauney, n.d.). Asbestos was very widely used worldwide until about the 1970s, when it was discovered that it had very negative health impacts ("Asbestos Timeline," 2017). In asbestos-related occupations, there was evidence of disease and premature mortality as compared to non-asbestos related occupations (Sen, 2014). Many workers exposed to asbestos developed lung diseases such as mesothelioma and lung cancer, and many eventually lead to death (Hillerdal, 2004).

Asbestos is a very fibrous material that breaks up into many small fibers that can become airborne (Figure 4). Asbestos can be either friable or non-friable. Friable is defined as the ACM breaking down or getting pulverized from the pressure of one's hand ("Substance Technical Information for Asbestos – Non-Mandatory," 1995). Friable asbestos becomes airborne much easier. Once airborne, if breathed in, these fibers become lodged in the lungs. The lungs will naturally react to these fibers and repair themselves in order to cover up the sharp needle-like fibers and make breathing easier (Churg et al., 1983). However, once the lungs repair themselves, it creates tissue deposits in the lungs, decreasing the volume of air that the lungs can take in. This condition is known as asbestosis (Wagner, 1997).

Figure 4. Asbestos Fibers (USDA, n.d.).

When asbestos was in its peak time of manufacture as well as before the negative health impacts were known, workers would be breathing in large amounts of fibers at a time. This would mean that large amounts of fibers would be covered up by hundreds or thousands of tissue deposits, severely decreasing lung function. However, the worst part of this condition is the fact that symptoms of asbestosis do not appear until 30-40 years later (Bianchi et al., 1997). Along with asbestosis, asbestos exposure is also commonly linked to lung cancer and mesothelioma. Essentially, prolonged exposure to high asbestos concentrations can be very dangerous and eventually may lead to several types of cancers, and ultimately death. There is no treatment for asbestosis and mesothelioma, so therefore the safe removal of asbestos in buildings before it can become airborne and people get exposed is essential (Sugarbaker et al., 2002).

2.2 Asbestos Laws and Regulations

With the dangers of asbestos and concerns about its effects to human health, laws and regulations were enacted. The U.S. Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) are two agencies that implemented many major laws that are related to asbestos and asbestos exposure.

EPA Regulations

One of the first laws implemented that regulates asbestos is the Toxic Substances Control Act of 1976 (TSCA). This law gives the EPA the authority to "require reporting, record-keeping and testing requirements, and restrictions relating to chemical substances and/or mixtures" ("Toxic Substances Control Act (TSCA) and Federal Facilities," n.d.). Under this law, there are six chemicals that require special attention, asbestos being one of them. Under Title II of TSCA, titled the Asbestos Hazard and Emergency Response Act (AHERA), local education agencies are required to inspect their buildings for asbestos and ACMs. AHERA also requires that management plans are to be developed if ACMs are discovered or if they should be found in the future. ("Asbestos and School Buildings," n.d.).

Two other laws that apply to asbestos and ACMs are the Clean Air Act (CAA) and Safe Drinking Water Act. The Clean Air Act (CAA) is another law that applies to asbestos. The CAA includes asbestos in the list of hazardous chemicals that need to be monitored and can cause dangerous air emissions harmful to human health ("Asbestos Laws and Regulations," n.d.). Under the CAA, there is a compliance program known as National Emissions Standards for Hazardous Air Pollutants (NESHAP). This rule is implemented by the EPA to regulate hazardous air pollutants with the goal to protect human and environmental health ("Asbestos National Emission Standards for Hazardous Air Pollutants (NESHAP)," n.d.). There are hundreds of pollutants that are covered under NESHAP, with asbestos being a major concern due to its link to cancer and other diseases. This rule was put into place to reduce negative health effects from exposure to asbestos by limiting air concentrations that can be worked with safely. Both the EPA and OSHA refer to NESHAP to create a safe working environment.

Another law regulated by the EPA in regard to asbestos is the Safe Water Drinking Act. The Safe Drinking Water Act lists chemicals that can be harmful to human health if ingested, with asbestos being listed. Another law that applies to asbestos is the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as the Superfund Act. This law relates to the disposal of asbestos and ACMs. CERCLA holds abandoned waste sites liable for cleaning up the sites and preventing the hazardous materials from getting into the surrounding environment. Asbestos is covered under this act because it is considered a hazardous material and needs to be cleaned up properly to prevent adverse health effects to people and the environment near Superfund sites (Carmean, 1995).

Michigan Department of Environmental Quality Regulations

At the state level, Michigan has an environmental regulatory agency known as the Department of Environmental Quality (DEQ). In Michigan, NESHAP is the most commonly followed asbestos program (“Understanding the Asbestos NESHAP,” 2015). The same laws and regulations that are recognized federally in regards to asbestos are followed in Michigan and the DEQ is closely involved with enforcing them. The DEQ’s Waste Management Division oversees the proper disposal of ACMs after abatement projects. The Air Quality Division within the DEQ oversees inspections in buildings that may contain asbestos and also receive reports from air monitoring companies such as Nova to ensure a clean and safe area within buildings after a removal project is complete. Lastly, the Department of Licensing and Regulatory Affairs handles asbestos abatement contractors and employees receiving proper training and certification prior to working on asbestos abatement job sites.

2.3 Overview of the Occupational Safety and Health Administration

In 1970, the Occupational Safety and Health Act was passed, which created the Occupational Safety and Health Administration (OSHA) to protect workers’ safety and health while on the job (“About OSHA,” n.d.). This was done by providing standards and regulations; as well as education, training, and outreach to employers and employees alike. OSHA was established primarily because during the late 1960s, worker related accidents and deaths increased dramatically, and many citizens decided something needed to be done about it (Fleming, 2001).

Specifically, since the establishment of OSHA, worker related accidents have decreased by half and workplace related illness has decreased by 40 percent (“OSHA Success Stories,” n.d.). The reason that OSHA has been so successful is due to the increase in regulations for worker safety. The main goal of OSHA is to protect workers’ safety, so most of OSHA deals with creating and enforcing regulations on job sites to decrease danger. For example, there are laws created with what the acceptable limit of asbestos that a worker can be exposed to before it is dangerous. Additionally, there are other rules and regulations that state that employees must go through industry specific safety training to ensure their competence and safety on the job.

Along with the ethical part of following OSHA and protecting employees, there can also be legal repercussions for companies that fail to follow OSHA’s rules and regulations. Companies that do not follow OSHA can face hefty fines, upwards of $70,000 based on the severity of the violation (Cotney Construction Law, n.d.). Additionally, if violations are knowingly occurring at a jobsite, companies can lose their licenses to practice their work.

2.4 Asbestos and OSHA Regulations

In 1983, OSHA began creating regulations that ruled asbestos unsafe in the workplace (“Occupational Exposure to Asbestos,” 1994). This was done not only to protect workers, but also to protect companies from lawsuits against them. Standards and limits were set into place based on what the safe exposure limit is for the workers, and for how long they are exposed. Specific OSHA regulations were put into place in several different areas: asbestos removal, sampling and analysis, building evaluation and use, worker protection, and more (“Construction,” n.d.). Additionally, workers are required to have certain training as well as special protective equipment in order to work around asbestos (“OSHA Fact Sheet: Asbestos,” 2014).

Before starting construction or demolition on existing buildings, OSHA requires an asbestos test on the materials that would commonly contain asbestos (floor tile, ceiling tile, fire proofing, insulation and roofing) to see if there is any asbestos present. Since asbestos was halted from production in building materials in 1984 in the United States, buildings older than that usually contain some type of asbestos in its materials (Dawson, 2012). If it is found that asbestos is present, then construction and/or demolition must be immediately halted and an asbestos abatement company and air monitoring company must be called in to complete the asbestos removal process and declare the area clear of all asbestos.

Along with the asbestos abatement and air monitoring, there are regulations set in place to protect the safety of the asbestos abatement workers on a job site. When removing asbestos containing materials (ACMs), there is a permissible exposure limit (PEL) set in place by OSHA. There are two permissible exposure limits set in place: the PEL with an 8-hour time weighted average, and the short-term exposure limit, over a 30-minute time period (Landrigan et al., 1999). The PEL for an 8-hour time weighted average is 0.1 fibers per cubic centimeter of air and for a short-term exposure limit for 30 minutes is 1 fiber per cubic centimeter of air (Landrigan et al., 1999). The reasoning behind this is if one is exposed to a higher concentration but at a shorter time, there will be fewer negative health effects when compared to asbestos exposure over a longer period of time. If these PELs are exceeded, then must take specific safety precautions and procedures.

If someone is working on a jobsite where the PEL is exceeded, for either the short term or long-term limits, then according to OSHA guidelines any workers on the site needs to wear personal protective equipment (PPE). Workers must wear PPE in the presence of asbestos. This requires but is not limited to the following: proper respiratory protective equipment (RPE), disposable suits, and disposable boot covers and/or washable rubber boots (Mayer et al., 1999). For RPE, when the PEL exceeds the acceptable limit then a High Efficiency Particulate Air (HEPA) half-face respirator must be used (Figure 8). HEPA is a type of certified filter that is inside the purple filter part of the mask of the mask. In terms of disposable suits, most job sites will have hundreds of them boxed up on site to ensure the crew never runs out. Disposable suits are used to ensure no asbestos fibers become trapped in the fibers of regular clothing and taken out of the asbestos exposure area (Figure 9). The suits are disposed of when leaving the asbestos exposure area. The third type of PPE is disposable shoe covers or washable rubber boots, which are important to ensure that no asbestos fibers get trapped in regular shoe fabric.

Figure 5. Half Face Respirator with HEPA Filter (Norkan, Inc., n.d.).

Figure 6. Disposable Suits (Safety Services Direct, n.d.).

2.5 Asbestos Removal Process and Air Monitoring

The first step in the removal of ACMs in a school is to determine if there actually is asbestos in an area, where it is, and how much asbestos is there. This is done during inspections in the buildings that are required to occur every three years. If an area of a school will not be renovated or worked on, then most likely any ACMs will remain until renovations are planned. If renovations are planned for the building, then the asbestos needs to be removed safely before renovations begin. This is a requirement under NESHAP (Tabler, 2012). This reduces the chances of asbestos fibers becoming airborne and inhaled by construction workers.

At the outset of a renovation, the isolated area must be constructed. There are three types of isolated areas: full isolated area, partial isolated area, and glovebags. The type of isolated area depends on the size of the area of ACMs to be removed. For instance, if there are only a few feet of asbestos-containing pipe insulation, then a glove bag is an acceptable isolated area (Figure 5). However, if there are several hundreds of feet of tile, then that entire area of the building must be isolated. These large isolated areas must contain negative air machines and a decontamination area for abatement workers to shower-off asbestos fibers. Partial isolated areas are also for little amounts of non-friable ACM removal. During the removal process, the air must be monitored to ensure it stays within the permissible exposure limits (PELs) for workers.

Once the asbestos removal is done, several air pumps are run in order to prove that the area is clear of asbestos. This standard, which is 0.01 fibers per cubic centimeter, is much stricter for school buildings than other buildings (Holmes et al., 1995). In schools, 2000 liters of air must be run through the high-volume air pumps to ensure an accurate asbestos concentration calculation. For other buildings, in order for an area to be clear of asbestos it must have an air concentration of 0.05 fibers per cubic centimeter of air or lower with a requirement of only 1200 liters of air to be ran through an air pump (“Occupational Exposure to Asbestos,” 1994).

Chapter 3: Introduction

My job at Nova is to monitor the air quality on job sites, as well as the workers' safety during asbestos removal. All of this is done based on OSHA's standards. In terms of the air quality, the air is constantly monitored throughout the removal process. This includes during the setup of the isolated area, during the removal inside the isolated area, and once the removal is finished.

3.1 OSHA Regulations on the Abatement Site

Figure 7. Low Volume Air Pump (Hamilton, 2018).

The air for PCM tests are monitored on two different types of pumps: a high-volume air pump and a low-volume air pump. The high-volume air pumps are set to take in eight liters of air per minute before and during removal and are set to take in 16 liters of air per minute after removal when running clearance. A clearance is the last sample that is run after an asbestos removal project is completed to declare an area clear of asbestos. The low-volume air pumps run around two liters of air per minute at all times. Both of these pumps have a cassette attached to them that contain a filter that is switched out after different amounts of time, depending on which step in removal is occurring. For example, OSHA requires at least 2000 liters of air to be run through an air pump at projects occurring in schools in order to declare an area clear of asbestos, so the pump runs for approximately 125 minutes to meet that criteria. As for the low-volume air pumps, also known as personal pumps, OSHA requires at least one 30-minute sample to be taken in order to calculate the short-term exposure limit for that time (Figure 7). With these pumps, the filters on the cassettes on the air pumps are taken and mounted on slides. These are the steps to mounting the filters onto the slides:

1. The consultant labels an empty slide with the sample number, the date of the project, the project's unique identification number, and the initials of the consultant working on the project.
2. A small wedge of the filter contained inside of the cassette is cut with a scalpel.
3. The small wedge is placed onto the empty labeled slide.
4. The consultant places the slide with the filter wedge under an acetone vaporizer, and sprays acetone vapor onto the wedge until it is transparent. This step is to make it easier to see fibers by disintegrating the actual filter so only the fibers are seen at this point under the microscope.
5. The consultant places three to four drops of triacetin (glue) on top of the now transparent filter wedge.
6. A slide cover is placed on top of the triacetin and is pressed down to eliminate air bubbles.
7. Clear nail polish is swiped on the borders of the slide cover to ensure the slide cover will stick to the slide and preserve the filter inside the slide cover.

Once the slides with the filters are prepared, the slide is observed under a microscope and the asbestos fibers are counted. Based on the asbestos fibers counted and the volume of air taken into the pump, the concentration of asbestos fibers in the air is calculated. Once the slide is dry, it is placed under a microscope at 400 times (400x) magnification. From there, 100 "fields" are counted and recorded whether or not they have a fiber of asbestos inside the graticule (Figure 8). The graticule is the circle in the middle of the field of vision on a microscope. Asbestos fibers look like hair fibers but with several splits in the fibers. Hair and carpet fibers under this magnification are much larger and are very distinct looking.

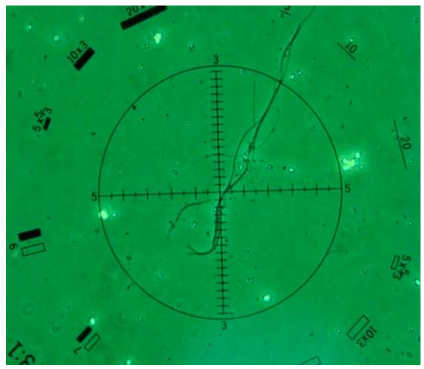

Figure 8. Asbestos Fiber under Microscope (Flickr, 2011).

After the fields are counted, a calculation is done to determine the air concentration, which is fibers per cubic centimeter of air. The number of fibers counted are divided by the area of the graticule, which is 0.00785mm^2. This will result in fibers per mm^2. From there, this number is multiplied by the total area of the microscope area, which is 385mm^2. This number is divided by the total volume of air sampled (varies based on the pump volume setting and length of the time the pump sampled) multiplied by 1000 cubic cm/L to help get the correct units for the concentration. This calculation will result in the number of fibers per cubic centimeter of air in that area (Figure 9).

$$\text{FIBERS/mm}^2 = \frac{(\text{Net Fiber Count})}{(\text{Counting Field Area})} = \frac{(\_\_\_\_\_\_\_\_\ \text{fibers/field})}{(\,0.00785\text{mm}^2\,)} = \boxed{\_\_\_\_\_\_\_\_\ \text{fibers/mm}^2}$$

$$\text{AIRBORNE ASBESTOS CONCENTRATION} = \frac{(\_\_\_\_\_\_\_\_\ \text{Fibers/mm}^2)(\,385\ \text{mm}^2)}{(\_\_\_\_\_\_\_\_\ \text{Volume L})(\,1000\ \text{cc/L})} = \boxed{\_\_\_\_\_\_\_\_\ \text{fibers/cc}}$$

Figure 9. Asbestos Concentration Calculations (Navy and Marine Corp Public Health Center, n.d.)

Lastly, at Nova we ensure workers are following OSHA's standards with the correct PPE and isolated asbestos removal areas. Workers must be wearing their proper PPE at all times, and the enclosure areas must completely isolated and secure from the clean areas of the worksite.

3.2 Case Study – Asbestos Removal in an Elementary School

Summary of Project

Every asbestos removal project will be different. For Nova Environmental, Inc., they mostly focus on schools, hospitals, churches, and other large community buildings. Throughout my internship, most of my projects sites were in schools, with a few taking place in hospitals. Some schools only need a small amount of piping removed, but some schools require several different types of asbestos containing materials (ACMs) removed throughout the entire building, such as ceiling tile, floor tile, insulation and piping. Nova requested that all clients remain anonymous in this report, so no client names will be used.

Most projects involved throughout the length of my internship were very short, lasting an average of two to three days. However, some projects could last only a few hours and others several weeks. The largest project I worked on took about four weeks to complete. This project involved the removal of several different types of ACMs throughout an entire elementary school. One aspect that made this project difficult and time consuming is the fact that many other trades (i.e., carpenters and electricians) needed to work on parts of the building at the same time so the project needed to be designed and managed well. This involved making sure that the other workers would not enter the parts of the building undergoing asbestos abatement.

Since the whole school could not be isolated at once due to the multiple different trades working simultaneously, the asbestos abatement project needed to be split into several smaller project phases. For this particular project, there were seven phases to completely remove all the ACMs in the building (Table 1). Some of the phases took up to a week, such as phase phases one, two, and four While others took as little as a few hours, such as phases three, five, and six. On some occasions, several phases were occurring at the same time. This happened if there was an abatement worker to work on one of the smaller side projects.

Table 1. Elementary school asbestos abatement phase number and description.

Phase Number	ACMs Removed
1	East Wing of school, ceiling and floor tile
2	North/West Wing of school, ceiling and floor tile
3	Small amount of pipe insulation in gym
4	Upstairs Wing of school
5	Small amount of floor tile in utility closet
6	Small amount of pipe insulation in teacher's lounge
7	Floor tile in basement

Each project phase needed to have an isolation area built, asbestos removed, the area declared clear, and the isolation area torn down before any of the other type of work could happen. For the larger projects involving the whole wings of the buildings as well as the basement, full isolated areas needed to be constructed. For the smaller projects, only small semi-isolated areas were constructed. No matter the size of the isolated area, a warning sign was posted outside the area alerting others that asbestos was present and access was limited to authorized personnel (Figure 10).

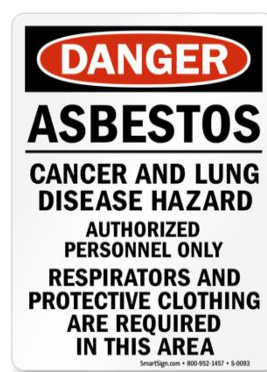

Figure 10. Asbestos Hazard Sign (U.S. Department of Labor, 2015).

Asbestos Abatement Procedure

When removing asbestos, there are five main operation and maintenance procedures that must be followed in order to minimize contact with asbestos as well as lessen the chance of asbestos fibers leaking into other parts of the building. Each of the following procedures were used in this project: using wet methods, using mini enclosures, using portable power tools, using area isolation, and avoiding activities such as sawing, sanding, and drilling ACMs ("Safe Work Practices," n.d.). The first step is to use wet methods while removing the ACMs. This means spraying the ACMs and surrounding materials with water in order to minimize the chance of friable asbestos fibers from getting into the air. The second step is to use mini enclosures. This applies to smaller projects for asbestos abatement. There are several different types of mini enclosures including small versions of full asbestos enclosures, or glove bags (Figure 11). Glove bags are basically a bag secured around a pipe used for the removal of pipe sections or insulation. A singular glove bag can be hung as well as several glove bags all next to each other.

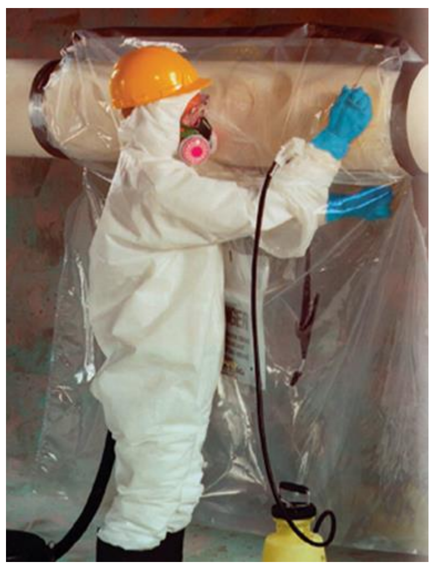

Figure 11. Asbestos Removal Glove Bag ("Glove Bags", n.d.).

The third step of ensuring safe work practices when removing asbestos is to use portable power tools with ventilation attachments. The use of large tools such as jackhammers and chain saws can create the asbestos to become friable, making it more hazardous. With small power tools, although it may take longer to remove an area of asbestos, it will be done more safely. The fourth step in safe asbestos removal is area isolation. As mentioned above, area isolation is important to make sure that other people do not enter the work areas where asbestos may be present, especially if they are not wearing proper respiratory protection equipment. Also, the isolation will prevent asbestos fibers from leaking into other parts of the building. The last step is to avoid certain activities such as sawing, sanding, and drilling ACMs, which can cause asbestos to become airborne.

The first, and largest, phase of this project was to remove all the ACMs from the eastern wing of the elementary school. The floor and ceiling tiles throughout much of this wing contained asbestos. The ACMs removed were in the hallway and twelve classrooms. A full isolated asbestos abatement enclosure was needed for this phase of the project. The hallways contained numerous lockers which all needed to be covered in plastic to minimize the chance of asbestos fibers getting into them. Additionally, all of the walls of every classroom being abated needed to be covered in plastic. The bathrooms and utility closets in this wing of the school did not contain any ACMs, and therefore were blocked and taped off from the rest of the isolated area. There were two classrooms in the wing that did not need to be abated, so these classrooms were sealed off to prevent contamination. Each of the classrooms undergoing asbestos abatement contained one or two negative air machines with HEPA filters linked to the outside air to reduce asbestos fibers in the air. The larger classrooms had two machines with the smaller classrooms only containing one. The end of the isolation area also contained a decontamination unit, which allows employees to remove all asbestos fibers before exiting the isolated area (Figure 12).

Figure 12. Asbestos Removal Decontamination Unit (The Center for Construction Research and Training, 2016).

<u>Declaring an Area Clear</u>

In order for an area to be declared clear from asbestos, several steps need to be taken before removing any of the protective plastic or isolation areas and cleaning up. First, after the employees are finished with removal, the area must be sprayed with water in order to eliminate as much asbestos in the air as possible. Next, the area must be dried for at least 30 minutes, but no longer than 24 hours. Next, air tests need to be conducted in order to determine the area clear. There are two different air clearance tests than can be used: a Phase Contrast Microscopy (PCM) or a Transmission Electron Microscopy (TEM) (Dement et al., 2008). Most commonly, PCM tests are used. PCM tests can be used on site by employees, such as myself, to determine the concentration of asbestos in the air. The concentration is determined by mounting the PCM filter onto a slide and calculating the number of asbestos fibers per cubic centimeter of air, which is described in more detail in Chapter 3. TEM tests are taken on the same air pumps as PCM, but the air filters used are a bit different.

Figure 13. High Volume Air Pump (Hamilton, 2018).

Also, the TEM filters are taken to a third-party lab to determine the asbestos concentration in the air more accurately. If the area previously had a large number of ACMs or had high fiber concentrations measured throughout removal, then both a PCM and a TEM are required. In my experiences, none of my projects required TEM tests.

When conducting PCM tests, the standards are different depending on the type of building and the regulations that apply. Schools have a higher standard and need more tests conducted as compared to a private residence or a hospital. For schools, which are covered under Asbestos Hazard Emergency Response Act (AHERA), five high volume air pumps are required to run at least 2000 liters of air through them to determine the concentration of asbestos fibers in the air after the completion of the removal project (Figure 13) ("Asbestos and School Buildings," n.d.). In order for an area to be safe for the tear down of the asbestos isolation area, the concentration of asbestos in the air must be below 0.01 fibers per cubic centimeter. If the concentration exceeds 0.01 asbestos fibers per cubic centimeter of air, then the workers must go into the enclosure again and remove any and all materials that could possibly contain asbestos. Once the area passes a clearance test, then the isolated area can be torn down and anyone is free to be in the area once again. All of the phases throughout this project passed their clearance tests during the first round of removal, meaning that the area was declared clear. The calculations performed to declare the area clear are described in Chapter 3. The asbestos abatement workers involved in this project all practiced worker safety measures. Many regulations are put into place by OSHA to prevent these workers from getting hurt or developing disease.

Chapter 4: IES Reflection

Working at Nova Environmental, Inc. for my professional experience for my Master's Degree in Environmental Science (M.En.) through the Institute for the Environment and Sustainability at Miami University was a very valuable experience. This internship definitely justifies the professional experience for the M.En. because it had great exposure to the real world in an environmental career. I learned a lot about the environmental consulting profession. Within environmental consulting, there are several different avenues a company can pursue. As for Nova, their major focus was indoor air pollution. This consists of air monitoring for asbestos, mold, lead, mercury, and more. Within this section of consulting, there are several other components that go into air monitoring. I gained experience in data management, communicating with superiors and other workers, safety regulations, laws about asbestos, and asbestos in general. The information I found most valuable learning while working at Nova was about environmental laws and regulations, and how they are applied to environmental consulting. It was very interesting to see the laws I learned about in coursework applied in real life to the consulting industry. These are all valuable experiences for my degree because my area of concentration for my M.En. is Environmental and Public Health and GIS. Indoor air pollution is a section of Environmental and Public Health, especially asbestos.

In terms of the M.En. program at Miami and its relevance to my career, it has been exceptional. So many of the classes that I took related to my internship experience, as well as my career goals in general. Environmental and Public Health was the most relevant to my internship experience, whereas I learned valuable information about asbestos and OSHA, which made me more qualified for the internship and gave me more knowledge that none of the other interns in my position had prior to the internship. Project Management was another useful class, that speaking to many graduates of the program or other employers in the Environmental Science field has shown that it is a very useful and impressive class to have on a resume. Additionally, the Professional Service Project (PSP) was very useful in terms of dealing with real life clients and projects. For my group's project, my team and I prepared a children's education program for the Village Green Farmers Market in Fairfield, Ohio. Although this is not directly related to my degree or area of concentration, it taught me how to work well in a group and strengthened my communication skills. Additionally, it was very valuable working for an actual client and ensuring that the final product met the client's expectations.

I am very happy that I pursued my Master's Degree in Environmental Science from Miami University. I have built lasting relationships with coworkers, professors, clients, and peers that could not have been made in other ways. I know that receiving this degree will be very beneficial to my future career and life in general.

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