ANL-11/02 (Summary)

Summary Site Environmental Report

for Calendar Year 2010

Environment, Safety and Quality Assurance Division

THOMAS YUREK

A MESSAGE FROM THE STUDENTS

BIOLOGY 2 STUDENTS FROM DOWNERS GROVE SOUTH HIGH SCHOOL

Front row from left: *Bridgett Albright, Becky Hays, Lillie Kase, Lori Pluchrat, Elizabeth Palumbo, Charles Chang, Amber Carpenter.*
Back row from left: *Mr. Scott Howard (teacher), Harry Miles, Ben Couillard, Tom Yurek, Maddie Snyder*

Once each year, Argonne National Laboratory publishes a Site Environmental Report (SER), which contains environmental monitoring data collected and compiled by Argonne scientists over the course of the previous year. Scientists collect this data in compliance with state and federal laws governing management of Argonne's facility. The assignment to write this summary was given to a select group of Downers Grove South seniors enrolled in a research biology class called Biology II. These select students are adept at reading and comprehending scientific writings, such as the SER. They were each asked to research one section of the SER and translate the various sections into small, but informative summaries, which Argonne then assembled into this Summary Site Environmental Report. The summary report is distributed to interested parties to help both scientists and the general public fully understand what takes place inside Argonne, from how much radiation comes from the site to what innovations Argonne is working on to improve national energy security.

The students enrolled in Biology II at Downers Grove South High School tackled the project of creating this summary booklet with eagerness and motivation, spending many hours on research before composing the section summaries that follow this introduction. When first approached with the idea of working with Argonne, many students were hesitant to accept such a gargantuan challenge. After the scientists from Argonne came into the class and presented the project, many of the students became excited about the idea of helping Argonne publish a knowledgeable and informative summary. Senior Charlie Chang stated, "I really didn't know what to expect when the project was first put in front of me, but I soon found myself being very interested in the inner workings of Argonne." Others within the group of students were intimidated by the length of their assigned SER section. Maddie Snyder said, "I panicked quite a bit when I realized I had to summarize Groundwater, the longest section of the SER, but it turned out to be a difficult yet rewarding challenge." Overall, the students of Mr. Howard's Biology II class had a great learning experience while researching Argonne and its involvement with the community and the nation.

This booklet was created not only for the scientists of Argonne to hand out at meetings and tours, but also to inform the public about what exactly happens within Argonne and what effect it has on the environment. While reading through the various sections of this booklet, a person who resides in a neighboring town can understand what Argonne is trying to accomplish in many different areas of both scientific discovery and environmental protection. They can also be informed about current research occurring at Argonne, like the Earth Microbiome project or advances in renewable energy.

A special thanks to Mr. Howard for allowing us the opportunity to work side by side with Argonne's scientists, and, of course, a thank you to Larry Moos, Norbert Golchert, and David Baurac for editing and presenting this project to us.

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For more information about Argonne and its programs, visit the laboratory's website at www.anl.gov or contact Communications, Education & Public Affairs at 630.252.5575.

The text was edited by David Baurac. Photos by George Joch. Graphic design by Michele Nelson.

CHARLES CHANG

WHAT IS ARGONNE?

Argonne National Laboratory serves as a significant resource for the advancement of our nation, both technologically and academically. The projects and research that take place at Argonne are contributing to the growth of our nation and improving the everyday lives of the citizens. Every day, research goes on in the laboratory that may change the world for the better; the next big breakthrough might be just around the corner.

HISTORY OF ARGONNE

Argonne's history begins in Chicago in 1942, when Enrico Fermi and his colleagues at the University of Chicago's Metallurgical Laboratory created the first controlled nuclear chain reaction under the stands of the University of Chicago's Stagg Field. The experiment was deemed too dangerous to continue with a major city nearby. Within a year, the breakthrough reactor was moved to a section of the Cook County Forest Preserve named Argonne Forest. In 1946, it was renamed Argonne National Laboratory and became the nation's first national laboratory. Within a few years the laboratory outgrew its small Cook County site and, between 1948 and 1953, Argonne moved to its current 1,500-acre campus in the southeast corner of DuPage County, encircled by the Waterfall Glen Forest Preserve.

Aerial view of the Argonne site. Argonne is a federally funded research and development facility managed by UChicago Argonne, LLC for the U.S. Department of Energy's Office of Science.

ARGONNE'S MISSION

Argonne has come a long way since Fermi's experiment. Today Argonne is one of the nation's leading centers of multiprogram research and development. Argonne's mission is to address the scientific and energy needs of the United States through research and technology development. Argonne brings together world class scientists, engineers, and user facilities to address our nation's most significant needs, such as alternative forms of safe and

plentiful energy, environmental health, economic competitiveness, and national security. Argonne is able to do the basic research that the private sector is unable to; they are then able to transfer technology to the private sector for further development. In addition, Argonne scientists often collaborate with universities and other national laboratories to discover and develop new technology to meet our nation's ever-changing needs.

ENVIRONMENTAL STEWARDSHIP

A major goal of the laboratory is to be a good neighbor and take responsibility for its impact on the environment. Argonne actively monitors environmental releases, conducts environmental clean-up actions, and performs environmental measurements in cooperation with the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Illinois Environmental Protection Agency (IEPA). This work ensures that future generations can enjoy the use of the land and helps safeguard the communities around Argonne.

GENERAL INFORMATION

Argonne employs approximately 3,400 full time employees, including about 1,250 scientists, engineers, and post-doctoral researchers. It is managed by UChicago Argonne, LLC, for the DOE's Office of Science. Argonne's annual operating budget is $717 million, which supports about 200 projects. In conjunction with government funding from DOE and other federal agencies, Argonne also receives some monetary support from corporations.

RESEARCH AT ARGONNE

Argonne National Laboratory conducts research and development in a wide range of areas and specialties. These include basic sciences, energy, national security, advanced computing, and environmental management. In addition, Argonne designs, builds, and operates state-of-the-art scientific user facilities that would be too expensive for a single company or university to build or to operate. These facilities are built for the benefit of researchers from a wide range of industry, academic, and government laboratories who come to Argonne to use these facilities in solving society's most complex scientific challenges.

TOM YUREK

CURRENT RESEARCH

Since becoming the nation's first national laboratory in 1946, Argonne has been involved with everything from nuclear reactors to contributing to the creation of the Chevy Volt battery. Not to mention that, by using Argonne's Advanced Photon Source, scientists have discovered an antibody that exploits a weakness within the virus that causes AIDS (HIV). With this new discovery, research can be started on producing a vaccine.

THE ADVANCED PHOTON SOURCE

The Advanced Photon Source (APS) is a facility at Argonne National Laboratory that produces the Western Hemisphere's brightest X-rays generated by a synchrotron source. By using this facility, scientists discover valuable information that can lead to new developments in chemistry, physics, materials science, pharmaceuticals, medicine, and many other fields; new technology from this research helps the economy. Proposed upgrades to the APS will increase the number of users and experiments, and make existing beam lines much more powerful.

Argonne Advanced Photon Source

ARGONNE TANDEM LINAC ACCELERATOR SYSTEM

The Argonne Tandem Linac Accelerator System, or ATLAS for short, is the world's first superconducting linear accelerator for heavy ions. ATLAS is used primarily for low-energy nuclear research, most often to study the properties of atomic nuclei, which are the core of matter and fuel of stars. Scientists come from all over the world to use the facility in order to understand the nuclear forces that bind protons and neutrons into nuclei.

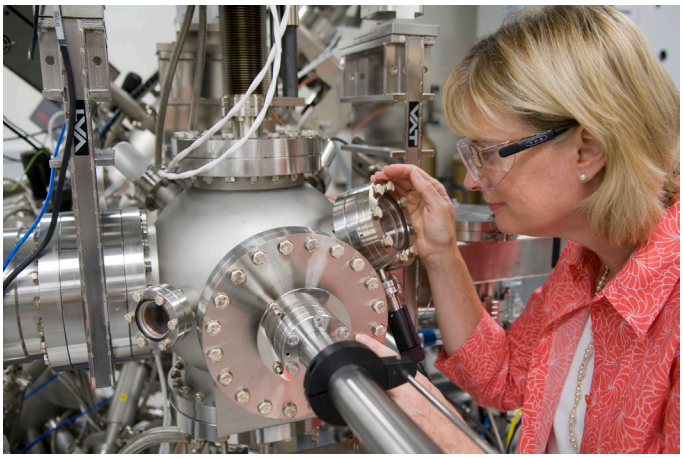
ARGONNE'S LEADERSHIP COMPUTING FACILITY

The purpose of this high-performance computing facility is to accelerate major scientific discoveries for humanity. Researchers are using this facility for the analysis and design of advanced nuclear reactors and to develop treatments for incurable diseases. In 2012, Argonne's Leadership Computing Facility will house one of the fastest and most energy-efficient supercomputers in the world, IBM's Blue Gene/Q. This computer is four times faster than today's fastest supercomputer and will be able to do more calculations in one second than every man, woman, and child in the world could do if they performed a calculation every second for more than two weeks.

Argonne's IBM BlueGeneP Computer

CENTER FOR NANOSCALE MATERIALS

One of the world's foremost nanotechnology research institutions and home of the world's highest-resolution X-ray microscope, the Center for Nanoscale Materials (CNM) focuses on areas that deal with electronic, magnetic, structural, chemical, and optical advances. CNM allows researchers from industry, academia, and other national laboratories access to premier instrumentation and the knowledgeable staff needed to create extremely tiny devices with the use of electron beams.



Research at Argonne's Center for Nanoscale Materials

EARTH MICROBIOME

Of the research projects currently taking place at Argonne, no task seems more complex and time-consuming than collecting DNA from every type of microbe on Earth. For the Earth Microbiome project, scientists are given the mission of cataloguing the DNA of every type of microbe. In our bodies alone there are 100 trillion microbes, with millions more in the oceans, air, plants, and soil. The knowledge that could be uncovered from gathering these microbes' information would allow scientists to better understand climate change and increase world food production.

THE ADVANCED BATTERY RESEARCH AND DEVELOPMENT

Argonne is helping renewable energy and green technology become more popular and practical. Argonne's energy storage and alternate energy programs focus directly on these types of projects, along with creating smart energy grids that are reliable and efficient while harnessing renewable resources. Argonne played a key role in developing battery materials used in the Chevrolet Volt plug-in hybrid. Argonne's scientists are currently directing their attention to the development of lithium-air batteries. Although experts say that commercial production is many years away, the lithium-air batteries would store five or 10 times more energy than today's lithium-ion batteries.

EXASCALE COMPUTING

High-performance computing is a bigger part of the advancement of U.S. science with every passing year. Now more than ever we need exascale computing, which will be roughly 1,000 times more powerful than any existing computer system. With these multi-core processors, we would be able to develop safer nuclear reactors faster; design a national smart grid that accommodates plug-in electric vehicles; and monitor global, national, and local weather with greater accuracy. These supercomputers would also allow the extension of biological modeling from molecules to cells to organs. Argonne is working with scientists from around the world to develop exascale computing to help solve important science and engineering problems. Acquiring this new computing technology would allow our nation to maintain our competitiveness with other scientifically advanced nations.

TRANSPORTATION RESEARCH AND ANALYSIS COMPUTING CENTER

The Transportation Research and Analysis Computing Center (TRACC) at Argonne uses a highly advanced parallel computer system that improves the efficiency and the economics of transportation systems across the nation. Ever wonder how safe you are in a bus that flips onto its side? TRACC users have too, so they performed multiple crash tests of actual vehicles and prepared computer models to simulate these experiments in order to help scientists better understand the innovations needed to make a common transit bus safer. A smaller research project at TRACC monitors and analyzes traffic in large metropolitan areas like Chicago. Using high-powered computers, scientists simulate traffic patterns of vehicles and humans alike in a second-by-second breakdown. These simulations allow transportation planning specialists to better understand what causes traffic and congestion within a city.

BRIDGET ALBRIGHT

ENVIRONMENTAL MANAGEMENT SYSTEM

When we think about the environment, we usually think about how pollution and greenhouse gases are destroying the earth. However, when we think about the solutions to these problems, the answers don't come quite so quickly. Argonne National Laboratory wants to work with the environment and not harm it. This task is difficult since the lab works with small amounts of harmful chemicals and dangerous substances, such as mercury, that can hurt the environment. The Environmental Management System (EMS) helps Argonne achieve its goal of sustaining the environment by creating alternative ways to reduce negative effects on the environment. The EMS is an ISO14001 accredited system. Argonne has developed methods to prevent pollution and reduce emissions in the environment by looking at lab operations and trying to "go green" in every way possible. Argonne has created several programs to achieve the goals of the EMS, like the Bike Share program to save energy and reduce carbon dioxide emissions, and the solid waste recycling program to divert material disposal and encourage reuse. In 2010 Argonne received $31,000 for recycled office paper and scrap metal. These examples are only a few of the solutions the EMS has helped implement throughout the years, and it is continuing to monitor and improve the practices used to sustain the environment.

EMS Integrated with ISM

The Environmental Management System works with other management systems within Argonne to minimize hazardous materials emitted from different facilities and to design programs that reduce the amount of waste created. The Environmental Management System provides structure and shows how problems can be fixed if something were to happen. The EMS is a part of Argonne's Integrated Safety Management System, which describes how work is done at Argonne in a safe manner. These systems help to create a strong, centralized system that manages risk to workers and the surrounding environment. The Environmental Management System is important because it helps Argonne meet the standards required to continue functioning as a national research laboratory.

The Environmental Management System is a tool to ensure Argonne meets all regulations set by federal, state, and local governments. To keep up to date with regulations, Argonne employees attend workshops and seminars, participate in professional organizations and conferences, monitor publications like the *Federal Register*, and work closely with agencies like the U.S. Department of Energy, U.S. Environmental Protection Agency, and the Illinois Environmental Protection Agency. Because of this monitoring, the lab is able to comply with environmental regulations such as the Clean Air Act.

Argonne's environmental policy states that all operations at the laboratory must be conducted in a way that protects the environment, prevents pollution, and minimizes waste. Argonne ensures that all aspects of the laboratory meet or exceed environmental permit expectations and regulatory requirements. If something isn't meeting expectations, they work to correct the conditions as soon as possible to protect the environment. Argonne also explores new ways to minimize its pollution output, attempts to preserve natural resources, and works with people inside and outside of Argonne to enhance the environment.

To help identify environmental issues as quickly and efficiently as possible, Argonne uses a scoring system to identify four activities that have potentially significant environmental impacts: regulated air emissions, wastewater discharges, waste generation, and pollution/waste minimization. These activities are ranked in terms of their regulatory compliance, environmental consequences, mission consequences, and likelihood of occurrence. This system allows Argonne to attack the most significant problems first to try and solve them. They have done this very well over the years and are working hard to meet sustainability goals set by the Department of Energy. These goals, involving sustainable practices, must be met by 2015. The table on the next page shows some of the areas where Argonne has accomplished the goals, and other areas that still need work. The table also discusses how Argonne plans to reach the unaccomplished goals by 2015.

STATUS OF SUSTAINABILITY GOALS FOR 2010			
GOALS	CURRENT STATUS	PLANNED ACTIONS	EXCEEDS, MEETS, IN PROGRESS
Reduce energy intensity by 30%	Reduced by 15.7%	Site-wide energy savings performance contracts, in-house energy projects, combined heat and power facility, steam loss reductions, APS lighting upgrades, building retro-commissioning, energy audits, and heat recovery systems	In Progress
Reduce the Scope 3 greenhouse gas (GHG) emissions	1.7% increase because of an increase in employees	Continue to educate employees on how to reduce GHG. Conduct internal contests to encourage employees to modify their commuting habits.	In Progress
Reduce the Scope 1 and 2 GHG emissions by 28%	Reduced by 11.3%	Combined heat and power plant, SF6 recovery systems, and renewable energy systems	In Progress
10% annual increase in fleet alternative fuel consumption	75% increase	Argonne will continue to use alternative fuel vehicles	Exceeds
Annual reduction of 2% in fleet petroleum consumption	81% reduction	Argonne will continue to use alternate fuel vehicles, hybrids, and electric vehicles	Exceeds
Every site should have at least one on-site renewable energy generating system	Argonne installed solar/ wind street lamps	Argonne will explore options related to wind and solar energy production	Meets

Argonne's Environmental Management System helps the laboratory to recycle more and to reduce the waste its activities generate. Without the EMS, Argonne would not be as successful at reducing its environmental impact or at planning ahead to minimize future impacts. It is a key component of Argonne's daily operations and helps protect the environment for Argonne's employees and neighbors.

AMBER CARPENTER

CLEAN AIR ACT

The average adult breathes in about 20,000 liters of air a day. If this air is not clean, our physical health is in danger. Air pollution is a significant risk factor for multiple health conditions, including respiratory infections, heart disease, and lung cancer. Argonne wants to prevent air pollution from harming its employees and citizens who live near its property. Argonne's goal is to improve the air quality rather than harm it.

The Clean Air Act defines the Environmental Protection Agency's (EPA) responsibilities for protecting and improving the nation's air quality and the stratospheric ozone layer. The goal of the act is to protect our environment from damage caused by air pollution. Within the Clean Air Act, there are emission standards set by the EPA for air pollutants that are enforced through a permit system. Argonne's permit from the Illinois EPA says the laboratory must stay within certain limits for every pollutant emitted. The permit also requires Argonne to monitor and keep records of the air pollution it emits and to report activities that emit air pollutants.

RADIONUCLIDE EMISSIONS

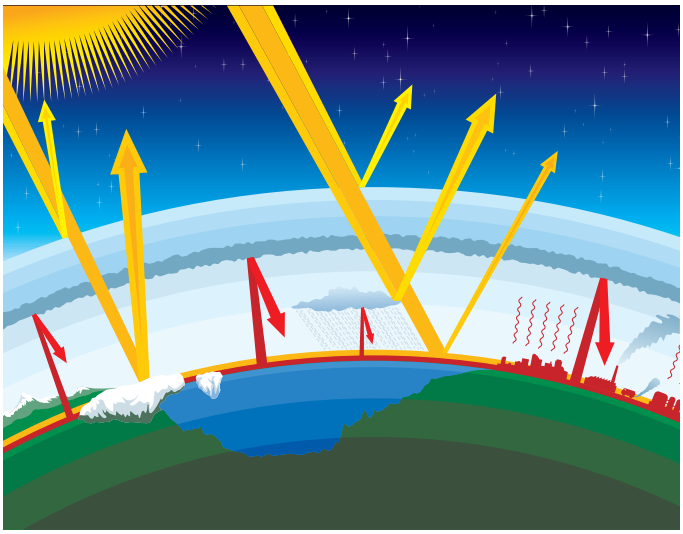
Radioactivity is defined as spontaneous emissions of radiation, either directly from unstable atomic nuclei or as a consequence of a nuclear reaction. When people hear the word radioactivity, they automatically think of nuclear power plant meltdowns or atomic bomb explosions. This is not a realistic view of radioactivity. Radioactivity comes from many natural and man-made sources, including microwaves, cell phones, cosmic radiation, and foods such as bananas. Argonne has numerous buildings and laboratories that sometimes emit radionuclides to the atmosphere. Radioactive content of particles in the air during 2010 was determined by collecting and analyzing air-filter samples. Radionuclide samples are collected at 11 perimeter locations and at four off-site locations on glass fiber filter media that are changed weekly. A comparison between off-site and perimeter locations found that perimeter locations had levels of radioactivity the same as the off-site locations.

ASBESTOS EMISSIONS

Originally, asbestos was used as a heat-resistant material; however, we now know it contains carcinogenic material. The inhalation of asbestos fibers can cause serious illnesses, including lung cancer, mesothelioma, and asbestosis (a type of pneumoconiosis). There are many buildings within Argonne that contain this material. Many of the older buildings from the '50s and '60s contain asbestos insulation, but as new construction occurs, Argonne removes this material and uses other, safer products. To prevent asbestos getting into the air, Argonne has a program to safely remove it. In approximately 100 removal projects in 2010, 9,772 cubic feet of asbestos was successfully removed from Argonne. Asbestos-containing material can also be found around some pipes and tanks, spray-applied surfacing material for fireproofing, floor tile, and asbestos-cement panels. This material is removed when renovations and maintenance are done to the facilities. Projects involving asbestos removal are regulated by the EPA and require workers to be specifically trained in its removal. Containment procedures used during removal ensure that any environmental impacts from asbestos removal and handling are minimized.

GREENHOUSE GAS EMISSIONS

Argonne uses many materials, including fossil fuels, in its daily operations and research activities. Some of these activities directly or indirectly emit greenhouse gas. Greenhouse gases absorb and emit radiation within the thermal infrared range. There are two reporting requirements for the greenhouse gases carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons. These pollutants have the potential to harm the environment if released. The majority of Argonne air emissions originate from discharges from five on-site steam boilers. Boiler #5 uses coal during the peak of winter. Air emissions are much greater while burning coal than gas. However, no exceedances (emissions greater than allowed by Argonne's permit) were noted over a period of 1,610 hours burning coal. Because there were no exceedances, the boiler house is operating within its correct limits. Most research conducted at Argonne uses chemicals only in small quantities. Consequently, the potential for a large release to the atmosphere is minuscule.



How Greenhouse Gases Warm the Planet

WHAT ARGONNE DOES TO HELP

Argonne's goal is to support environmental stewardship by doing everything they can to improve the environment. To reduce the amount of carbon dioxide, methane, and nitrous oxide emitted, Argonne has switched out many of its gasoline-powered fleet vehicles with electric and bio-based fueled vehicles. Argonne has also implemented a Bike Share program that supplies 120 bikes to employees to use as a simple and green method of transportation on the Argonne campus. A program to capture and reuse sulfur hexafluoride, a powerful greenhouse gas, was also begun during 2010. Sulfur hexafluoride is used in electrical equipment, and one pound emitted to the air is equivalent to almost 12 tons of carbon dioxide. These new programs reduce greenhouse gas emissions from the laboratory. Programs such as this allowed Argonne to win the Secretary of Energy's Achievement Award in 2010. This award is the Department of Energy's highest non-monetary honor for a group or team effort.

ELIZABETH PALUMBO

SURFACE WATER MONITORING

Between 70 and 75 percent of the Earth's surface is covered in water. It is a vital resource to every ecosystem and an integral part of every person's life. Argonne strives to protect this precious substance, along with keeping employees, neighbors, and the community safe from pollution within the surface water system.

THE CLEAN WATER ACT OF 1977

The Clean Water Act (CWA) was established in 1977 as the primary federal law governing water pollution in America. This act has the ultimate goal of providing and maintaining "fishable and swimmable" water quality all across the country and eliminating toxic substances in surface water. This act is keeping water safe for human sport and recreation. The National Pollutant Discharge Elimination System (NPDES) issues permits for each wastewater discharge point (also called outfall), where wastewater is discharged into a receiving stream, and other points where pollution may occur. The NPDES program issues water-quality regulations and requires monitoring of discharge points. Argonne's NPDES permit is issued by the Illinois Environmental Protection Agency (IEPA) and is good for five years.

CLEAN WATER AT ARGONNE

There are two different programs at Argonne that sample surface water, one of them being the NPDES program. During 2010, Argonne monitored 43 different outfall points under its NPDES permit that was in effect that year. They are located at various points throughout the Argonne campus. Argonne must sample each outfall at varying time intervals, depending on the specifications of the permit. The IEPA determines all sampling locations, parameters, and frequencies. The outfalls have certain permit limits for the acceptable level of various chemicals that can be contained within the water. Samples must be analyzed and compared to these permit limits to determine Argonne's compliance with the NPDES permit, and to keep the surface water clean and safe. In addition to the monitoring required by the NPDES permit, Argonne also collects other samples of surface water to measure the impacts of Argonne activities on nearby surface water bodies.

There were only 11 exceedances of Argonne's NPDES permit in 2010, meaning that Argonne went above the permit limits only 11 times during the entire year. Studies show that the majority of these exceedances were caused by the salt used to melt snow on the roads during winter. Argonne staff members have devoted their time to finding a substitute for this salt (beet juice and other chemicals) in order to reduce these exceedances.

The other monitoring program is the Environmental Surveillance program. Under this program, Argonne's main water treatment plant discharge (Outfall 001), as well as Sawmill Creek (a small stream that flows across Argonne's campus), are sampled weekly and analyzed. The Des Plaines River is sampled each month. At these and other points, Argonne monitors for radionuclides and chemical pollutants that may have been added to the environment through experimental discharge or waste handling. A radionuclide is a radioactive contaminant. They are found at very low levels in most natural surface-water sources; however, high levels can be dangerous. Argonne must monitor these in order to prevent an overabundance of radioactive material in Sawmill Creek from endangering the ecosystem. Table 1 shows the amounts of radioactive material released to Sawmill Creek during 2010.

TOTAL RADIOACTIVITY RELEASED IN ARGONNE WASTEWATER DURING 2010	
RADIONUCLIDE	WTP OUTFALL (Ci)
Hydrogen-3	0.18
Strontium-90	0.0003
Uranium-234	0.0003
Uranium-238	0.0003
Plutonium-239	<0.0001
Other transuranics	<0.0001
Total	**0.18**

PROTECTING CLEAN WATER

Argonne has many programs in place to protect the communities surrounding Sawmill Creek and Des Plaines River by ensuring the health of these streams. Because exposure to toxic or radioactive material could harm residents and wildlife, Argonne purifies wastewater before it is discharged.

Argonne uses two different treatment systems to protect surface water from pollution. Wastewater from laboratories is processed through a laboratory system. This wastewater may contain harmful chemicals or radioactive substances from experiments that could endanger the ecosystem surrounding Sawmill Creek and Waterfall Glen. To combat this danger, laboratory wastewater is collected in tanks, treated, analyzed, and certified before it is released to the wastewater outfall.

A sanitary system processes wastewater from sanitation facilities such as restrooms, the cafeteria, and office buildings. This wastewater is treated through a series of treatment steps, including primary clarifiers, trickling filters, secondary clarifiers, and slow sand filters. After treatment, this water is released into Sawmill Creek, which flows into the Des Plaines River. For the health and safety of Argonne employees and neighbors, these bodies of water must be kept clean and free of pollution and radioactive material. For years, Sawmill Creek has been cleaner when it leaves Argonne than when it arrives. Keeping the environment and us safe is what counts, and Argonne is doing their part.

MADDIE SNYDER

GROUNDWATER MONITORING

BUILDING SANDCASTLES

When you go to the beach, there's one experience you can't miss: building a sandcastle. Preparing for construction of an enormous castle, you find that the sand is damp as you dig deeper. Little kids may come up with their own tale of magical lands underground, but it's actually caused by the great unseen supply of groundwater within the sand.

Even though there isn't a sandy beach and ocean at Argonne National Laboratory, there is no short supply of groundwater in the area. Argonne monitors the groundwater in and around its campus to ensure that no waste or radioactive material affects the safety of the water. Monitoring groundwater helps keep the environment and surrounding community happy and healthy.

WHAT IS GROUNDWATER?

Groundwater is a build-up of rain or melted snow that seeps into the ground where it's stored. In fact, over half the United States uses groundwater as their water supply. When the water from the rain or snow sinks into the ground, gravity naturally pulls it down through layers of the earth. On its way down, the water is filtered through layers that consist mostly of sand, gravel, clay, and porous rock. Eventually, the water reaches the end of the road in an area already saturated with water, known as the saturated zone. Water is stored in these nature-created reservoirs, known as aquifers.

GROUNDWATER AT ARGONNE

With all the experiments that Argonne undertakes, it generates waste that needs safe disposal. In the past, some radioactive materials and harmful wastes were stored underground in waste units that have potential to affect groundwater. Argonne regularly monitors its groundwater for a variety of chemicals – volatile organic compounds, semi-volatile organic compounds, pesticides, metals, nonmetals, and radionuclides – and follows the underground path that groundwater takes to make certain groundwater is clean and safe all the way through its journey underground. Argonne samples groundwater several times throughout the year and compares the results against the Illinois Environmental Protection Agency's groundwater protection standards for Class I (potable resource groundwater). The table below is a summary of groundwater monitoring in 2010.

Argonne scientists have developed some interesting ways to clean groundwater. Phytoremediation, a method started at Argonne in 1999, involves planting trees that soak up radiological and chemical residues from the groundwater as it passes through their roots. As the water is circulating through the trees, they release the less harmful toxins into the atmosphere. This process is gradually cleaning up areas of Argonne that were contaminated from former waste disposal practices and is doing so in an environmentally healthy way.

SUMMARY OF GROUNDWATER MONITORING IN 2010

GROUNDWATER MONITORING ELEMENT	NUMBER OF WELLS IN AREA	NUMBER OF WELLS SAMPLED	NUMBER OF ANALYSES PERFORMED	% OF RESULTS NON-DETECTABLE
Former water supply wells	4	2	518	96%
317/319 Area wells and manholes	10	10	5,601	96%
317/319/ENE and GMZ wells	71	44	8,414	86%
800 Area Landfill wells	21	21	9,912	91%
CP-5 wells	6	6	480	75%

At Argonne, water seeps first through the uppermost layer of glacial drift, which is made of clay, silt, sand, and gravel. Groundwater can be found in the sand and gravel regions within this layer. Secondly, there is a deeper dolomite bedrock layer with cracks and fissures that enable water to filter through the rock. This layer of earth creates the porous rock aquifer that Argonne used as a water source until the laboratory switched to Lake Michigan water in 1997. Another saturated layer of sandstone lies underneath the dolomite, but this area is too deep within the earth to be affected by Argonne's actions or to be used as a groundwater source.

WHAT'S GOING ON DOWN THERE?

Most of Argonne's groundwater meets or beats safe drinking-water standards. The 317/319 area is the only area on the Argonne campus that has chemical contamination greater than groundwater standard requirements. Yet contamination in this area is declining when compared to last year's data. Argonne is doing its best to understand what is happening to the groundwater and trying to clean all of it to the Illinois Environmental Protection Agency standards.

GROUNDWATER AND YOU!

Argonne does a lot of extra monitoring of groundwater because Argonne wants to make sure the surrounding community is safe and unaffected. Argonne realizes that it's not going to be there forever. That is why they try their best to protect the environment. While Argonne is a national laboratory, it is also a neighbor to nearby communities and to adjacent forested land that houses a variety of wildlife. While groundwater helps to make big, sturdy sandcastles, it also sustains life in and around Argonne.

Phytoremediation Trees at Argonne

BENJAMIN COUILLARD

RADIATION

DID YOU KNOW THAT YOU ARE RADIOACTIVE?

Even though radiation is widely feared as a health hazard, everyone on Earth is radioactive. In every human, complex processes occur that emit energy, and one form of this energy is radiation. In fact, a recent Japanese experiment showed that humans glow faintly in the dark. Radiation is the transfer of energy through space in the form of subatomic particles, waves, or vibrations. Common forms of radiation include light, heat, radio waves, and microwaves [see Fig. 1]. Another form of radiation is emitted by the decay of unstable atoms. Unstable, or radioactive, atoms (called radionuclides) give off energy to become stable, and that energy is called nuclear radiation. While there is nuclear radiation inside you from naturally occurring radionuclides in your cells, some of this type of radiation is man-made. Naturally occurring nuclear radiation comes from unstable elements present in the earth or from distant stars in space. Humans can release nuclear radiation into the environment through the detonation of nuclear weapons, the use of technology that incorporates those unstable atoms, or by operating nuclear reactors.

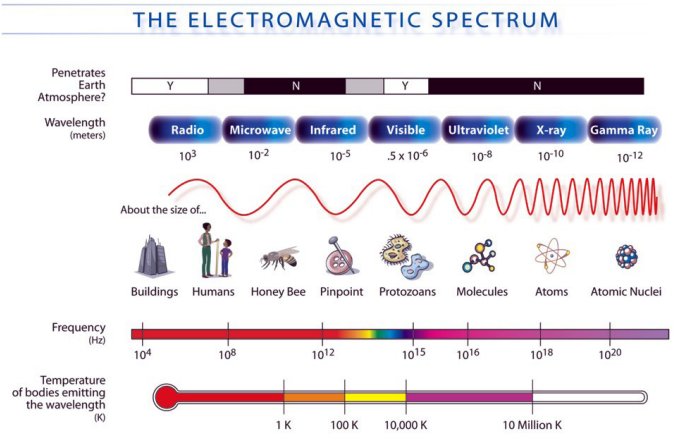


Figure 1. Types of radiation

IONIZING RADIATION

Ionizing radiation is strong enough to damage cells. It consists of alpha particles, beta particles, gamma rays, X-rays, and neutrons. What sets ionizing radiation apart is that the particles and waves have enough power to destabilize and break down biological molecules in living cells by knocking an electron from its orbit around the nucleus [see Fig. 2].

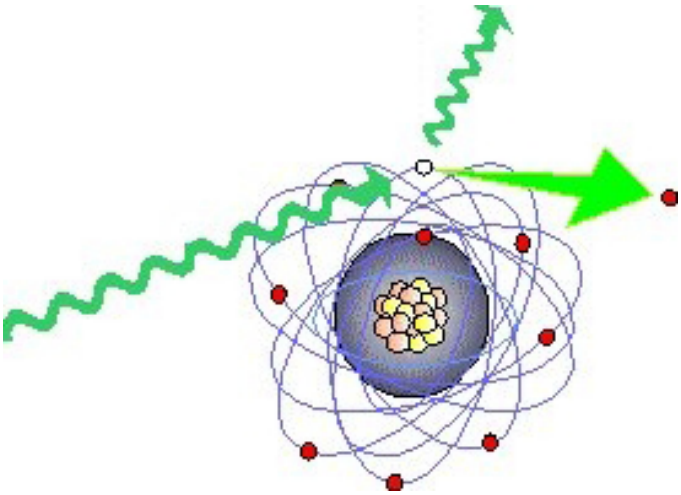


Figure 2. Effects of ionizing radiation

In extreme cases, such as a nuclear meltdown or a nuclear bomb being dropped, this can result in radiation sickness. Radiation sickness occurs when cells are killed by high radiation bombarding them and the body starts to shut down. Low levels of exposure over long periods of time can result in cancer.

Alpha radiation occurs when two neutrons and two protons, the nucleus of a helium atom, are emitted [see Fig. 3]. The relatively large size of this particle hampers its penetrative ability; most alpha radiation is stopped by skin. Beta radiation is the emission of a positively or negatively charged electron. Electrons are much smaller than neutrons and protons, and this means they can penetrate more easily than alpha radiation, but can be stopped by clothes. All ionizing radiation types have the ability to cause radiation poisoning or cancer, but only in high enough exposures. Because the penetrative ability of alpha and beta radiation is weak, they cause harm only when the source of the radiation is very close to the cells; they can be very harmful if taken inside the body. The types of radiation that are dangerous far from the source are gamma radiation, X-rays, and neutrons. Gamma radiation is in the form of waves, not particles, and it has a much longer range and greater penetrative power than alpha or beta radiation. Neutrons are rarely present in the environment since

they occur only near a nuclear reaction or a particle accelerator. X-rays are found only close to an active X-ray producing device; they are also rarely found in the environment.

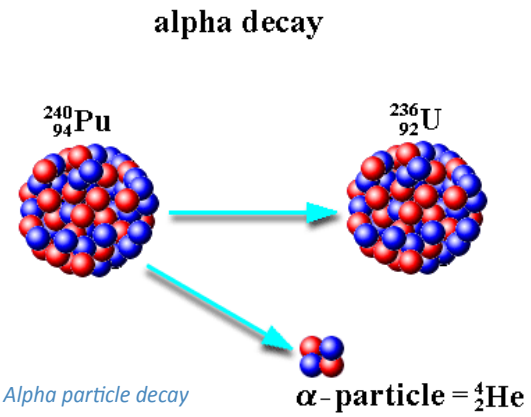


Figure 3. Alpha particle decay

MEASUREMENT OF IONIZING RADIATION

There are many devices to measure ionizing radiation, and many qualities that could be measured. Film badges can give information on the amount of radiation encountered over a period of time, and personal dosimeters (personal radiation monitoring devices) can give personal exposure information in real time. Some devices can measure a specific type of ionizing radiation, like alpha, beta, or gamma. Radiation is most commonly measured in the United States in units known as curies. Curies (Ci) measure how much ionizing radiation is actually present, and are usually expressed in units of picocuries or pCi (billionths of a curie). The unit pCi/L expresses the amount of ionizing radiation present in a liquid. The risk that radiation exposure poses to humans is expressed in terms of rem (abbreviated from Roentgen equivalent man), which measures how much damage is done to a biological organism as a result of exposure to ionizing radiation. It is often expressed as millirem or mrem (thousandths of a rem).

SOURCES OF IONIZING RADIATION

Humans experience 624 mrem of background ionizing radiation per year on average. About half of this is man-made and the other half is natural. The 311 mrem of natural radiation comes from a great variety of sources. There are radioactive particles in all food we eat, and it is estimated that humans receive 29 mrem internal dose per year from food. Cosmic rays from stars and other unknown sources in outer space bombard the planet regularly; a person living at sea level would receive 33 mrem from those sources per year. Another 21 mrem come from radioactive elements in the earth itself. The remaining approximately 228 mrem of natural radiation come from radon in the atmosphere, for a total of 311 mrem of natural radiation. Meanwhile, the 313 mrem of man-made ionizing radiation comes from sources such as medical X-rays, smoking, construction materials, and common items like TVs, glasses, smoke detectors, and pottery. Medical procedures such as X-rays account for 300 of the 313 mrem of man-made radiation. Living near a nuclear power station would give someone less than 1 mrem per year. DOE requires Argonne to limit Argonne-generated radiation exposure to members of the public to less than 100 mrem per year. The actual amount of radiation released from Argonne is much less than this limit.

NON-IONIZING RADIATION

Non-ionizing radiation is all other ways that energy is transferred through space, such as radio waves; microwaves; infrared, ultraviolet, and visible light; and heat. It is not measured in the same units as ionizing radiation. Sources of man-made non-ionizing radiation are any technological devices that emit light, radio waves, or heat, which encompass almost everything we use. Although it is all around us in unexpected places, it can still pose a risk. Even if non-ionizing radiation cannot knock electrons out of place as ionizing radiation can, it causes the atoms in a cell to vibrate very slightly and very fast. The friction resulting from this vibration causes heat. This mechanism is in effect when we use a microwave to heat our food or bask in the sun's warmth. This all happens on a scale small enough that no one notices and no harm is done unless the exposure is great. So basically, non-ionizing radiation surrounds us and usually has a negligible health risk.

RADIATION AND YOU

In our everyday lives we receive only a tiny fraction of the radiation necessary to give us radiation sickness. You would need to multiply the yearly average background dose of 624 mrem by about 100 to approach a 50 rem total, where symptoms of radiation sickness would begin to appear. The technology around us may slightly increase the risk of cancer later in life, but the benefits of having that technology outweigh the small, unconfirmed risks. Radiation surrounds us; it is in the food we eat, the air we breathe, and the sun that warms our skin. Life would not exist without it.

HARRISON MILES

RADIATION MONITORING

Have you ever wondered if the amount of radiation you absorb is unhealthy or even safe? While Argonne does research involving radiation and radioactive materials, it is careful to release as little of this to the environment as possible. Argonne makes sure you are safe by following government requirements and regulations. The laboratory observes, detects, and records releases of radioactive material from its processes that use radiation or radioactive material, monitoring it in the air, water, and sediment. External penetrating gamma radiation, which can cause exposure off the Argonne campus, is also monitored. Gamma radiation is different from other types of radiation and is important to monitor because it is in the form of waves, so it can travel much farther distances, and is more penetrating. Numerous government organizations protect the public and our natural environment from harmful amounts of radiation.

- The Environmental Protection Agency (EPA) requires long-term environmental monitoring and assessment of releases of radioactive materials to the air. Argonne works with this agency to ensure gathered data is as accurate as possible and discharges are below EPA limits.
- The Department of Energy (DOE) requires that an environmental monitoring and surveillance program be conducted to oversee the management of radioactive waste material and the operation of radiation-producing equipment. DOE has also developed regulations to prevent radiation from exceeding certain limits. Argonne takes all steps necessary to keep the emitted levels of radiation under these limits by monitoring radiation released and working with DOE to quickly address any issues.
- The Department of Transportation (DOT) regulates packaging and transport of radioactive materials, as well as carriers of radioactive materials. Argonne complies with all DOE and DOT requirements when transporting radioactive materials.

WHERE RADIATION COMES FROM

Most of the radiation people receive comes from natural sources, also known as background radiation; however, Argonne operations also release small amounts of radiation. Argonne monitors the amount of radiation present in the air, surface water, and sediment at the bottom of bodies of water at the Argonne site. Argonne also ensures the safety of residents in nearby towns by monitoring the external penetrating gamma radiation, or radiation that leaves Argonne through the air. Argonne uses 11 air-particulate samplers to detect radioactive particles in the air. Four off-site sampler filters are changed weekly and mailed to Argonne by cooperating local agencies. When a sample is collected, the date and time are recorded on a label and it is then transported to the Argonne analytical laboratory, where it is analyzed. The results are transferred to Argonne's Environmental Protection Data Management System. The sampling units are serviced every six months, and air flow rates are recalibrated every year.

Liquid wastewater from buildings or facilities that use or process radioactive material is collected in retention tanks beneath the buildings. When a tank is full, it is sampled and analyzed for radioactivity. If the amount of radioactivity exceeds government limits, the tank is processed as radioactive waste. If it is below the regulatory limits, it is pumped to the sewer and treated in the laboratory wastewater treatment plant. The treated wastewater is also sampled and tested for radioactivity.

One way Argonne protects the environment from dangerous doses of radiation is by monitoring radiation levels in the groundwater. To do this, Argonne samples three groundwater seeps and 68 wells. The wells are located at strategic points around Argonne to monitor the amount of radiation in groundwater with an accuracy of at least 95 percent. Twenty-one wells are located around the 800 Area Landfill, 34 wells between Areas 317 and 319, seven wells in the ENE Landfill Area, and six wells around the former CP-5 reactor. To determine the amount of radiation present in the bottom sediment of Sawmill Creek, which flows through Argonne, many samples are taken and analyzed for radioactivity.

To see how much radiation nearby residents could receive from Argonne, they also measure direct penetrating radiation at 17 locations, mostly along the site boundary. Direct penetrating radiation measurements were taken during four quarterly exposure periods, and the results were calculated in terms of an average annual dose. The off-site results for normal background levels averaged 98 mrem/yr. The radiation level at the Argonne fence line ranged from 91 to 102 mrem/yr, statistically the same as the background dose. This shows that Argonne releases very little penetrating radiation off its site. The total radiation dose from all other releases of radioactive materials from Argonne in 2010 was 0.027 mrem/yr. The DOE limit for radiation exposure is 100 mrem/year, so Argonne was far below this limit. For comparison, the average background radiation dose from natural and manmade sources is 624 mrem/yr.

In conclusion, the members of the public are safe because of the many regulations and procedures Argonne follows. Argonne is well equipped for preventing radiological hazards and accurately testing for radiation. Because Argonne hasn't operated any nuclear reactors on its campus for decades, there is little chance the laboratory will emit dangerous amounts of radiation.

LORI PLUCHRAT

WASTE MANAGEMENT

Argonne puts effort into making the earth a healthy environment. Storing, treating, and disposing of waste properly creates a better place to live. Argonne provides waste management services and programs to safely dispose of normal trash, waste chemicals, and radioactive waste. Waste can be classified as hazardous or nonhazardous, which is why different treatment, storage, and disposal methods are needed for proper waste management, and that is what this program at Argonne does. Waste management is defined as properly dealing with multiple kinds of waste in order to promote a healthy environment and enhance human safety.

ENVIRONMENTAL LAWS

Many different environmental laws help regulate waste management, and Argonne follows these laws. The Toxic Substances Control Act (TSCA) regulates the use of certain chemicals and how the waste is managed, and provides data about those substances. The Environmental Protection Agency (EPA) helps regulate the requirements of TSCA and provides authorization to manage these chemicals. Polychlorinated biphenyls (PCBs) are the only chemicals at Argonne regulated by TSCA. The act requires Argonne to record data on PCBs in use and the amount of PCBs disposed of each year. Another act, the Resource Conservation and Recovery Act (RCRA), regulates facilities that generate, store, or dispose of hazardous waste. Such facilities must dispose of waste in a careful, healthy way that protects the environment. The TSCA and RCRA both help make sure that all facilities handling waste do so properly by requiring reports that describe, for example, the different kinds of wastes generated, how Argonne treats them, and where Argonne stores them and disposes of them.

WASTE MANAGEMENT PROGRAMS

There are many benefits of proper waste management, which is why Argonne encourages its employees and the public to be aware of the laboratory's many programs. Argonne's waste generator education program shows employees proper handling and disposal of different wastes. Argonne has other programs, such as Pollution Prevention/Waste Minimization (P2/WM) and the solid waste recycling program. P2/WM helps identify the different kinds of waste and recyclable materials at Argonne and finds different ways to reuse waste or recycle unneeded materials. The solid waste recycling program helps Argonne save money and improve the environment by recycling hazardous materials.

WASTE DISPOSAL

Hazardous waste at Argonne is managed in 15 different storage and treatment units, depending on the type of waste. Nonhazardous waste is sent to off-site treatment facilities or landfills for disposal. Argonne used to operate an on-site landfill for disposal of nonhazardous wastes, but it was closed in 1992. Twelve different underground storage tanks store potentially hazardous liquids such as oil, diesel, gasoline, ethanol-gasoline blend, other fuels, used oil, and antifreeze. The Illinois State Fire Marshal regularly inspects these tanks.

Argonne generates large volumes of waste and a variety of it. In 2010, Argonne shipped about 490,000 pounds of non-radioactive waste and 35,000 cubic feet of radioactive mixed waste off site for proper disposal. The table below lists the nonradioactive waste disposed of in 2010.

WASTE DISPOSAL AT ARGONNE IN 2010	
WASTE	WEIGHT (POUNDS)
Hazardous solids	24,909
Hazardous liquids	20,093
Hazardous aerosols	870
Hazardous gas cylinders	39
PCB articles	10,717
PCB liquids	822
Lead-acid batteries (recycle)	6,198
Light bulbs (recycle)	823
Potentially infectious waste	455
Other batteries (recycle)	189
Lead scrap (recycle)	505
Mercury universal waste (recycle)	88
Asbestos	350,078
Nonhazardous liquids	23,078
Nonhazardous oil (recycle)	27,260
Nonhazardous gas cylinders (disposal)	19
Nonhazardous gas cylinders (re-use)	467
Nonhazardous solids	20,951
Total	**488,181**

BECKY HAYS

WILDLIFE AND HABITAT MANAGEMENT

What's the first thing that you see when you enter the Argonne area? Animals and plants! The wildlife management program at Argonne allows the plant and animal populations to remain protected and healthy.

WILDLIFE MANAGEMENT

The goal of wildlife management is to balance the needs of wildlife with the needs of people, using the best available science. At Argonne, ecologists and natural resource managers work to make sure that the wildlife on the campus remains safe even though Argonne uses many hazardous materials in its research.

Ecologists at Argonne monitor the grounds for any environmental problems that affect wildlife or habitat areas. Plants and animal species are monitored to keep their populations healthy, free of invasive organisms, and sustainable. At Argonne, the U.S. Department of Energy (DOE) manages the number of native white-tailed deer and fallow deer (exotic white deer released by the previous owner of the Argonne site) through an agreement with the U.S. Department of Agriculture (USDA). The USDA began the deer management program at Argonne in 1995 to lessen vehicle safety hazards and ecological damage caused by very large deer populations then on Argonne's campus. The USDA manages deer populations to improve biodiversity and keep ecosystems functioning in an efficient and sustainable way. In 2001, DOE lowered its target density to 15 deer per square mile to reduce the number of vehicle collisions, to allow more native oak trees to grow, and to allow plants that deer eat to grow and flourish.

White-tailed deer and fallow deer are the wildlife management program's main focus. In the winter of 1995-1996, more than 600 of the white-tailed deer were removed and in the winter of 1996-1997 another 80 deer were removed to achieve the desired density of 15 deer per square mile for both species. Smaller numbers of deer have been removed each year since 1997 to maintain this density.

INSECTICIDES, FUNGICIDES, AND RODENTICIDES

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) states that pesticides and herbicides at Argonne must be applied by an Illinois Department of Public Health (IDPH) licensed contractor. Argonne uses pesticides that are applied by an IDPH-licensed contractor to ensure that the ecosystem is maintained in balance and that the undesirable invading species are taken care of. The contractor's job is to provide the chemicals, apply the chemicals themselves, and remove any unused chemicals. The Environmental Protection Agency makes sure chemicals used by the contractor are safe for everything except the unwanted invader.

The gypsy moth eats oak trees and could endanger them. Argonne wants to control gypsy moths on site to save the site's oak trees. In 2010, these gypsy moths were sprayed to protect the large number of mature oaks on the site.

ENDANGERED SPECIES

The Endangered Species Act (ESA) of 1973 states that Argonne must protect plant and animal resources from the harmful effects of human activities. To achieve this goal, all Argonne projects undergo a review to assess potential environmental impacts. If the assessment identifies any harmful impacts, the proposed project must develop a plan to mitigate them. Before the project can proceed, the plan must be reviewed and approved by relevant agencies, such as the Environmental Protection Agency and the U.S. Fish and Wildlife Service.

There are no federally listed threatened or endangered species on the Argonne site, but three endangered and one threatened species inhabit the Waterfall Glen Forest Preserve that surrounds the Argonne property. The endangered species are the Hine's Emerald Dragonfly (*Somatochlora hineana*), the Leafy Prairie Clover (*Dalea foliosa*), and the Indiana Bat (*Myotis sodalist*). The threatened species is the Lakeside Daisy (*Tetraneuris herbacea*), which is also a state-listed endangered species.

Other species that live within the Argonne area are considered endangered species by the State of Illinois but are not covered by the ESA. These species include the Blanding's Turtle (*Enydoidea blandingii*), Eastern massasauga (*Sistrurus catenatus catenatus*), Tennessee milkvetch (*Astragalus tennesseensis*), Tuckerman's sedge (*Carex tuckermanii*), and Yellow-crowned night heron (*Nyctanassa violacea*). The state-threatened species that live within the Argonne area are the Buffalo Clover (*Trifolium reflexum*), Kirtland's snake (*Clonophis kirtlandi*), Marsh speedwell (*Veronica scutellata*), and Shadbush (*Amelanchier interior*).

LILLIE KASE

CURRENT ENVIRONMENTAL INITIATIVES

Whether it be in newspapers, on the TV, in magazines, or on the radio, there is always news about issues arising in our environment. While these reports may seem bleak, Argonne scientists work every day to help devise new solutions to make a cleaner and healthier environment. Argonne is monitored by the U.S. Department of Energy, in conjunction with other government agencies, to ensure that they comply with environmental laws and have all the right permits to conduct their work safely and protect the environment. Effective environmental management is allowing Argonne researchers to explore new frontiers in the areas of alternative fuels, energy storage, and nuclear energy that can help solve some of the world's problems.

ALTERNATIVE FUELS

Alternative fuels have become a popular topic due to the rising price of gasoline. This has resulted from a series of gas crises, most famously in the 1970s, where gas was limited and prices soared. With gas bordering on the four dollar mark presently, many are worried that they will not be able to keep up with the cost of owning and driving a car. In consequence, Argonne scientists are working to create fuel sources that are not only more efficient and less dependent on foreign sources, but cheaper as well. In addition, these alternative sources would not only be easier on America's wallet, but easier on the environment, since much of the ozone and greenhouse gas pollution is created by car emissions. One focus of Argonne's research is the development of alternative fuels and optimized engines to improve transportation fuel efficiency. To achieve this goal, scientists are working in the areas of chemical fuel development, advanced biofuel development, and fuel combustion and engine optimization.

ENERGY STORAGE

Argonne is focused on a subject that has interested the American public for many years: better energy storage. Energy storage has appeared in the news in the form of electric cars and wind and solar electric power generation. New energy storage promises cheaper ways to do mundane tasks that help families, their wallets, and the planet. With 30 years of experience in developing advanced battery technology, Argonne is striving to create a safer battery that will dramatically increase storage capacity and power densities for electrification of the transportation sector. By using lithium technologies, Argonne hopes that their efforts will "span the continuum from basic materials research to prototype device and systems development, and ultimately deployment by industry." Argonne is trying to make the switch from lithium-ion batteries to lithium-air batteries. Lithium-ion batteries present problems including costly manufacturing, costly transportation of the units, and complex chemical reactions inside the battery. Argonne National Laboratory is working to create lithium-air batteries that would reduce these issues. The process of making a lithium-air battery is complicated and involves a lot of time, resources, and labor but has maximum benefits.

NUCLEAR ENERGY ADVANCES

When Argonne was founded in 1946, it was commissioned to develop nuclear reactors. It only makes sense that many decades later, Argonne still goes back to its roots in discovering new uses for nuclear technology, including nuclear energy. A controversial topic, nuclear energy has been debated world-wide. The issue of where to store nuclear waste has been an important issue for many people. The issue is that nuclear waste has components that could remain dangerous for hundreds or thousands of years. This would mean that hazardous waste would need to be carefully managed for thousands of years.

Today, nuclear energy is the world's largest non-carbon emitting electricity production method. Argonne's goal is to advance the safe, sustained use of nuclear energy by incorporating scientific and engineering breakthroughs in design and operation of nuclear energy systems. Their research centers mainly on fast reactor (reactors that use higher energy neutrons compared to conventional reactors) and fuel cycle technologies, advanced modeling and simulation, and science and engineering of innovative nuclear energy systems. These strategies are being pursued to ensure that nuclear energy will be safer, more economical, and will produce less radioactive waste. Argonne works on their goals by collaborating with other laboratories and universities.

There is a need to solve many problems that are harming our earth. Argonne conducts research like this in the hope of coming up with solutions that benefit America and the entire planet.

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