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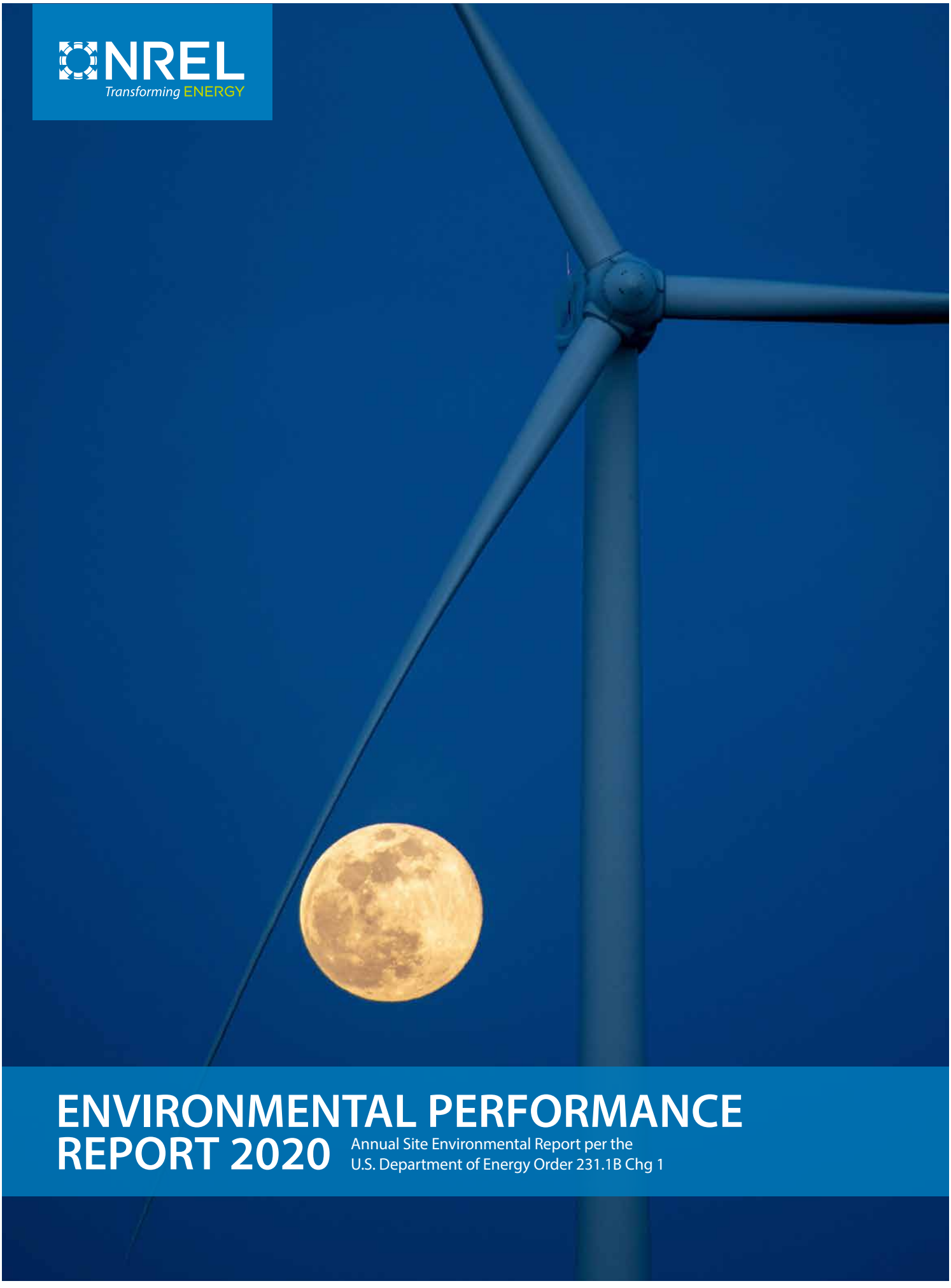

ENVIRONMENTAL PERFORMANCE REPORT 2020

Annual Site Environmental Report per the
U.S. Department of Energy Order 231.1B Chg 1

Cover Photo: A pink supermoon rises behind a wind turbine at the National Renewable Energy Laboratory's Flatirons Campus.
Photo by Werner Slocum, NREL 61701

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Photo by Werner Slocum, NREL 61046

NOMENCLATURE

APCD	Air Pollution Control Division
APEN	air pollutant emission notice
APHIS	Animal and Plant Health Inspection Service
AST	aboveground storage tank
CCR	Colorado Code of Regulations
CEQ	Council on Environmental Quality
CDPHE	Colorado Department of Public Health and Environment
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
CGI	controllable grid interface
cm	centimeter
CO_2e	carbon dioxide equivalent greenhouse gas emissions
CoMET	Composites Manufacturing Education and Technology
COVID	coronavirus disease
CY	calendar year
DERTF	Distributed Energy Resources Test Facility
DOE	U.S. Department of Energy
DOPS	Division of Oil and Public Safety
EMS	Environmental Management System
EO	executive order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPEAT	Electronic Product Environmental Assessment Tool
ESA	Endangered Species Act
ESH&Q	Environment, Safety, Healthy, and Quality Office
FTLB	Field Test Laboratory Building
FY	fiscal year
GHG	greenhouse gas
HAP	hazardous air pollutants
HFC	hydrofluorocarbon
HFO	hydrofluoroolefin
ISO	International Organization for Standardization
kg	kilograms
km	kilometers
L	liters
MBTA	Migratory Bird Treaty Act
mCi	millicurie
MCL	maximum contaminant level
m	meters
mg/L	milligrams per liter
mrem	millirem
MS4	Municipal Separate Storm Sewer System

MT	metric ton
NEPA	National Environmental Policy Act
NOx	nitrogen oxides
NREL	National Renewable Energy Laboratory
ODS	ozone-depleting substances
ORC	operator in responsible charge
OTF	Outdoor Test Facility
PFAS	per- and polyfluoroalkyl substances
PIT	passive integrated transponder
PUE	power usage effectiveness
RCRA	Resource Conservation and Recovery Act
ReFUEL	Renewable Fuels and Lubricants
SPCC	spill prevention control and countermeasures
SRRL	Solar Radiation Research Laboratory
STL	Structural Testing Laboratory
STM	South Table Mountain
TTF	Thermal Test Facility
TTHM	total trihalomethanes
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compounds
VTIF	Vehicle Testing and Integration Facility
yr	year

A female (queen) bobcat (*Lynx rufus*) and her kittens (kindle) are making themselves at home in the front entrance of the Research Support Facility. *Photo by Dennis Schroeder, NREL 62513*

EXECUTIVE SUMMARY

Purpose

The National Renewable Energy Laboratory's (NREL's) *Environmental Performance Report 2020* describes the laboratory's environmental management activities in 2020. It includes information on environmental and sustainability performance; environmental compliance activities and status; and environmental protection programs, highlights, and successes.

The purpose of the report is to ensure the U.S. Department of Energy (DOE) and the public receive timely, accurate information about events that have positively affected or could adversely affect the health and safety of the public or workers, the environment, or the operations of DOE facilities. The report meets the DOE requirements of the Annual Site Environmental Report and has been prepared in accordance with DOE Order 231.1B Chg 1, *Environment, Safety and Health Reporting*.

Environmental and Sustainability Performance

NREL is committed to environmental stewardship, pollution prevention, compliance with environmental requirements, and continual improvement in environmental protection and sustainability performance. The laboratory's Environmental Management System (EMS) implements a framework of policies, procedures, and programs that integrates environmental protection into daily work practices. The EMS is structured based on a plan-do-check-act continual improvement management model, and it is implemented as part of NREL's Integrated Safety Management System.

Each year, the laboratory sets measurable goals for environmental improvement through the EMS planning process. Goals are also established through the Performance Evaluation and Measurement Plan and the Site Sustainability Plan. Progress for all goals is tracked throughout the year using an online tracking system. A summary is prepared annually for the DOE Golden Field Office on Performance Evaluation and Measurement Plan results and for DOE Headquarters on Site Sustainability Plan results. The laboratory identified several

goals in 2020 to enhance sustainability and environmental performance and made—and continues to make—significant progress toward them.

Sustainability is integral to both NREL's research and operations, and the laboratory is committed to demonstrating federal leadership in sustainability. NREL operates as a living laboratory by implementing strategies and technologies in its facilities and then studying the adoption and effectiveness through participation by staff.

The following are some of the laboratory's key accomplishments in 2020:

- Connected onsite renewable energy assets at the Flatirons Campus to provide power when a campus substation malfunction resulted in a sustained total power outage: Solar arrays, battery energy storage devices, and wind turbines minimized the need for diesel generators and demonstrated the ability to use grid integration tools to power the campus allowing uninterrupted activities and operations.
- Monitored drinking water and developed and implemented new procedures to ensure water quality was within required parameters at the STM Campus. Building occupancy was low due to the COVID-19 pandemic, which affected water quality.
- Continued stabilizing the hillside adjacent to the FTLB. The building was first damaged by a water line break and further impaired by the erosive effects of the September 2013 flood event. Most of the project was completed in 2020, and it included installing retaining walls, installing a sidewalk, and stabilizing vegetation.
- As a result of the COVID-19 pandemic and consequent reduced onsite staffing, chemicals were placed in a secure and safe state and chemical containers were inspected to address long-term storage concerns.
- Formalized contingency plans for NREL's Chemical Response Team to allow for continual training and operational drills for unplanned release of hazardous material, while maintaining COVID-19 precautionary measures.
- Encouraged a bobcat (*Lynx rufus*) family to relocate. A family of bobcats moved into the Research Support Facility main entrance courtyard where a mother and three kittens took up residence under a foot bridge in September. The area was cordoned off to protect NREL staff and bobcats. Although COVID-19 restrictions limited the number of staff on the STM Campus, it was prudent to discourage the bobcats from using the courtyard. Using a combination of predator noises and scents, the bobcat family eventually moved and were seen in other parts of the campus through December.
- Conducted separate internal assessments for (1) alcohol permitting and reporting, (2) construction particulate emissions, (3) ASTs, and (4) weed management. Actions to address the nonconformities and opportunities for improvement have been completed or are in progress.
- Coordinated with the Jefferson County Sustainability Coordinator and Facilities Management Director to review and discuss bird-friendly solutions applied at the STM Campus. Jefferson County's intent is to apply techniques that have been successful at the STM Campus to county buildings where bird strikes have been a growing problem.
- Provided virtual nesting bird survey training to staff who frequently conduct flights of unmanned aircraft systems, commonly referred to as drones. Training focused on bird nesting awareness during field operations and how to properly "clear" an area before conducting work.

NREL's Continued International Organization for Standardization (ISO) 14001 Certification Demonstrates Commitment to Environmental Leadership

NREL's Environmental Management System has been ISO 14001-certified since 2011, and the laboratory maintained this certification in 2020. A team of external auditors conducted an independent assessment of the policies, procedures, tools, and roles and responsibilities used in environmental management at NREL. The assessment verified that the laboratory continues to meet the requirements of ISO 14001, which demonstrates the laboratory's commitment to environmental stewardship.

Prestigious Environmental Sustainability Awards and Recognition Received

NREL received the following important recognitions in 2020 for its environmental and sustainability accomplishments:

- Four-star Electronic Product Environmental Assessment Tool (EPEAT) purchases award from the Green Electronics Council for excellence in the procurement of sustainable electronics.
- DOE GreenBuy Superior Award for demonstrating leadership and continuous improvement in transitioning to more sustainable products.
- Colorado Environmental Leadership Program Gold-Level Leader status for exceeding regulatory requirements and for continued partnership with the Colorado Department of Public Health and Environment since 2004

- Submitted wetland delineations to the U.S. Army Corps of Engineers and received approved jurisdictional determinations for the Middle Drainage area within the STM Campus and for the Flatirons Campus. This information will be used to inform future planning efforts for the development of the STM and the Flatirons Campuses.
- Captured and tagged eight rattlesnakes with passive integrated transponders at South Table Mountain Park and inside the STM Campus boundary. This brings NREL's total number of PIT-tagged snakes to 20 over the course of 3 years.
- Added an additional 10 spill kits to various locations to allow for quicker response at those locations and to provide more spill resources that could be moved and deployed as needed.
- Developed and implemented a NEPA strategy and schedule to support campus growth initiatives.

Environmental Compliance and Monitoring

NREL is subject to many federal, state, and local environmental laws and regulations, in addition to executive orders, DOE requirements, and agreements with government agencies.

The laboratory continued its excellent record of environmental compliance in 2020. No violation notices were received from any regulatory agency and all required permits were received or renewed, required registrations were completed, and required notifications and reports were submitted.

Unlike many other DOE facilities, NREL does not conduct work involving nuclear materials and does not have legacy radiological or other contamination issues associated with past nuclear weapons production or research activities; therefore, continuous radiation or radiological contamination monitoring is not conducted.

NREL collaborates with many federal, state, and local governments. Here, Federal Energy Regulatory Commission staff walk alongside NREL employees under a wind turbine at the Flatirons Campus. *Photo by Werner Slocum, NREL 62649*

The laboratory continued to improve its environmental management and performance in 2020, as demonstrated by its record of excellent compliance with regulatory requirements and established leadership in environmental and sustainability management. Major environmental programs at NREL include:

- Air quality protection, including air permitting, ozone-depleting substance management, and greenhouse gas emissions monitoring
- Water quality protection, including construction stormwater management, drinking water monitoring, and prevention of unallowable sanitary sewer system discharges
- Hazardous materials and waste management, including pollution prevention; spill response; proper storage, use, and disposal of hazardous chemicals and materials; planning, permitting, and reporting the use and emissions of materials
- National Environmental Policy Act reviews
- Protection of natural and cultural resources, including wildlife, vegetation, protected species, wetlands, and cultural resources management.

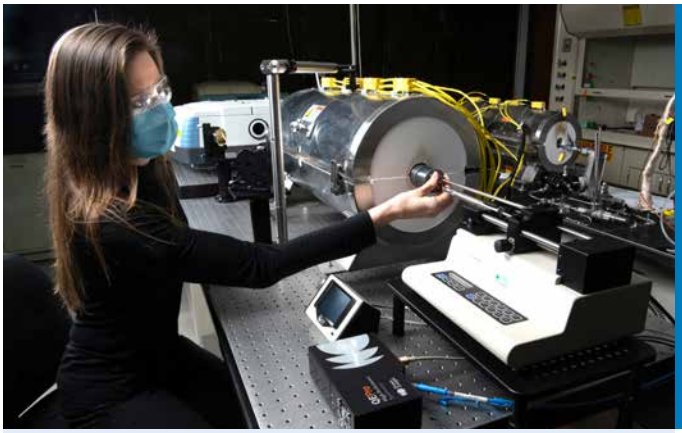
ABOUT NREL

NREL is the principal research laboratory for DOE's Office of Energy Efficiency and Renewable Energy. The laboratory also conducts research for the DOE Office of Science and the DOE Office of Electricity. The Alliance for Sustainable Energy, LLC, a partnership of MRIGlobal and the Battelle Memorial Institute, manages the laboratory for the DOE Office of Energy Efficiency and Renewable Energy.

NREL is the only DOE national laboratory solely dedicated to advancing renewable energy and energy efficiency technologies from concept to commercial application. The laboratory's innovations, analysis, and expertise have helped enable the emergence of a U.S. clean energy industry and have led to numerous success stories across the laboratory. NREL's two campuses—the 327-acre (132-hectare) South Table Mountain (STM) Campus in Golden, Colorado, and the 305-acre (124-hectare) Flatirons Campus in northern Jefferson County—are living models of sustainable energy integration.

NREL develops renewable energy and energy efficiency technologies and practices, advances related science and engineering, and transfers knowledge and innovation to address the nation's energy and environmental goals. The laboratory's research and development achievements have helped shape clean energy alternatives for powering our homes and businesses, and the nation's transportation infrastructure. NREL's science and technology teams span the full spectrum of innovation from fundamental science and market-relevant research to systems integration and testing and validation.

The rising sun begins to strike the Energy Systems Integration Facility on an autumn morning. *Photo by Werner Slocum, NREL 63010*



A researcher works on a reactor in Building 16. This optical access flow reactor informs kinetics models for characterization of sustainable fuels for transportation applications. *Photo by Dennis Schroeder, NREL 63388*

1 INTRODUCTION

This report summarizes the National Renewable Energy Laboratory's (NREL's) environmental management activities in 2020, including:

- Environmental protection programs
- Environmental and sustainability performance
- Environmental compliance activities and their status
- Environmental management highlights and successes.

The report incorporates the U.S. Department of Energy (DOE's) most recent guidelines for the Annual Site Environmental Report, as required by DOE Order 231.1B Chg. 1, *Environment Safety and Health Reporting*.

1.1 Our Mission

NREL's mission focuses on advancing the energy goals of DOE and our nation as captured in the laboratory's mission statement:

> NREL advances the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies and provides the knowledge to integrate and optimize energy systems.

NREL fulfills its mission through technology portfolios. A brief description of each major technology area follows.

- **Advanced Manufacturing:** Scientific and engineering research focuses on reducing energy requirements associated with the most energy-intensive manufacturing industries and accelerating those innovations to commercialization of next-generation technologies and processes.
- **Bioenergy:** Bioenergy investigations advance technologies to produce bio-based fuels, products, and energy. Research ranges from discovery science to pilot-scale processing related to biochemical conversion, thermochemical conversion, and life cycle analyses.

- **Buildings Research:** Buildings research is transforming energy through building science and integration. This research seeks to optimize energy use, generation, and storage in the built environment at multiple scales to enhance the resiliency, efficiency, and affordability of energy systems across the United States and the world.

A local building crew from the Yup'ik tribe in Atmautluak, Alaska, alongside an NREL architect from the Cold Climate Housing Research Center, carries a floor beam from the barge landing to the building site. Members of NREL's Cold Climate Housing Research Center worked together with the Yup'ik community to design a sustainable home in the traditional Yup'ik village. With no roads or heavy equipment in the village, all building materials are designed to be lightweight and simple to assemble. *Photo by Molly Rettig, NREL 64251*

- **Chemistry and Nanoscience:** NREL investigates materials and processes for converting renewable and clean energy resources into chemical and electrical energy. Resources, such as sunlight, heat, and renewable materials, are converted to fuels and other chemical and electrical energy-storage modes. Staff conduct research across the entire chemistry and nanoscience spectrum—from performing foundational science to working closely with industry to commercialize new technologies.
- **Computational Sciences:** Computational science staff work to solve energy challenges using high-performance computing; computational science; applied mathematics; and scientific data management, visualization; and informatics. NREL is also home to the world's largest high-performance and most energy-efficient data center dedicated to advancing renewable energy and energy efficiency technologies.
- **Energy Analysis:** NREL conducts energy analysis to inform policy and investment decisions that lead to more resilient, reliable, and efficient energy systems. With objective, technology-neutral analysis, the laboratory aims to increase understanding of energy policies, markets, resources, technologies, and infrastructure to address economic, security, and environmental priorities.
- **Grid Modernization:** Grid modernization work at NREL advances critical science and technology through innovative research and development to improve the nation's electric grid infrastructure, making it more flexible, reliable, resilient, secure, and sustainable.

NREL researcher in the Energy Systems Integration Facility works on a hybrid battery energy storage system. *Photo by Dennis Schroeder, NREL 62813*

- **Geothermal Energy:** NREL is developing new techniques to increase the production of geothermal energy; exploring the benefits of combining geothermal and other renewable energy systems; and collaborating with industry, government agencies, and other partnering entities to advance the use of geothermal energy worldwide.
- **Hydrogen and Fuel Cells:** Research focuses on developing, integrating, and demonstrating hydrogen production and delivery, hydrogen storage, and fuel cell technologies for transportation, stationary, and portable applications.
- **Integrated Energy Solutions:** Research supports the transition to renewable energy portfolios at the city, state, national, and international levels by performing technical and economic evaluations of renewable energy opportunities that address technology, policy, social, and market systems.
- **Materials Science:** Research applies fundamental and applied materials science discovery and problem-solving to current and next-generation renewable energy and energy-efficient technologies. Focus areas include materials physics, electronic structure theory, analytical microscopy and imaging science, interfacial and surface science, materials discovery, and thin-film material science and processing for photovoltaics and other energy applications.

- **Photovoltaics and Solar Power:** Photovoltaics work at NREL include both fundamental and applied research and development, such as theory and modeling, materials deposition, device design, measurements and characterization, and reliability testing and engineering. Solar energy research at NREL includes photovoltaics, concentrating solar power, solar grid and systems integration, and market research and analysis.

A researcher conducts optical imaging of solar cells in a photovoltaic laboratory in the Solar Energy Research Facility. *Photo by Dennis Schroeder, NREL 63413*

- **Transportation:** NREL researchers collaborate with industry experts to develop advanced vehicles and transportation systems. The laboratory also works with energy companies and manufacturers of vehicles and engines to develop advanced motor vehicle fuels for improved energy and environmental performance.
- **Water Power:** Water power research at NREL focuses on advancing the use of hydropower through data validation, development of innovative water power technologies, and the use of toolkits to assist water power sector businesses in navigating hydropower regulations.
- **Wind Energy:** From conceptualizing taller turbines capable of greater energy capture to assessing U.S. offshore wind energy needs and potential, the National Wind Technology Center at NREL drives wind industry acceleration. Facilities at the Flatirons Campus also enable testing of turbine-drivetrain components; designing, researching, and validating advanced wind power plant control systems; and manufacturing and testing turbine blades of various new composite materials.

1.2 Sites and Facilities

NREL's facilities occupy separate locations in Colorado, Washington, D.C., and Alaska. These include:

- South Table Mountain (STM) Campus, Golden, Colorado
- Flatirons Campus, Arvada, Colorado
- Building 16, Lakewood, Colorado
- Golden Warehouse, Golden, Colorado
- Renewable Fuels and Lubricants Research Laboratory (ReFUEL), Denver, Colorado
- Research and Testing Facility, Fairbanks, Alaska
- Washington, D.C., Office, Washington, D.C.

Climate of Colorado Facilities Locations

The climate of the geographic region of NREL's Colorado operations is classified as semiarid and is typified by limited precipitation, low relative humidity, abundant sunshine, and large daily and seasonal temperature variations.

The area experiences an average annual rainfall of less than 20 inches (50 centimeters [cm]). Almost half the annual precipitation occurs from March to June. Summer showers contribute 33% of the annual precipitation total. Precipitation begins to decrease significantly in the fall and reaches the minimum in winter. Winter is the driest season, contributing less than 10% of the annual precipitation, primarily in the form of snowfall.

Spring is a season of unstable air masses with strong winds along the foothills of the Front Range. The highest average monthly snowfall typically occurs in March, when at least one snowstorm of 6–10 inches (15–25 cm) often occurs.

The solar radiation (sunlight energy) of the region is excellent for conducting research outside and testing solar energy conversion devices and systems. Sunshine is abundant throughout the year and remarkably consistent from month to month and season to season.

Climate of Alaska Facility Location

The Research and Testing Facility is located in a subarctic climate that is characterized by typically long (5–7 months), cold winters and short (45–100 days at most), cool summers. The region is typified by limited precipitation (less than 15 in. [31 cm]) and temperatures can range throughout the year from minus 50–80 degrees Fahrenheit (10–27 degrees Celsius).

Climate of Washington, D.C., Facility Location

The Washington, D.C., Office is located in Washington, D.C., in a humid, subtropical zone. Winters are typically cool with light snow, and summers are hot and humid. Although hurricanes are unlikely, flooding of the Potomac River caused by high tide, storm surge, and runoff, has been known to cause considerable property damage. The city's climate continues to warm, and rainfall continues to increase.

South Table Mountain Campus

The STM Campus is the main research center for NREL—nearly 80% of the laboratory's staff has offices and laboratories there. The STM Campus is approximately two miles (3.2 kilometers [km]) east of Golden and 12 miles (19.3 km) west of downtown Denver.

Land Use

The STM Campus is a roughly triangular parcel of land occupying portions of the top and lower south-facing slopes of South Table Mountain, a mesa that stands 492 feet (150 meters [m]) above the adjacent lowlands. It is composed of sedimentary rocks below a basalt lava cap that is quite resistant to erosion.

The STM Campus is a 327-acre (132-hectare) area bordered predominantly by open grassland zoned for recreation and light commercial activity. Portions of the community of Pleasant View are located immediately to the south and west. Pleasant View has constructed a recreational park immediately south of the STM Campus; offices, shops, and a tree nursery owned by the Colorado State Forest Service are located at the western edge of the STM Campus. Undeveloped state land and a Colorado State Highway Patrol pursuit driver-training track are located along the northwestern boundary of the STM Campus on top of the mesa. Jefferson County Open Space wraps around the northern and eastern edges of the site. Portions of the Denver West Business Park and apartment homes lie to the east.

More than half of the STM Campus (177 acres [72 hectares]) is preserved in a conservation easement north of the STM Campus. No development is allowed on that land, except for some existing utility easements and recreational trails to be established by Jefferson County Open Space. For details, see Section 10, Conservation Lands.

Geology, Soils, and Hydrogeology

South Table Mountain was formed as weak sedimentary rocks surrounding lava were eroded away, leaving the lava-capped mesa in relief. The sedimentary rocks beneath the lava caprock are part of the Denver Formation, which consists of layers and lenses of claystone, sandstone, and conglomerate. Sedimentary rocks of the Arapahoe Formation underlie the Denver Formation.

The Arapahoe, Laramie-Fox Hills, and Denver Formations are considered to be aquifers in portions of the Denver Basin. The Denver Formation underlies the areas on which most NREL construction has taken place. Groundwater on the STM Campus is found primarily in the weathered and fractured silts and sands of the Denver Formation. Some groundwater, in the form of perched aquifers, may also be below the basaltic lava cap on South Table Mountain and within the materials above the Denver Formation, which are largely the result of stream deposits. Groundwater flow on the site is in a southeasterly direction.

The soil covering the top of South Table Mountain is Lavina loam. Loam is composed of a mixture of clay, sand, silt, and organic matter. The loam on the mesa top is a shallow, well-drained clayey soil. Soil on the upper side slopes of South Table Mountain is also loam and consists of extremely stony soils with significant amounts of clay. Much of the remainder of the site, including the area designated for major development, has a deep well-drained soil referred to as Denver clay loam that consists of clayey material containing some calcium carbonate. Also, two smaller soil areas on the southwestern portion of the site that consist of cobbly clay loam and very stony clay loam are similar character to other site soils.

NREL's South Table Mountain (STM) Campus. *Photo by Dennis Schroeder, NREL 30709*

Surface Water

About 90% of the surface drainage from the site, both from the mesa top and across the lower portions of the site, flows in a southeasterly direction toward Lena Gulch (a tributary of Clear Creek). Though there is no permanent stream flow on the STM Campus, occasional flow from extended periods of precipitation, usually in the late winter and early spring, is found in the drainage channels, with seasonal springs being evident along some of the mesa top slopes. The mesa top features one seep that is often active throughout much of the year, but the water that reaches the surface infiltrates and evaporates quickly in the dry season.

Vegetation

Two primary vegetation types are present on the STM Campus: grasslands and shrublands. The most common plant communities on the STM Campus are mixed grasslands; they comprise more than 80% of the vegetation on the site. These communities are generally dominated by short- and mid-grass species. Two primary upland shrub communities are found on the STM Campus: mountain mahogany shrublands are found on the shallow soils of the mesa, and upland shrublands appear in both drainages lacking active channels and drainages with associated wetlands. Field surveys have identified limited wetland and riparian areas along drainages. The wetland communities identified on the STM Campus are a minor component of the total vegetation cover, accounting for less than 1% of the vegetation. Riparian shrub communities are also found adjacent to the emergent wetlands. For details, see Appendix D, Plant Communities at the STM Campus and the Flatirons Campus.

Sunflowers (*Helianthus* spp.) grow outside the Science and Technology Facility. *Photo by Werner Slocum, NREL 63038*

Wildlife

Since 1987, several comprehensive wildlife surveys have been conducted on the STM Campus. Numerous mammals, and several types of amphibians and reptiles, have been identified in the surveys. More than 75 species of birds and several raptor species have also been recorded at or above the STM Campus through formal wildlife surveys or employee observations. For details, see Section 8.1, Wildlife Management, and Appendix C, Wildlife Species Observed at the STM and Flatirons Campuses.

Flatirons Campus

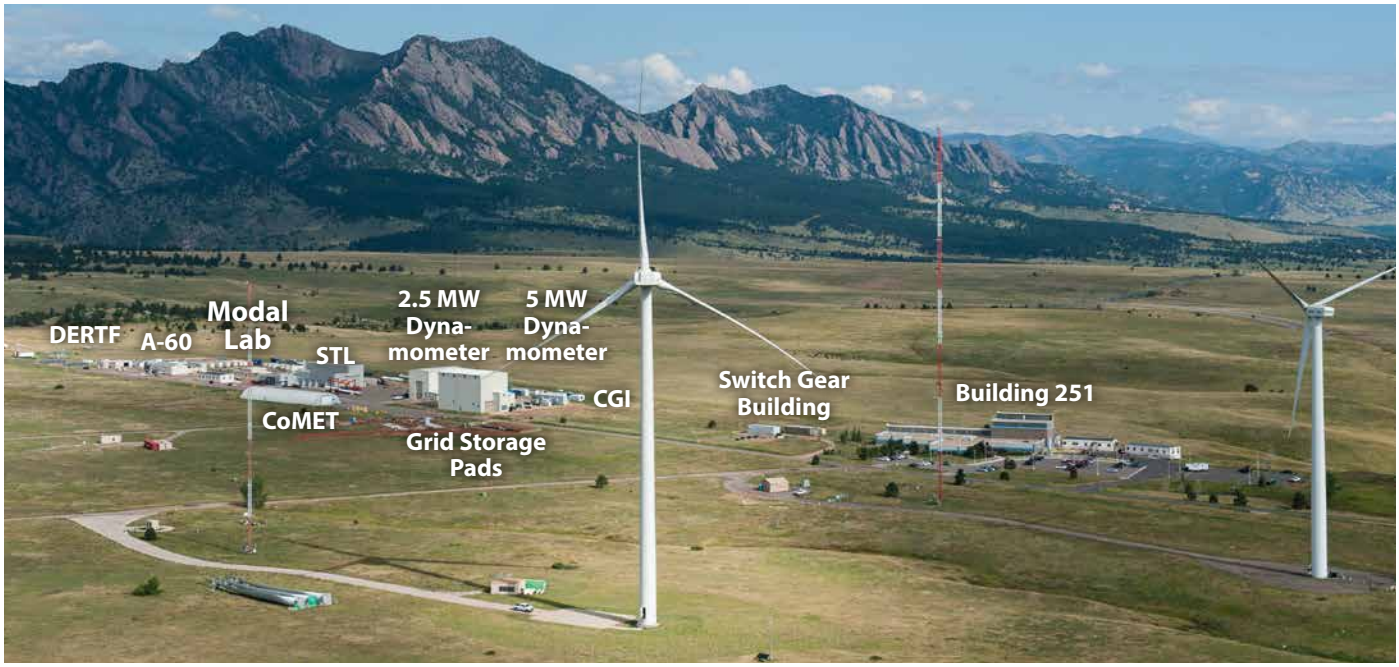
The Flatirons Campus is the main facility for NREL's wind turbine technology, water power, and grid integration research. Located at the Jefferson County-Boulder County border just east of the foothills of the Front Range, the Flatirons Campus has abundant wind resources that are critical for the variety of projects conducted at the site. The Flatirons Campus is located near the intersection of Colorado Highway 93 and Colorado Highway 128, between Boulder and Golden, and is approximately 15 miles (24.2 km) north of the STM Campus.

Land Use

The Flatirons Campus occupies 305-acres (124 hectares) that are surrounded by open space, grazing, and industrial land uses. The Rocky Flats National Wildlife Refuge borders the Flatirons Campus to the south and east. A restored sand and gravel mine is located due south (on the Refuge's property) of the campus, and an expanded shale and clay lightweight aggregate production operation is located along the southern portion of the western boundary of the Flatirons Campus. A propellant fracturing company also has a small installation along the northern portion of the western site boundary. The City of Boulder owns open space bordering the Flatirons Campus to the north; State Highway 128 lies north of that open space.

Geology, Soils, and Hydrogeology

The Flatirons Campus is located on a plain formed by stream deposits. The uppermost geological stratum beneath the site is known as the Rocky Flats Alluvium. It is composed of cobbles, coarse gravel, sand, and gravelly clay. Below the Rocky Flats Alluvium are the Laramie Formation, Fox Hills Sandstone, and Pierre Shale. These formations consist primarily of claystones with some siltstones. Unconfined groundwater flow occurs in



NREL's Flatirons Campus. *Photo by Dennis Schroeder, NREL 30766*

the Rocky Flats Alluvium toward the east/southeast, and small perched zones are common. Groundwater occurs as confined aquifers in the deeper bedrock formations.[1]

The Flatirons Campus has a strongly developed soil defined as a very cobbly, sandy loam. The soil is characterized by a large amount of cobble and gravel in the soil volume, and by subsoil dominated by clay.

Surface Water

The area surrounding the Flatirons Campus is drained by five streams: Rock Creek, North Walnut Creek, South Walnut Creek, Woman Creek, and Coal Creek. Rock Creek flows eastward and is located southeast of the Flatirons Campus. North Walnut Creek and South Walnut Creek flow eastward into the Great Western Reservoir. Woman Creek drains eastward into Standley Lake in Westminster. Coal Creek flows in a northeasterly direction across the City of Boulder Open Space north of the Flatirons Campus.

Most of the Flatirons Campus drains into a tributary to Rock Creek. Some of the northern portions of the site drain into Coal Creek or its tributaries.

Vegetation

The Flatirons Campus is in the transition area between the Great Plains and the Rocky Mountains.[2] This location results in a flora that contains elements of both mountain and prairie ecosystems, as well as associations that represent residual tallgrass prairie, short-grass plains, ponderosa pine woodland, and foothill ravine flora.[3]

Vegetation surveys conducted on the Flatirons Campus have identified more than 270 vascular plant species and defined five major habitat types, including xeric-mixed grasslands, pine woodlands, shrublands, wetlands, and disturbed areas.

Along a northwestern ridge of the Flatirons Campus is a ponderosa pine woodland area. Vegetation found in this area includes woody species with an understory of grasses, forbs, and shrubs. For details, see Appendix D, Plant Communities at the STM Campus and the Flatirons Campus.

Wildlife

Although the site of the Flatirons Campus was heavily grazed by cattle before 1975, surveys conducted since then have identified several species of mammals that use vegetation and habitat at the Flatirons Campus. Amphibians, reptiles, and numerous species of birds have been documented in surveys conducted since 1992. For details, see Appendix C, Wildlife Species Observed at the STM and Flatirons Campuses.

1. EG&G Rocky Flats, Inc. 1992. *Rocky Flats Plant Site Environmental Report: January through December 1992.* Golden, Colorado.
2. Plantae Consulting Services. 2000. *Vegetation Survey: NREL National Wind Technology Center. Unpublished.*
3. ERO Resources. 2018. *Wildlife and Vegetation Monitoring Report at the National Wind Technology Center. Golden, CO: National Renewable Energy Laboratory. NREL/SR-1900-70362.* https://doi.org/10.2172/1457673.

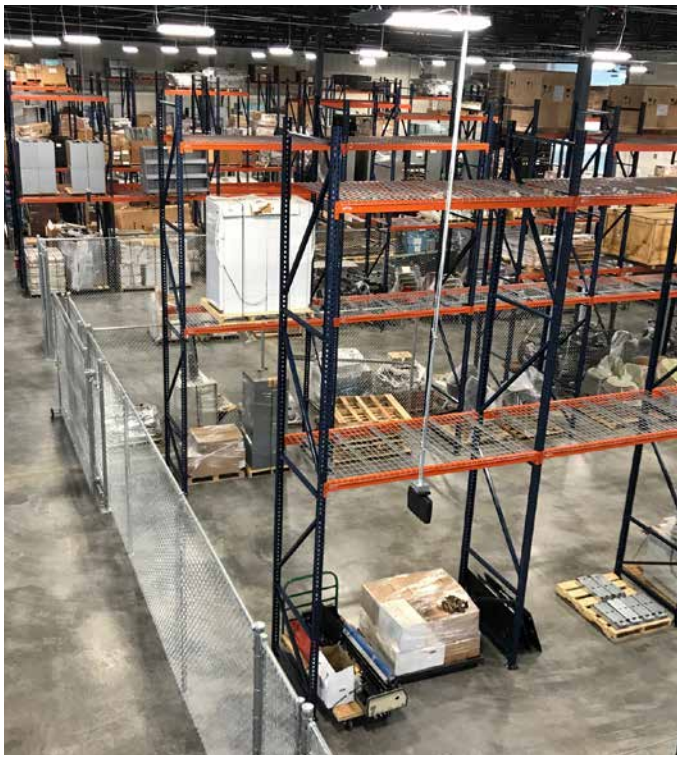
Building 16

Building 16 is a leased office building within the Denver West Business Park, which is located within the city of Lakewood, approximately two miles (3.2 km) east of Golden and 12 miles (19.3 km) west of downtown Denver. The Denver West Business Park is a fairly flat, landscaped office complex, consisting of several four-story office buildings, parking lots, and common areas. Building 16 is bordered on the south by commercial areas (on West Colfax strip), and on the west by the Pleasant View residential area, Camp George West facility, and the STM Campus. In addition to office spaces, activities at Building 16 include fuel and battery characterization research, thermal analyses of vehicle cooling loops, vehicle electrical systems analysis, and photoelectrochemical hydrogen production research.

Denver West Office Park, Building 16. *Photo by Dennis Schroeder, NREL 44872*

Golden Warehouse

The Golden Warehouse is located at 16201 Table Mountain Parkway in Golden, about 6.1 miles (9.8 km) north of the STM Campus. It is in a commercial area surrounded by residential neighborhoods and small businesses just east of North Table Mountain. It is primarily used as a secure warehouse space.



Overlooking the inside of the Golden Warehouse. *Photo by Scott Walters, NREL 61700*

Renewable Fuels and Lubricants Research Laboratory

NREL's Renewable Fuels and Lubricants Research (ReFUEL) Laboratory is used for research, testing, and support activities related to advanced fuels, engines, and vehicles to objectively evaluate performance, emissions, and energy efficiency impacts, including the evaluation and development of heavy-duty hybrid vehicles. The laboratory consists of a single-vehicle high bay and a small office area housed within the Regional Transportation District's District Shops and Operations Center at 1900 31st Street in Denver, approximately 12 miles (20 km) east of the STM Campus. The operations center facility occupies approximately 22 acres (9 hectares) and serves as the primary maintenance facility for the Regional Transportation System's bus and light-rail train systems. The area around the facility consists of commercial and light industrial development. The ReFUEL Laboratory lies on fairly flat terrain with a slight gradient to the northwest. The general area is highly developed with concentrated industrial and commercial activities. Very little natural vegetated habitat exists within the site or in the immediate vicinity. Trees and shrubs line the South Platte River adjacent to the site's southern, eastern, and northeastern boundaries.

A transit bus being tested at the Renewable Fuels and Lubricants Research (ReFUEL) Laboratory. *Photo by Dennis Schroeder, NREL 17948*

Research and Testing Facility

In 2020, NREL leased the Research and Testing Facility at the Cold Climate Housing Research Center in Fairbanks, Alaska. This LEED Platinum facility is dedicated to the development, use, and testing of energy-efficient, durable, healthy, and cost-effective building technologies for people living in circumpolar regions around the globe. This expanded access to the Arctic environment provides a new dimension to NREL's energy systems integration specifically as it is applied to extreme climates.

Washington, D.C., Office

Staff in the NREL's Washington, D.C., Office provides energy analysis and technical program support to DOE.

A snowy view of the Cold Climate Housing Research Center in Fairbanks, Alaska, during a late morning sunrise. *Photo courtesy of the Cold Climate Housing Research Center, NREL 63775*

Snow blankets the photovoltaic field at the South Table Mountain (STM) Campus. *Photo by Dennis Schroeder, NREL 63556*

2 ENVIRONMENTAL MANAGEMENT SYSTEM

NREL's Environmental Management System (EMS) supports the laboratory's commitment to continually improving environmental and sustainability performance by providing environmental stewardship and minimizing the environmental impacts of the laboratory's activities and operations. The EMS integrates environmental protection into daily activities throughout the laboratory, including:

- Protecting and enhancing of vegetation, wildlife, and natural resources
- Practicing pollution prevention
- Complying with environmental requirements
- Continually improving environmental protection and sustainability performance.

The laboratory strives to continually minimize waste and prevent pollution, and thus reduce its environmental footprint. Pollution prevention is implemented through the laboratory's EMS, the hazard identification and control process, and sustainability practices.

ISO 14001: 2015 Certification

NREL's EMS is certified to the International Organization for Standardization (ISO) 14001:2015 standard for environmental management systems. ISO 14001 is a globally recognized standard that defines the structure of an organization's EMS to improve its environmental performance. ISO 14001 requires an organization to identify potential environmental impacts and establish controls needed to minimize impacts, monitor and communicate environmental performance, and establish a formal process for continually improving the EMS.

2.1 Structure of NREL's Environmental Management System

NREL's EMS is structured based on a plan-do-check-act continual improvement framework described in this section and depicted in Figure 1.

Planning

- **Environmental Policy:** NREL states its commitments to the environment through this overarching policy. The policy commits specifically to environmental stewardship, pollution prevention, compliance with legal requirements and voluntary commitment, and continual improvement of environmental and sustainability performance.
- **Environmental Aspects of the Laboratory:** NREL's environmental aspects (see Figure 2) are those activities, products, or services that are identified annually and that have the potential to interact with the environment. The significance of an identified aspect is determined by assigning a frequency of occurrence and a severity. Using this method, NREL's Environment, Safety, Health, and Quality (ESH&Q) staff review potential impacts to the environment annually, and activities in the EMS are prioritized according to the aspects that are identified as significant. NREL also uses a robust hazard identification and control process as part of its Integrated Safety Management System to manage environmental risks.
- **Legal and Other Requirements:** NREL maintains a formal process to identify regulations and standards that are necessary and sufficient to address specific environmental hazards, including federal laws and regulations, state and local requirements, executive orders, and DOE orders.
- **Objectives and Targets:** Regular planning of activities and programs is needed to achieve NREL's environmental goals. The laboratory plans, implements, monitors, and reports on environmental stewardship goals and actions to generate continual improvement. For details, see Section 2.3, Performance Indicators and Progress.

Implementation

- **Structure and Responsibility:** NREL policies and procedures establish roles and responsibilities for environmental management within the organization.
- **Competence, Training, and Awareness:** NREL verifies that staff are competent based on education, training, or experience, and the laboratory implements a robust environment, health, and safety training program.
- **Communication:** NREL provides several avenues for communication between the laboratory and the community, including community meetings, lunch-and-learn events, publicly available websites and scientific publications, newsletters, and periodic community mailings. NREL tracks and responds to all environmental concerns through the NREL Communications Office. Internal communication regarding environmental issues is provided via intranet sites, newsletters, emails, meetings, posters, trainings, and personal interaction with ESH&Q staff.
- **Operational Control:** NREL plans and manages operations and activities in line with its environmental policy and objectives. Staff continually identify and review activities that could impact the environment, and engineering and administrative controls are put in place to minimize or avoid impacts to the environment.
- **Document and Records Control:** Policies and procedures ensure the current, correct versions of documents are available for use and that records are maintained to meet requirements.

Figure 1. NREL's continual improvement cycle

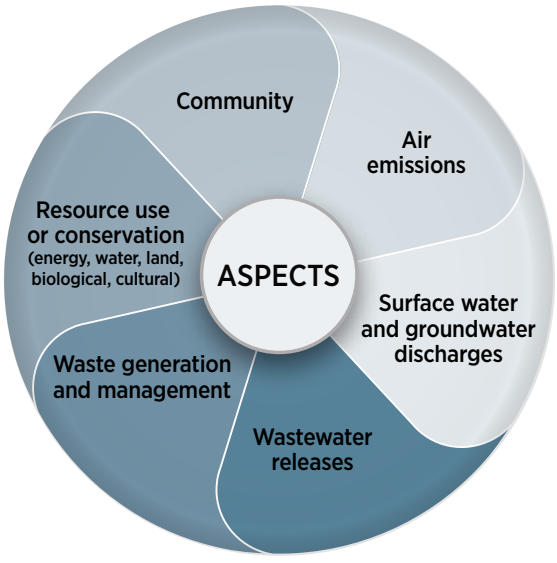


Figure 2. NREL's environmental aspects

Checks and Corrective Action

- **Monitoring, Measuring, and Evaluating Compliance:** NREL monitors key activities, tracks performance and progress toward environmental objectives, and conducts periodic assessments of compliance with legal requirements.
- **Internal Assessment:** NREL periodically conducts assessments to verify that its EMS is operating as intended. A formal system for tracking corrective and preventive actions supports continual improvement of the management system. For details, see Section 2.4.

Feedback

- **Management Review:** NREL's management reviews the EMS regularly to provide feedback and direction to continually improve the environmental performance of the organization.

2.2 Pollution Prevention

NREL has made a formal commitment to pollution prevention through its laboratory-wide environmental policy. The laboratory fulfills this commitment by implementing various controls to reduce the potential environmental impacts of laboratory operations, including NREL's use and storage of chemicals and fuels, as well as laboratory activities such as employee commuting and travel, and energy and water use. NREL's hazard identification and control process helps staff regularly identify opportunities to prevent pollution, and formal pollution prevention assessments are conducted periodically to identify opportunities to reduce pollution and improve program effectiveness. Though most of NREL's environmental management programs were established to meet compliance requirements, many of the programs go beyond compliance requirements and contribute to continual improvements of the laboratory's environmental performance.

Reducing Pollution

Examples of positive impacts of reducing pollution from NREL's activities include:

- Replacing toxic chemicals with safer alternatives where possible to reduce potential exposure to employees, the public, and local ecosystems
- Choosing bio-based and recycled-content products to reduce impacts on natural systems
- Encouraging employees to telecommute or take alternative transportation, and supporting web-based meetings to reduce traffic, air pollution, and health effects on surrounding communities
- Using sustainable, low-energy, and low-water use designs for buildings to reduce greenhouse gas emissions and use of Colorado's limited water supplies
- Performing waste audits in facilities to improve diversion of materials from the waste stream to recycling/reuse streams.

2.3 Performance Indicators and Progress

NREL's measurable goals for environmental improvement are identified in two documents:

- The Performance Evaluation and Measurement Plan establishes key priorities and provides specific objectives, expected outcomes, and measures of performance for managing and operating NREL. Each fiscal year, the laboratory and the DOE Golden Field Office collaborate to develop the performance objectives.
- The Site Sustainability Plan supports DOE's sustainability goals. The results of implementing the plan are presented in Section 3.1, Sustainability Goals.

Progress on each goal is tracked throughout the year and results are reported annually. Some examples of performance related to these goals are described in Table 1.

NREL reduces waste in several ways, including by offering alternate waste streams near most trash receptacles. Here, an employee discards an NREL biodegradable take-out container in a "Compost Only" receptacle. *Photo by Dennis Schroeder, NREL 27227*

Table 1. Environmental Goals and Achievements in 2020

Goal	Examples of Achievements	Status
Provide a comprehensive, effective, and responsive environmental management program	Demonstrated a shared commitment to efficiency, excellence, and compliance with requirements • Developed training for the ESH&Q field support staff to enhance knowledge skills and abilities to identify hazards in the workplace • Completed construction of a weir gate to help prevent onsite release of spilled chemicals offsite into surrounding neighborhoods • Inspected Flatirons Campus offsite transmission line right-of-way to verify land rehabilitation is underway and bird diverters were installed per specifications • Encouraged a family of bobcats to relocate from a heavily trafficked pedestrian area on the STM Campus by using a combination of predator noises and scents. The bobcat family moved and have been seen in other parts of the campus • Completed wetland delineations at the STM Campus and the Flatirons Campus to support proposed construction projects Shared successes, best management practices, expertise, and lessons learned to promote excellence and collaboration in environmental performance • Provided wind turbine bat acoustic data to U.S. Geological Survey researchers studying the effectiveness of infrared cameras and ultraviolet lighting at wind turbines to reduce bat collisions and fatalities • Coordinated with Jefferson County Open Space to review snow "push areas" on the STM Campus affecting nearby offsite trails in response to a community concern • Coordinated with Jefferson County Open Space to assess potential for a new trail installation on the mesa top; Jefferson County is exploring the idea of a loop trail that would link to trails farther north on the mesa • Coordinated with Jefferson County Sustainability Coordinator and Facilities Management Director to review and discuss bird-friendly solutions applied at the STM Campus; Jefferson County's intent is to apply techniques that have been successful at the STM Campus to county buildings where bird strikes have been a growing problem • Provided an overview of NREL's cultural resource program to the DOE Cultural Resource Management Coordinators group • Continued participation in the Battelle Environmental Community of Practice, a forum that provides a valuable opportunity to share issues, actions, and lessons learned with other national laboratory environmental staff • Continued participation in the rattlesnake tracking and relocation study by Adaptation Environmental • Consulted with an agronomist to review and modify native grasses revegetation requirements identified in construction specifications to improve restoration success in areas where construction activity has occurred • Coordinated with the U.S. Fish and Wildlife Service on reporting of Platte River depletions to understand constraints and requirements for additional water use associated with proposed construction projects	Goal met

2.4 Assessment and Improvement

Assessments support the continual improvement of environmental management. Periodic assessment of the EMS and its components provides assurance that the EMS continues to be an effective tool to achieve and maintain compliance with regulatory and legal requirements, meet the established environmental goals of the laboratory, and demonstrate to ourselves and others that NREL is "walking the talk."

Internal and external assessments are performed to evaluate the functionality of NREL's EMS:

- Internal assessments are performed regularly to evaluate consistency of the EMS with the ISO 14001 standard, legal, and other requirements.
- Periodically, external third-party assessments may be conducted by technical experts for specific components of environmental programs as part of continual improvement efforts. Annual surveillance assessments and triennial recertification assessments are conducted for the EMS as a whole to maintain ISO certification.

Improvements are developed and implemented as needed based on the results of each assessment performed.

The following assessment activities that took place in 2020 allowed NREL to enhance program effectiveness and make substantial environmental performance improvements:

- **Internal Assessments:** Separate internal assessments were completed for (1) alcohol permitting and reporting, (2) construction particulate emissions, (3) aboveground storage tanks (ASTs), and (4) weed management. No major issues were identified.
- **External Assessments:** NREL underwent a maintenance assessment to verify conformance to the ISO 14001:2015 standard. The virtual assessment was conducted by a team of external auditors and included several interviews with staff at all levels of the organization, observations of processes in place, and reviews of documents and records. No major issues were identified, and certification was maintained.

Benefits of the EMS to NREL

- **Reduced Risk to Facility and the Organizational Mission:** NREL's Hazard Identification and Control procedure incorporates an environmental risk assessment. System improvements also support the use of requirements to reduce the risk of noncompliance and potential enforcement actions.
- **Improved Fiscal Efficiency and Cost Avoidance:** Cost savings are realized through energy efficiency projects, new renewable energy installations, waste reduction and recycling, and reduced environmental incidents such as spills.
- **Greater Understanding and Recognition of Environmental Issues at all Levels of the Organization:** Staff are made aware of the potential environmental impacts of their work activities through the postings on the NREL intranet; new employee orientation and activity-specific trainings; published policies and procedures; management communications; sustainability communications; and special events such as Staff Awards (an annual employee recognition event), and Earth Week.[4] These actions help improve awareness of environmental issues and support environmental performance throughout the laboratory.
- **Empowerment of Individuals to Contribute to the Betterment of the Organization's Environmental Footprint:** Staff members are empowered to reduce the laboratory's environmental footprint by participating in programs and events for recycling single-stream materials, batteries, electronic equipment, and shredded paper, as well as a composting program.
- **Integration of Environment into the Organizational Culture and Operations:** NREL strives to maintain a high level of awareness in the laboratory about safety, health, and environmental responsibilities. This awareness is supported through regular communications from executive management, training, inspections, and risk assessments.
- **Integration of Environment into Real Property Asset Management:** NREL includes environmental considerations into long-term planning for the STM Campus and the Flatirons Campus. Long-term site plans consider wildlife movement across the site, surface water management, and climate change impacts.
- **Improved Community Relations:** The laboratory works to improve community relations by responding to and tracking all community input through phone calls, email, and community meetings, and by soliciting feedback from stakeholders through the National Environmental Policy Act (NEPA) review process. NREL takes proactive measures to engage the community with public tours, newsletters, and mailings to neighborhoods near its facilities.
- **Improved Effectiveness in Overall Mission:** NREL's EMS supports the organization's overall mission and improves effectiveness by systematically addressing environmental opportunities and risks, ensuring compliance with regulations, and implementing voluntary commitments to achieve superior performance.
- **Improved Collaborative Conversation with Other Groups:** The laboratory actively collaborates with stakeholders on environmental issues, such as sustainability, renewable energy, and resource conservation and management. This includes cooperating with other agencies in controlling noxious weeds and the management of conservation areas..

4. In lieu of NREL's traditional on-site Earth Day events, during the COVID-19 pandemic, Earth Week was implemented as a virtual event where employees were encouraged to virtually share stories, photographs, and videos highlighting what Earth sustainability means to them.

2.5 2020 Awards and Recognition

NREL received several awards and recognition of its environmental and sustainability achievements, including those described in this section.

Green Electronics Council Award

In 2020, NREL received the Five-Star EPEAT Purchaser Award from the Green Electronics Council for 2019 EPEAT purchases. NREL is committed to purchasing products designated by EPEAT, ENERGY STAR, and the Federal Energy Management Program, whenever feasible, to continue to positively impact the environment through such purchases.

DOE GreenBuy Superior Award

NREL and the DOE Golden Field Office again earned a GreenBuy Superior Award from DOE for demonstrating leadership and continual improvement in transitioning to more sustainable products. This award program recognizes DOE sites for excellence in "green purchasing" beyond minimum compliance requirements. All federal agencies, including DOE, are required to purchase products that are energy-efficient, water-efficient, made from bio-based or recycled content, and are nontoxic or less-toxic than conventional alternatives. The Superior Award recognizes sites that earn the GreenBuy Gold Award five times.

Colorado Environmental Leadership Program Gold-Level Leader Recognition

The Colorado Environmental Leadership Program[5] recognizes facilities that voluntarily:

- Exceed regulatory requirements
- Implement an environmental management system that focuses on incorporating environmental considerations into normal management processes and improving internal environmental management effectiveness
- Work closely with their communities
- Establish three-year goals focusing on measurable results.

NREL maintained its status as a Colorado Environmental Leadership Program Gold-Level Leader, the highest level awarded by the program. The Colorado Environmental Leadership Program is a voluntary partnership of CDPHE and participating private and public Colorado facilities. It is intended to recognize environmental leadership and performance.

In early 2004, NREL was accepted into the program as a Gold-Level Leader and has maintained this leadership level. As part of program membership, NREL's voluntary environmental performance goals, described above, further enhance operations, EMS performance, and pollution prevention at the laboratory.

Members of NREL and DOE are joined by a U.S. Senator to break ground for NREL's newest facility, the Research and Innovation Laboratory.
Photo by Dennis Schroeder, NREL 62407

5. Learn more about this voluntary program at the state's Environmental Leadership Program website ("Environmental Leadership Program," CDPHE, https://www.colorado.gov/pacific/cdphe/environmental-leadership-program).

2.6 Integrated Environmental Stewardship in Construction Management

NREL designs, builds, and refurbishes facilities using an integrated approach that allows the laboratory to achieve its mission needs while addressing environmental, safety, health, and community considerations.

Project Planning and Design

An interdisciplinary team that includes members of the laboratory's research, facilities, and operations staff, along with DOE Golden Field Office staff collaborate on projects beginning with conceptual planning and design selection and continuing through construction. Project staff facilitate the identification and inclusion of environmental requirements, sustainability requirements, and best management practices into project designs. In 2020, NREL took the following notable actions to address environmental concerns during the planning, design, and construction of projects:

- Reviewed hazardous air pollutant (HAP) emissions before the Solar Energy Research Facility ventilation replacement project to determine whether an air permit was required
- Supported the development of a process to complete "supplemental analysis" for the STM Campus and the Flatirons Campus site-wide environmental assessments
- Reviewed new projects for potential per- and polyfluoroalkyl substances (PFAS) contamination in drinking water at the STM and Flatiron Campuses
- Completed wetland delineations at the STM and Flatirons Campuses to support proposed construction projects.

Environmentally Responsible Construction Practices

During construction projects, DOE and NREL staff participate in weekly construction team meetings, monitor performance criteria, and provide ongoing feedback to project teams regarding environmental management. Environmentally responsible construction practices include reviewing preconstruction project plans, performing nesting bird surveys before commencing earth-disturbing activities, using a "plan of the day" to coordinate and control activities, implementing stormwater controls before starting excavations, tracking waste diversion, properly storing hazardous materials, and controlling dust. Minimizing impacts to wildlife is a consideration for all construction projects.

Benefits of the EMS to the Environment

- **Improved Overall Compliance Management:** NREL maintains a formal process to identify regulations and standards that are applicable to the laboratory, including federal laws and regulations, state and local requirements, executive orders, and DOE orders. In addition, compliance with these requirements is regularly reviewed through various mechanisms, including internal assessments, inspections, and monitoring.
- **Personnel Health and Safety:** Continually improving environment, safety, health, and quality management helps make NREL a safer, more environmentally responsible workplace and enhances the quality of our work processes.
- **Pollution Prevention:** Staff regularly identify opportunities to prevent pollution through NREL's hazard identification and control process. Resources are dedicated to sustainable operations and pollution prevention through the laboratory's sustainability efforts.
- **Improved Air and Water Quality:** EMS goals related to using alternative energy sources, using clean-burning fuels, and minimizing the quantity of chemicals used onsite all contribute to improved air quality. NREL continually strives to protect water quality both onsite and offsite by refining and implementing requirements related to the management of runoff, facility operations, and outdoor storage and use of materials throughout facility grounds, including at temporary construction sites.
- **Improved Hazardous Material, Hazardous Waste, and Solid Waste Management:** Hazardous material tracking through NREL's chemical inventory reduces the purchase of new supplies by allowing staff to determine whether a needed chemical is already onsite, which in turn minimizes the generation of hazardous waste. For several years, the laboratory has averaged a landfill diversion rate for solid waste of higher than a 75%, which greatly exceeds DOE goals for waste diversion.
- **Increased Conservation of Water, Natural Resources, Energy and Fuel:** Each year, the laboratory sets goals for water, energy, and fuel usage, and it monitors progress toward each throughout the year.
- **Reduced Number of Operating Permits Needed:** Implementation of the EMS provides a mechanism to identify, evaluate, and implement pollution prevention opportunities, including waste minimization, product substitution, and process modification. Such efforts can reduce the number of regulatory requirements that the laboratory must meet.

In 2020, NREL took the following notable actions to address environmentally responsible construction practices:

- Participated in the project team for the new Research and Innovation Laboratory facility on the STM Campus; helped develop and review design guidelines and construction procedures
- Inspected the Flatirons Campus transmission line to verify land rehabilitation was underway and bird diverters were installed per previous design alterations
- Consulted with an agronomist to review and modify native grasses revegetation requirements identified in construction specifications to improve restoration success in areas where construction activity has occurred

2020 Accomplishments and Highlights

- Maintained certification to the 2015 version of the ISO 14001 standard. An external third-party assessment verified that the laboratory meets the requirements of the standard and demonstrates our commitment to environmental stewardship.
- Conducted separate internal assessments for (1) alcohol permitting and reporting, (2) construction particulate emissions, (3) ASTs, and (4) weed management. Actions to address the nonconformities and opportunities for improvement have been completed or are in progress.

Common sunflowers (*Helianthus annuus*) grow outside the Solar Energy Research Facility at the STM Campus.
Photo by Werner Slocum, NREL 63040

3 SUSTAINABILITY

NREL pursues sustainability in all laboratory operations and strives to minimize the environmental impacts of doing business. As one of the nation's foremost scientific institutions, the laboratory embraces the best in energy and ecological conservation practices, setting the standard for the wise use of natural resources. As a leader in sustainability, NREL's goal is to minimize the use of energy, materials, and water while conducting clean energy research. In all site development, opportunities to integrate energy efficiency and renewable energy, high-performance buildings, and sustainable transportation options are sought. NREL's dedication to sustainability supports the laboratory's success by applying what is learned, through research and development, to campus facilities and infrastructure systems.

3.1 Sustainability Goals

In accordance with DOE Order 436.1, *Departmental Sustainability*, NREL develops a site sustainability plan every year to report on past performance and set goals for the coming year. These performance goals are integrated with the laboratory's EMS.

To meet DOE sustainability performance goals, sustainability considerations are incorporated into operations. The goals address:

- Energy, water, and waste management
- Building design, construction, and ongoing maintenance
- Environmental management planning
- Resilience planning
- Measurement and tracking of environmental objectives, targets, and actions
- Awareness and engagement of staff and community members.

NREL's progress in meeting the sustainability performance goals in 2020 is presented in Table 2.

Table 2. Sustainability Goals and Performance Summary

DOE Goal	Current Performance	Status
Multiple Categories		
Year-over-year[a] Scope 1 and Scope 2 greenhouse gas (GHG) emissions[b] reduction from a Fiscal Year (FY) 2008 baseline	In FY 2020, NREL reduced Scope 1 and 2 GHG emissions 43.8% from FY 2019. (Scope 1 reductions do not include emissions from fleet.)	Goal met
Year-over-year Scope 3 GHG emissions[c] reduction from a FY 2008 baseline	In FY 2020, NREL reduced Scope 3 emissions 21.1% from FY 2019.	Goal met
Energy Management		
30% energy use intensity (measured in British Thermal Units [BTUs] per gross square foot) reduction in goal-subject buildings by FY 2015 from a FY 2003 baseline and 1% year-over-year reduction thereafter	In FY 2020, energy use intensity decreased by 59% from a FY 2003 baseline, and it decreased by 11% from FY 2019.	Goal met
Continuous (four-year cycle)[d] energy and water evaluations per Energy Independence and Security Act, Section 432	Energy and water audits were conducted at the NREL Café, Research Support Facility, Solar Energy Research Facility, and South Site Entrance buildings on the STM Campus in FY 2020.	Goal met
Metering of all individual buildings for electricity, natural gas, steam, and water use, where cost-effective and appropriate	91% of relevant buildings have electricity meters, all of which are advanced meters.[e] 75% of relevant buildings have chilled water meters, all of which are advanced meters. 75% of relevant buildings have hot water meters, all of which are advanced meters. 94% of relevant buildings have natural gas meters. 94% of relevant buildings have potable water meters, and 28% of relevant buildings have advanced potable water meters.[f]	On track to meet goal
Water Management		
20% reduction of potable water intensity (measured in gallons per gross square foot) by FY 2015 from a FY 2007 baseline and a 0.5% year-over-year reduction thereafter	In the FY 2020, potable water intensity decreased by 17% from a FY 2007 baseline, and it decreased by 19% from FY 2019.	Goal not met
Year-over-year reduction in industrial, landscaping, and agricultural non-potable freshwater consumption in gallons; no set target	NREL does not use industrial, landscaping, or agricultural non-potable freshwater.	N/A

DOE Goal	Current Performance	Status
Waste Management		
Diversion of at least 50% of nonhazardous solid waste, excluding construction and demolition debris, to treatment and disposal facilities	In FY 2020, 45% of waste was diverted from municipal landfills.	Goal not met
Year-over-year reduction of construction and demolition materials and debris sent to treatment and disposal facilities; no set target	In FY 2020, 96% of construction and demolition waste was diverted from landfills. There was no change in the percentage of construction and demolition waste sent to landfill from FY 2019.	Goal not met
Fleet Management		
20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline and a 2.0% year-over-year-reduction thereafter	For the FY 2020 reporting year, DOE reported on these goals as a summary across all DOE facilities rather than on an individual site basis.	N/A
10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter	For the FY 2020 reporting year, DOE reported on these goals as a summary across all DOE facilities rather than on an individual site basis.	N/A
75% of light-duty vehicle acquisitions to consist of alternative fuel vehicles	For the FY 2020 reporting year, DOE reported on these goals as a summary across all DOE facilities rather than on an individual site basis.	N/A
Renewable Energy		
"Renewable electric energy" is required to account for not less than 7.5% of a total agency electric consumption by the end of FY 2013 and each year thereafter.	In FY 2020, approximately 17% of electricity used was renewable electric energy.	Goal met
Continue to increase nonelectric renewable energy with a year-over-year increase; no set target	In FY 2020, 32% of energy consumed was from nonelectric renewable energy usage.	Goal met
Sustainable Buildings		
At least 15% (by square footage) of owned existing buildings in compliance with the revised Guiding Principles for High-Performance and Sustainable Buildings by FY 2010, with annual progress thereafter	As of FY 2020, 57% gross square footage of buildings met High-Performance and Sustainable Buildings Guiding Principles.	Goal met
Acquisition and Procurement		
Promotion of sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred[9] and bio-based provisions and clauses are included in all applicable contracts	As of FY 2020, 100% of NREL's contracts contain sustainability provisions.	Goal met

DOE Goal	Current Performance	Status
Measures, Funding, and Training		
Set annual targets for sustainability investment with appropriated funds and/or financed contracts for implementation	The laboratory explored the use of economically feasible options to improve energy performance in FY 2020 by releasing a notice of opportunity for energy-savings performance contract awards at the STM and Flatirons Campuses. Refer to Section 3.2 Resilience Planning, for details.	Goal met
Electronic Stewardship		
100% of used electronics are reused or recycled to use environmentally sound disposition options each year	In FY 2020, 100% of electronics were reused or recycled.	Goal met
Establishment of a power usage effectiveness (PUE) target for new and existing data centers; NREL's target: average annual PUE of ≤1.20	The Research Support Facility data center had an average PUE of 1.20. The laboratory's High-Performance Computing Data Center in the Energy Systems Integration Facility had an average PUE of 1.03.	Goal met
Organizational Resilience		
Discussion of overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols	Refer to Section 3.2, Resilience Planning, for a discussion of NREL's accomplishments related to the integration resilience planning in facilities operations and planning.	Goal met

[a] Year-over-year calculation compares a statistic for one year to the same statistic for the previous year.

[b] Scope 1 emissions (direct GHG) are emissions from sources that are owned or controlled by an organization. Examples of such sources at NREL include fuel used for comfort heating equipment, fleet vehicle gasoline or other fuels, and some cryogenic materials used in laboratory experimental processes.

Scope 2 emissions (energy indirect GHG) are defined as emissions from the consumption of purchased electricity, steam or other sources of energy generated upstream from an organization. An example of such sources at NREL is grid electricity used to power buildings and laboratory experiments.

[c] Scope 3 emissions (other indirect GHG) are defined as emissions that are a consequence of the operations of an organization but are not directly owned or controlled by the organization. Examples of such sources at NREL include fuel use associated with employee commuting and business travel, and waste being sent to landfills.

[d] Energy Independence and Security Act Section 432 requires that, at a minimum, buildings representing at least 75% of a facility's total energy consumption undergo energy and water audits every four years. DOE sites are responsible for ensuring facilities are audited on a four-year cycle.

[e] An advanced meter, as defined by DOE, records energy or water consumption data hourly or more frequently and provides for daily or more frequent transmittal of measurements over a communication network to a central collection point.

[f] The BioPreferred Program is a U.S Department of Agriculture-led initiative that aims to assist in the development and expansion of markets for bio-based products.

3.2 Resilience Planning

NREL is proactively engaged in mitigation and adaptation strategies to manage the risks that extreme events pose to laboratory operations. Improving operational resilience ensures continuity for the laboratory to achieve its mission.

Solar photovoltaic arrays and wind turbines were among the research equipment used to return power to the Flatirons Campus in an extended power outage in the summer of 2020. *Photo by Joshua Bauer, NREL 61807*

2020 Accomplishments and Highlights

- Prepared a notice of opportunity for energy-savings performance contract awards at the STM and Flatirons Campuses. The first award to be issued will implement energy/cybersecurity and operational resilience measures to transform a security entrance building at the STM Campus into microgrid-interactive efficient building, to ensure continuity of operations in an emergency.
- Initiated conceptual design and scoping for a project to connect the Flatirons Campus to a nearby municipal water supply, reducing NREL's reliance on trucked-in water to meet onsite potable water and firewater needs. This vulnerability was identified as a resilience risk to NREL in its 2015 resilience assessment. The scoping process has included working with the water provider, Consolidated Mutual Water Company, to identify requirements for purchasing water shares and to develop rough costs associated with conceptual level water needs.
- Connected onsite renewable energy assets at the Flatirons Campus to provide power when a campus substation malfunction resulted in a sustained total power outage. Solar arrays, battery energy storage devices, and wind turbines minimized the need for diesel generators and demonstrated the ability to use grid integration tools to power the campus, allowing uninterrupted activities and operations.

A herd of mule deer (Odocoileus hemionus) bucks roam the STM Campus. *Photo by Werner Slocum, NREL 58278*

4 COMPLIANCE SUMMARY

NREL is subject to many federal and state laws and regulations, executive orders, and DOE orders and memoranda of understanding with government agencies. By observing these rules and regulations, NREL continues its excellent record of environmental compliance.

Table 3 includes a brief description of the statute or regulation and how compliance requirements were met this year. Detailed information for each area of compliance is found in the referenced sections of this report. For details, see Appendix B, Environmental Permits, Registrations, and Notifications.

Table 3. Compliance Status for Federal, State, and Local Environmental Laws and Regulations

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Environmental Performance Report		
DOE Order 231.1B, Chg 1, Environment, Safety and Health Reporting, was implemented to ensure DOE receives timely, accurate information about events that have affected or could adversely affect the health and safety of the public or workers, the environment, or the operations of DOE facilities. The order requires DOE facilities to report specific site environmental information annually, including environmental management performance, environmental occurrences and response, compliance with environmental standards and requirements, significant programs and efforts, and property clearance activities for property contaminated with radiological materials.	NREL reports annually via this Environmental Performance Report.	DOE Order 231.1B, Chg. 1: Environment, Safety and Health Reporting
EMS and Sustainability		
Executive Order 13834, Efficient Federal Operations, was established May 17, 2018 and references requirements established by the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007. It requires federal agencies to meet statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment. DOE has established goals that accomplish those objectives. DOE Order 436.1, Departmental Sustainability, requires the laboratory to implement an EMS that conforms to the ISO 14001 structure. The EMS is implemented as part of a DOE-required Integrated Safety Management System, which systematically integrates safety and environmental protection into management and work practices at all levels to protect the public, the worker, and the environment.	Each year, a site sustainability plan is developed to report on past performance and set goals for the coming year. These performance goals are integrated with the laboratory's EMS. NREL's EMS is certified to the ISO 14001:2015 standard for environmental management systems; it has been certified to ISO 14001 since 2011. Annual assessments verify that NREL meets the ISO standard and is continually improving performance.	Executive Order 13834: Efficient Federal Operations DOE Order 436.1: Departmental Sustainability
Resilience Planning		
DOE Order 436.1 requires facilities to annually develop a site sustainability plan that facilitates identifying and addressing opportunities for resiliency.	The laboratory investigated the establishment of a local microgrid at the STM Campus, which would allow research to continue in the event of a power outage on the larger electric grid. Initial steps toward pursuing a connection of the Flatirons Campus to a nearby municipal water supply began. This will provide reliable and consistent water availability to the campus for drinking water and fire protection purposes. The laboratory demonstrated its resilience capability at the Flatirons Campus when campus substation equipment malfunctioned resulting in a sustained total power outage. Renewable energy devices located on site for research purposes were brought on-line to power the site, demonstrating the ability of grid integration tools to provide reliable power for campus operations.	Executive Order 13834: Efficient Federal Operations DOE Order 436.1: Departmental Sustainability

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Air Quality		
The Air Pollution Control Division of CDPHE administers the federal Clean Air Act, which implements regulations for all point sources (facilities or other types of operations) in Colorado, under authority delegated by the U.S. Environmental Protection Agency (EPA). Categories of regulated air pollutants include criteria air pollutants, hazardous air pollutants (HAPs), ozone-depleting substances, and GHGs. For facilities and stationary sources that emit criteria air pollutants and hazardous air pollutants, there are both federal and state requirements for permitting, reporting, emission controls, emission limits, and operations, depending on the source, type, and amount of air pollutants emitted. Generally, these requirements become stricter as the quantity of air pollutants emitted increases or as the air pollutants have a higher potential for harm or adverse effect. GHGs emitted by certain facilities are required by EPA regulations to be tracked and reported if the emissions are greater than 27,557 U.S. tons (25,000 metric tons [MT]) of carbon dioxide-equivalent (CO_2e) per year. The purpose of this reporting is to better identify the actual emissions of such gases across the United States and provide the EPA with data on which to base future GHG regulations. Reporting and permitting of GHGs may be required under the EPA Prevention of Significant Deterioration regulation, Title V Tailoring Rule, and the EPA Greenhouse Gas Mandatory Reporting Rule, depending on the amount of GHGs emitted. Permits for major emissions sources (greater than 100 U.S. tons [90.7 MT] per year of a criteria pollutant) may be required to include GHGs in the permit if CO_2e emissions are greater than 100,000 U.S. tons (90,718 MT) per year. EPA's Protection of Stratospheric Ozone (40 Code of Federal Regulations [CFR 82]) includes repair, servicing records and other requirements for appliances containing more than 50 pounds (lb), or (23 kilograms [kg]), of all regulated refrigerants, including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and hydrofluoroolefins (HFOs). Appliances containing 5 or more pounds (2.3 kg) of these refrigerants are subject to end-of-life refrigerant recovery, recycling, and documentation requirements. There are several state air regulations for sources of particulate pollution. These regulations include large construction sites and street sanding operations in the winter. Particulate emissions, such as dust from construction sites larger than 25 acres (10.1 hectares), or occurring for more than six months, are subject to state fugitive particulate emissions permits. State regulations require federal, state, and local government facilities to track street sanding in the winter and to minimize sand use.	Program activities were in compliance with requirements. NREL did not exceed any air permit standard or other air regulatory requirement at any facility. In 2019, EPA redesignated the Denver metropolitan area's ozone nonattainment status from "moderate" to "serious," which resulted in a lowering of the major source permitting threshold for nitrogen oxides (NOx) and volatile organic compounds (VOC) from 100 U.S. tons (90.7 MT) per year to 50 U.S. tons (45.4 MT) per year. The STM Campus is on track to limit NOx emissions and be classified as a "synthetic minor" source of NOx emissions. HAPs emissions for each individual facility were well below the reporting and permitting thresholds of 10 U.S. tons (9.1 MT) per year for each individual HAP and 25 U.S. tons (22.7 MT) per year for all HAPs combined. NREL completed an annual evaluation of compliance with federal and state facility-wide permitting and emission-control requirements. All facilities and individually permitted equipment items remain classified as minor sources and actions were taken to avoid Title V permitting. The laboratory provided an annual street sanding report to the State of Colorado and Jefferson County as required. The report confirmed that no sand was used at the STM Campus or the Flatirons Campus. Laboratory CO_2e and GHG emissions were below the federal reporting and permitting threshold of 27,500 U.S. tons (25,000 MT). All equipment registrations, including annual registration renewals, for state-required ozone-depleting substances were completed for the STM Campus and the Flatirons Campus. Refrigerant recovery equipment is no longer required to be registered with the EPA. Air permits were renewed for the FTLB Standby Generator, FTLB Thermal Oxidizer, Research Support Facility 1 Standby Generator, and Flatirons Campus Site 4.0 Standby Generator.	EPA 40 Code of Federal Regulations (CFR) Part 40: Mandatory Greenhouse Gas Reporting EPA 40 CFR Part 50: National Primary and Secondary Ambient Air Quality Standards EPA 40 CFR Part 51: Requirements for Preparation, Adoption, and Submittal of Implementation Plans EPA 40 CFR Part 52: Approval and Promulgation of Implementation Plans EPA 40 CFR Part 60: Standards of Performance for New Stationary Sources EPA 40 CFR Part 63: National Emission Standards for Hazardous Air Pollutants for Source Categories EPA 40 CFR Part 70: State Operating Permit Programs EPA 40 CFR Part 71: Federal Operating Permit Programs EPA 40 CFR Part 82: Protection of Stratospheric Ozone EPA 40 CFR Part 98: Mandatory Greenhouse Gas Reporting CDPHE 5 Colorado Code of Regulations (CCR) 1001-3: Stationary Source Permitting and Air Pollutant Emission Notice Requirement CDPHE 5 CCR 1001-15: Control of Emissions of Ozone Depleting Compounds CDPHE 5 CCR 1001-16: Street Sanding Emissions

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Drinking Water Quality		
The federal Safe Drinking Water Act establishes minimum drinking water standards and monitoring requirements for drinking water supplies. Under this act, the EPA has established allowable levels for contaminants in drinking water that are known as maximum contaminant levels. The Water Quality Control Division of CDPHE implements the federal Safe Drinking Water Act in Colorado under authority delegated by the EPA.	Program activities were in compliance with requirements. All monitored parameters met applicable requirements. Annual state-required sampling of lead and copper levels in drinking water was performed. All lead sample results were below the maximum allowable concentration in drinking water of 0.015 milligrams per liter (mg/L) and were below the limit at which the chemical analysis method can detect lead of 0.001 mg/L. Copper levels ranged from 0.137 mg/L to 1.104 mg/L, which is far below the maximum allowable concentration in drinking water of 1.3 mg/L. These results were reported to the Water Quality Control Division of CDPHE, as required. A total of 375,046 gallons (1,419,704 L) of drinking water were provided to the Flatirons Campus.	EPA 40 CFR Part 141: National Primary Drinking Water Regulations EPA 40 CFR Part 142: National Primary Drinking Water Regulations Implementation EPA 40 CFR Part 143: National Secondary Drinking Water Regulations EPA 40 CFR Part 144: Underground Injection Control Program EPA 40 CFR Part 145: State Underground Injection Control Program Requirements EPA 40 CFR Part 146: Underground Injection Control Program, Criteria and Standards EPA 40 CFR Part 147: State, Tribal, and EPA-Administered Underground Injection Control Programs EPA 40 CFR Part 148: Hazardous Waste Injection Restrictions EPA 40 CFR Part 149: Sole Source Aquifers CDPHE 5 CCR 1002-11: Colorado Primary Drinking Water Regulations

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Groundwater Quality		
Colorado groundwater quality standards are established by CDPHE. Permits for groundwater wells are issued by the Colorado Department of Natural Resources. Permits are required for drinking water, water use by irrigation, livestock watering, dewatering, monitoring wells, and geothermal technologies, including well installations.	Program activities were in compliance with requirements. There were no spills or releases that impacted groundwater. Three groundwater monitoring wells at the STM Campus were closed in accordance with state requirements.	CDPHE 2 CCR 402-2: Rules and Regulations for Water Well Construction, Pump Installation, Cistern Installation, and Monitoring and Observation Hole/Well Construction CDPHE 2 CCR 402-10: Rules and regulations for Permitting the Development and the Appropriation of Geothermal Sources Through the Use of Wells CDPHE 5 CCR 1002-41: The Basic Standards for Ground Water
Surface Water Quality		
Surface water quality is controlled through the federal Clean Water Act, the Energy Independence and Security Act of 2007, and the Colorado Water Quality Control Act. Stormwater discharges resulting from construction activities at federal facilities that disturb one or more acres (0.4 hectares) of land are administered in Colorado by the EPA. To obtain coverage under an EPA "construction general permit" for stormwater discharges, a site-specific stormwater pollution prevention plan must be prepared and a notice of intent must be filed with the EPA. The Water Quality Control Division within CDPHE regulates stormwater discharges at nonfederal facilities within Colorado. For NREL construction projects that occur off federal property, a Colorado Discharge Permit System stormwater permit might be required. Owners and operators of regulated municipal separate storm sewer systems (MS4s) are required to develop a management program to minimize the discharge of pollutants into local bodies of water. The Energy Independence and Security Act requires federal agencies to reduce stormwater runoff from federal development projects to the maximum extent technically feasible. Stormwater runoff levels should reflect predevelopment hydrology, specifically with regard to runoff rate, volume, duration, and water temperature. Compliance can be achieved by using low-impact design elements such as porous pavers, cisterns, and bioswales, or by retaining stormwater runoff and releasing it at predevelopment rates.	Program activities were in compliance with requirements. Periodic stormwater inspections were performed at locations where earth-disturbing activities occurred. The inspections and all required maintenance of structural stormwater erosion and sediment controls were completed on construction sites operating under an EPA construction general permit, as well as smaller areas where permit coverage is not required but where stormwater best management practices are followed. Development continued on several MS4 permit program areas intended to reduce the discharge of pollutants in stormwater runoff from the STM Campus. Accomplishments include improvements to key forms and checklists, including monitoring and assessing stormwater outfalls; managing stormwater and environmental issues at construction sites; and evaluating new construction design documents for consistency with NREL environmental requirements. NREL completed mapping of STM Campus storm drain inlets and subsequently applied "no dumping" stencils to a subset of those inlets. Coverage under the EPA "construction general permit" for a landscaping improvement project at the Solar Energy Research Facility and the Science and Technology Facility (both on the STM Campus) was extended and remains active through December 31, 2022. Coverage under the EPA "construction general permit" for the Flatirons Campus' site improvements, power generation upgrade, and secondary feeder project was terminated on September 2, 2020.	EPA 40 CFR 122.26 Storm Water Discharges EPA 40 CFR 122.34: Permit Requirements for Regulated Small MS4 Permits CDPHE 5 CCR 1002-38: Classifications and Numeric Standards South Platte River Basin Laramie River Basin Republication River Basin Smoky Hill River Basin CDPHE 5 CCR 1002-61: Colorado Discharge System Permit Requirements CDPHE 5 CCR 1002-65: Regulation Controlling Discharges to Storm Sewers CDPHE 5 CCR 1002-93: Colorado's Section 303(D) List of Impaired Waters and Monitoring and Evaluation List Executive Order 13834: Efficient Federal Operations

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Wastewater Quality		
Wastewater is regulated at the federal level under the Clean Water Act and at the state level under the Colorado Water Quality Control Act by the Water Quality Control Division of CDPHE. The Metro Wastewater Reclamation District (Metro District) manages wastewater at its treatment plant per federal and state requirements. Domestic and nondomestic wastewater flows are delivered to the Metro District's plant via conveyance systems owned, operated, and regulated by numerous sanitation districts. Nondomestic wastewater discharges to the Metro District must comply with the Metro District's rules and regulations, which incorporate requirements of the Clean Water Act. Onsite septic systems are regulated by the CDPHE Water Quality Control Division. Inspection and permitting of individual sewage disposal systems have been delegated to Jefferson County by CDPHE.	Program activities were in compliance with requirements. Installation of a new onsite wastewater treatment system for the Flatirons Campus was completed. The new system provides additional capacity for both current and anticipated future campus growth.	EPA 40 CFR 122: EPA Administered Permit Programs, The National Pollutant Discharge Elimination System EPA 40 CFR 123: State Program Requirements EPA 40 CFR 125: Criteria and Standards for the National Pollutant Discharge Elimination System EPA 40 CFR 127: National Pollutant Discharge Elimination System Reporting EPA 40 CFR 129: Toxic Pollutant Effluent Standards EPA 40 CFR 130: Water Quality Planning and Management EPA 40 CFR 131: Water Quality Standards EPA 40 CFR 133: Secondary Treatment Regulation EPA 40 CFR 136: Guidelines Establishing Test Procedures for the Analysis of Pollutants CDPHE 5 CCR 1002-62: Regulations for Effluent Limitations CDPHE 5 CCR 1002-63: Pretreatment Regulations

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Hazardous Materials Management		
Hazardous material management is regulated at the federal level through Superfund Amendments and Reauthorization Act Title III, which is also known as the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986. EPCRA was created to help communities and federal, state, and local governments plan for emergencies involving hazardous substances. It also requires industry to report on the storage, use, and accidental release of hazardous chemicals to federal, state, and local governments. NREL facilities are subject to Sections 302, 304, 311, 312, and 313 of EPCRA. EPCRA Section 302 requires a facility to notify state and local emergency response and planning agencies if any extremely hazardous substances in the facility's inventory are stored in quantities greater than regulatory thresholds. EPCRA Section 304 requires facilities to immediately notify state and local emergency response and planning agencies if there is an accidental spill or release of more than the predetermined reportable quantity. In accordance with Sections 311 and 312 of EPCRA, NREL provides safety data sheets for chemicals stored onsite in quantities greater than regulatory thresholds. In addition, NREL provides inventory reporting for these chemicals in an annual hazardous materials report, called a Tier II report, to state and local emergency response agencies and local fire departments. EPCRA Section 313 requires that a toxic chemical release inventory report be filed with the EPA in the event of a release for any chemical that is manufactured, processed, or otherwise used in quantities exceeding regulatory thresholds. Annual hazardous materials permits are required by West Metro Fire Rescue for the STM Campus and Building 16 at the Denver West Business Park. Permits are issued for seven buildings where hazardous materials are stored or used. Before issuing the permits, a representative of West Metro Fire Rescue conducts a walk-through inspection of the entire STM Campus and Building 16. The ReFUEL Laboratory, which is located within the City and County of Denver, is subject to the Denver Fire Department's Hazardous Materials Information System requirements, including permitting, inventory, and annual inspection. This facility's inventory of listed materials, including various fuels such as biodiesel, must be reported to the Denver Fire Department annually. Hazardous materials permits are currently not required at the Flatirons Campus, the Golden Warehouse, Washington D.C. Office, or the Research and Testing Facility in Fairbanks, Alaska. Executive Order 13834 states the acquisition and use of products and services are to be in accordance with statutory mandates and applicable federal procurement policies.	Program activities were in compliance with requirements. Section 302 notification was not required. There were no releases of hazardous materials that required reporting under Section 304. In accordance with DOE requirements, NREL screened selected chemicals to confirm that quantities fell below those requiring elevated operational protocols. EPCRA Tier II hazardous materials reports under Section 312 were submitted for two facilities. The reports help state and local emergency response and planning agencies, and local fire departments, plan for chemical emergencies. Chemicals reported include diesel fuel, petroleum oil, sulfuric acid, and lead contained in sealed lead-acid batteries. A Section 313 Toxic Release Inventory report was not required. Hazardous materials permits were acquired for facilities as appropriate. No reportable hazardous material spills occurred.	EPA 40 CFR 355: Emergency Planning and Notification EPA 40 CFR 370: Hazardous Chemical Reporting, Community Right-To-Know EPA 40 CFR 372: Toxic Chemical Release Reporting, Community Right-To-Know Executive Order 13834: Efficient Federal Operations DOE Order 151.1D: Comprehensive Emergency Management System

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Hazardous Waste Management		
The Resource Conservation and Recovery Act (RCRA) established requirements for the management of regulated waste, including hazardous waste. In Colorado, the Hazardous Materials and Waste Management Division of CDPHE administers requirements under authority delegated by the EPA. In Alaska, the EPA administers the RCRA requirements with the Alaska Department of Environmental Conservation, which manages certain aspects of waste generated by a "very small quantity generator." Additional requirements for hazardous material transportation are regulated by the U.S. Department of Transportation. NREL maintains unique EPA identification numbers for four of its seven facilities: the STM Campus, Building 16, the Flatirons Campus, and the ReFUEL Laboratory. Per state and federal regulations, annual generator notifications are made and applicable fees are paid to the state based on monthly volumes of hazardous waste generated at each facility. EPA has three hazardous waste generator classifications: • Large quantity generator • Small quantity generator • Very small quantity generator. Executive Order 13834 states that facilities shall implement waste prevention and recycling measures and shall comply with federal requirements.	Program activities were in compliance with requirements. Hazardous and universal waste disposal and mandatory employee training was completed in compliance with state and federal regulations. All regulatory notifications were completed and applicable waste generator fees were paid for: • STM Campus: small quantity generator, episodically large quantity generator. • Flatirons Campus: very small quantity generator • Building 16: very small quantity generator • ReFUEL Laboratory: very small quantity generator • Golden Warehouse: very small quantity generator • Research and Testing Facility: very small quantity generator • Washington D.C. Office: no waste generated The leased Joyce Street Facility was vacated in 2018, and the EPA identification number is pending termination. A 20 g (0.04 lb) container of a peroxide forming chemical was found to have crystal formation, indicating it was potentially unstable. An emergency treatment permit was obtained from CDPHE and the chemical was treated to render it inactive.	EPA 40 CFR 260-273: Hazardous Waste EPA 40 CFR 279: Standards for the Management of Used Oil Executive Order 13834: Efficient Federal Operations Alaska Department of Environmental Conservation 18 AAC 60.020: Hazardous Waste
Aboveground Storage Tank Management		
ASTs are regulated in Colorado by the Colorado Department of Labor and Employment's Division of Oil and Public Safety (DOPS) under the Colorado AST regulation. Regulations require that ASTs be constructed and installed according to specific standards, that they be regularly inspected with all inspections being documented, and that facilities meeting certain oil storage quantities employ a spill prevention, control, and countermeasures (SPCC) plan to manage oil sources of 55 gallons (208 L) or more.	Program activities were in compliance with requirements. All tanks were inspected to confirm continued adherence to State of Colorado regulations. Annual AST training was provided to staff members responsible for operating and fueling ASTs or performing oversight for tank safety and environmental compliance.	Colorado Department of Labor and Employment 7 CCR 1101-14: Storage Tank Regulations National Fire Protection Association 704: Standard System for the Identification of the Hazards of Materials for Emergency Response

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Spill Prevention and Response		
Oil spill prevention and response is managed at the federal level under the Oil Pollution Prevention Act and the Clean Water Act, and at the state level under the Colorado Storage Tank Regulations as implemented by DOPS. SPCC plans are required by EPA and Colorado regulations for facilities that meet certain oil storage criteria. In general, facilities that store more than 1,320 gallons (5,000 L) of oil and have the potential for a spill to enter waters of the United States or Colorado waters must have an SPCC plan. SPCC regulations require that any equipment or containers with the capacity to store 55 gallons (208 L) or more of oil be included in the plan. The purpose of the SPCC plan is to prevent the discharge of oil and hazardous substances, provide site-specific petroleum storage information, list spill response resources, and minimize the impact of spills to adjacent waterways should a spill occur.	Program activities were in compliance with requirements. No reportable spills occurred. Twelve spills occurred at the STM Campus, and two spills occurred at the Flatirons Campus. The size of spills ranged from less than 0.25 gallons (0.95 L) to 15 gallons (56.8 L), with a total approximate quantity spilled of 38.6 gallons (146 L). Of the 14 spills, four were from vehicles, nine were from service and construction equipment, and one was due to failure of a high voltage transformer. Each spill received immediate remedial action, and there was no significant impact to the environment. SPCC training is required annually of all staff who manage fuel storage tanks; tracking of that training is now maintained electronically. The training was revised to include an updated spill history and associated response activities and emphasized spill prevention and immediate response requirements.	EPA 40 CFR Part 112: Oil Pollution Prevention EPA Clean Water Act, Section 319: Nonpoint Source Management Program Colorado Department of Labor and Employment 7 CCR 1101-14: Storage Tank Regulations Colorado Water Quality Control Commission Colorado Revised Statutes 25-8-205: Control Regulations
Radiological Materials and Waste Management		
Air emissions are regulated by Section 112 of the Clean Air Act and implemented by the EPA. 40 CFR Part 61 established the National Emissions Standards for Hazardous Air Pollutants and its Subpart H specifically sets standards for radiological materials. DOE Order 458.1, Radiation Protection of the Public and the Environment, establishes radiation emission limits for DOE facilities. These facilities, including NREL, must annually demonstrate compliance with EPA radiological air standards that limit emissions to amounts that would prevent any member of the public from receiving an effective dose equivalent of 10 millirem (mrem) per year or more. DOE Order 458.1 establishes requirements that must be followed when the release of any radiologically contaminated equipment or real property to another DOE national laboratory, collaborating agency, or outside entity is proposed. These requirements detail the measurable radiological levels that must be verified and documented to comply with DOE authorized limits. DOE Order 435.1, Radioactive Waste Management, establishes requirements to ensure radioactive waste is managed in a manner that protects the health and safety of workers and the public, and the environment. This is accomplished by evaluating and planning for proposed activities that would generate radioactive waste and documenting all requirements before those activities are authorized to commence.	Program activities were in compliance with requirements. Only small quantities (less than 2 cubic yards [1.5 cubic meter]) of low-level radioactive waste are in storage awaiting offsite disposal. In 2018, two chemical fume hoods and laboratory cabinetry were removed during decommissioning of the laboratory's only low-level radioactive work area. Radiological sampling indicated the items were within limits for release and would not pose a hazard to workers, the public, or the environment. The items are being prepared for offsite disposal in accordance with DOE requirements. In accordance with a federal regulation and DOE order, NREL submitted its annual Radionuclide Air Emissions Annual Report to the EPA confirming that the laboratory is in compliance with air emissions standards. For calendar year 2020, the effective dose equivalent of radiation to the public was 0.039 mrem, which is far below the 10 mrem per year limit. No property was either requested or authorized for clearance to be released for reuse or disposal.	EPA 40 CFR 61, Subpart H: Emissions of Radionuclides Other Than Radon from Department of Energy Facilities DOE Order 458.1: Radiation Protection of the Public and the Environment DOE Order 435.1 Chg 1: Radioactive Waste Management

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
National Environmental Policy Act		
The National Environmental Policy Act (NEPA) requires that federal agencies analyze and disclose the potential environmental impacts of proposed federal actions and alternatives as part of its decision-making process. DOE regulations and orders establish how NEPA is implemented for DOE, and the Council on Environmental Quality (CEQ) reviews and approves federal agency NEPA procedures. Under NEPA, DOE considers the potential impacts to the environment, including natural, social, and economic factors, to determine the appropriate level of review for a proposed action. These include categorical exclusions, environmental assessments, and environmental impact statements.	Program activities were in compliance with requirements. A total of 167 documented environmental evaluations were completed; 134 actions were covered by a NEPA programmatic determination or existing environmental assessment; and 33 actions were submitted to DOE for review.	CEQ 40 CFR 1500-1508: Regulations for Implementing the Procedural Provisions of NEPA DOE 10 CFR 1021: NEPA Implementing Procedures
Wildlife Management		
The Migratory Bird Treaty Act (MBTA) of 1918, as implemented by the U.S. Fish and Wildlife Service (USFWS), and the Damage or Destruction of Dens or Nests—Harassment of Wildlife statute as administered by the Colorado Division of Parks and Wildlife, address the protection of migratory birds. The MBTA and its amendments implement several treaties between the United States, Great Britain, Mexico, Japan, and the former Soviet Union. The MBTA prohibits the taking, killing, or possession of migratory birds, nests, and eggs. The USFWS developed a system of permits for activities that involve the "taking" of migratory birds, including those governing scientific collection and bird banding, lethal and nonlethal measures taken to prevent depredation of agricultural crops, and to protect public health and safety. Within Colorado, no wildlife dens, nests, young, or eggs may be damaged or destroyed unless permitted by the Colorado Division of Parks and Wildlife. It is unlawful for any person to willfully harass wildlife, including birds. Under the memorandum of understanding between the Department of Energy and the U.S. Fish and Wildlife Service Regarding Implementation of EO 13186, Responsibilities of Federal Agencies to Protect Migratory Birds, DOE agrees to integrate migratory bird conservation principles, measures, and practices into agency activities and to avoid or minimize adverse impacts on migratory bird resources and their habitats. Under the Presidential Memorandum, Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators, a Pollinator Health Task Force was created to develop the National Pollinator Health Strategy to enhance pollinator habitat on federally managed lands and facilities, and to incorporate pollinator health as a component of all future restoration and reclamation projects.	Program activities were in compliance with requirements. Ground-nesting-bird surveys were conducted before annual mowing, weed control operations, and various research projects at the STM Campus and the Flatirons Campus in compliance with the MBTA.	USFWS 16 U.S.C. 703-712: The Migratory Bird Treaty Act Colorado Division of Parks and Wildlife Colorado Revised Statutes 33-6-128: Damage or Destruction of Dens or Nests, Harassment of Wildlife Memorandum of Understanding between DOE and the USFWS Executive Order 13186: Responsibilities of Federal Agencies to Protect Migratory Birds Presidential Memorandum: Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Endangered Species and Species of Concern		
The Endangered Species Act (ESA), which is jointly administered by the USFWS and the National Marine Fisheries Service, protects threatened and endangered wildlife and plant species and associated critical habitat. Federal agencies are required to abide by the ESA to ensure their actions do not adversely affect species that are federally listed under the ESA as threatened, endangered, or candidate species. Additional federal and state laws and regulations protect wildlife, such as the Bald and Golden Eagle Protection Act. DOE's formal consultation with the USFWS for the 2014 site-wide environmental assessments for the STM Campus and the Flatirons Campus resulted in an agreed-upon threshold for water usage to limit impacts to the Platte River system. The Colorado Division of Parks and Wildlife maintains a list of endangered, threatened, and wildlife species of concern for Colorado. Furthermore, the Colorado Natural Heritage Program has a list of rare species that is not regulatory in nature but is unique in that it is the only designation besides the ESA's that considers rare plants.	Program activities were in compliance with requirements. No activities were conducted in designated critical habitat for the federally threatened Preble's meadow jumping mouse (*Zapus hudsonius preblei*). No threatened or endangered plant species were identified at the STM Campus or the Flatirons Campus. The 27.6 million gallons (104.4 million liters) of water used at the STM Campus and the Flatirons Campus were reported to the USFWS.	USFWS 50 CFR 17: Endangered and Threatened Wildlife and Plants Colorado Division of Parks and Wildlife: 2 CCR 406-10, Article 2: Endangered Wildlife Colorado Division of Parks and Wildlife 2 CCR 406-10, Article 3: Threatened Wildlife
Vegetation Management		
The Federal Insecticide, Fungicide, and Rodenticide Act, as implemented by the EPA, regulates the use, storage, and disposal of herbicides and pesticides. For application of certain types of herbicides designated as "restricted use" by the EPA, a certified applicator must be used. In Colorado, the Commissioner of Agriculture develops and implements state noxious weed management plans for three categories of weed species. Class A plants are targeted for eradication. Class B species are subject to management plans designed to stop their continued spread. Class C species are subject to additional planning intended to support the efforts of local governing bodies to facilitate more-effective integrated weed management. EO 13112, Invasive Species, requires the control of invasive species at federal facilities. Importation of regulated plants and animals/organisms from other states and countries requires permitting by the Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture. NREL's Biosafety Program manages the importation and use of these materials.	Program activities were in compliance with requirements. At the STM Campus and on the conservation easement land, herbicides were applied to control Class A-, B-, and C-listed weeds in conjunction with other management methods, such as mowing and hand pulling. At the Flatirons Campus, herbicides were applied to control Class B- and C-listed weeds in conjunction with other management methods, such as mowing and hand pulling. NREL held two active APHIS permits in 2020, both of which were issued in 2019. The permits were obtained for microorganisms imported to the STM Campus from within the United States and from Japan.	Executive Order 13112: Invasive Species EPA 40 CFR 162: State Registration of Pesticide Products EPA 40 CFR 171: Certification of Pesticide Applicators Colorado Water Quality Control Commission 25-8-205: Noxious Weed Management, Municipal Authority U.S. Department of Agriculture 7 U.S. Code Ch. 61: Noxious Weeds U.S. Department of Agriculture Public Law 106-224: Agricultural Risk Protection Act of 2000 EPA 7 U.S. Code 136 et seq.: Federal Insecticide, Fungicide, and Rodenticide Act

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Wetlands and Floodplains		
Wetlands became regulated under the 1972 amendments to the Clean Water Act. Wetlands that meet certain soil, vegetation, and hydrologic criteria are protected under Section 404 of the Clean Water Act, which is administered by the U.S. Army Corps of Engineers (USACE) and the EPA. Under EO 11990, Wetlands Protection, federal agencies must provide leadership and take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. EO 11988, Floodplain Management, requires federal agencies to provide leadership and take action to reduce the risk of flood loss; minimize the impact of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains. Counties protect floodplains by mapping 100-year floodplain boundaries within their jurisdiction in coordination with the Federal Emergency Management Agency. Counties then formulate regulations to control the type and amount of development within the designated boundary. Jefferson County requires approval of development proposed in floodplains within its jurisdiction.	Program activities were in compliance with requirements. An approved jurisdictional determination was received from the USACE for the Middle Drainage area at the STM Campus. A wetland delineation was conducted at the Flatirons Campus, and an approved jurisdictional determination was obtained from the USACE.	USACE Clean Water Act Section 404: Permit Program Executive Order 11988: Floodplain Management Executive Order 11990: Protection of Wetlands DOE 10 CFR 1022: Compliance with Floodplain and Wetland Environmental Review Requirements
Cultural Resources		
Cultural resources are protected under Sections 106 and 110 of the National Historic Preservation Act, which is administered in Colorado by the Colorado Office of Archaeology and Historic Preservation and the State Historic Preservation Office. Federal agencies must establish preservation programs—commensurate with their mission and the effects of their activities on historic properties—that provide for the careful consideration of historic properties. Significant cultural resources are either eligible for, or listed in, the National Register of Historic Places. Cultural resources are defined as any prehistoric or historic district, site, building, structure, or object considered important to a culture, subculture, or community for scientific, traditional, religious, or other reason.	Program activities were in compliance with requirements. A cultural resource survey was conducted on the STM Campus in advance of proposed construction activities. No artifacts were found, and no direct effects were identified.	National Park Service 36 CFR 60: National Register of Historic Places National Park Service 36 CFR 63: Determinations of Eligibility for Inclusion in the National Register of Historic Places National Park Service 36 CFR 79: Curation of Federally-Owned and Administered Archaeological Collections National Park Service 36 CFR 800: Protection of Historic Properties 16 U.S.C. 470: National Historic Preservation Act State Historic Preservation Office 8 CCR 1504-7: Historical, Prehistorical, and Archaeological Resources

Small generators outside of the Renewable Fuel Heat Plant help power building operations on the STM Campus. *Photo by Werner Slocum, NREL 64475*

5 AIR QUALITY

Good air quality is fundamental to the overall well-being of individuals and the environment. Each person inhales approximately 3,700 gallons (14,000 L) of air per day, and contaminants that may be present can affect the individuals' health and ability to enjoy life. Air pollutants in the environment also can affect materials, vegetation, aquatic life, and wildlife that may be exposed to those pollutants.

NREL strives to protect air quality and the environment by (1) minimizing air emissions from research and operations activities and employee commuting, (2) tracking air emissions from the onsite sources, and (3) meeting federal and state air emissions and permitting requirements. Emitted air pollutants include criteria pollutants (e.g., carbon monoxide, NOx, VOCs, particulate matter, and sulfur dioxide) and noncriteria pollutants (e.g., hazardous air pollutants, GHG compounds, and ozone-depleting substances). Minimizing air emissions generated by the laboratory contributes to the improvement of regional air quality, benefiting both neighbors immediately adjacent to the laboratory and those in the Denver metropolitan area. ESH&Q staff members participate in project planning, safety evaluations, start-up reviews, and operations activities to ensure permit and regulatory compliance and address air quality considerations.

5.1 Criteria Pollutants and Hazardous Air Pollutants

The primary sources of regulated pollutants at NREL are a result of fuel use, chemical use, and facility operations. Sources include process heat boilers, process cooling systems, comfort heating and cooling systems, standby generators, construction and maintenance equipment with gasoline or diesel engines, bench- and pilot-scale research activities using chemicals, and facility operation and maintenance activities.

In December 2019, EPA redesignation of the Denver metropolitan area's ozone nonattainment area changed

from "moderate" to "serious" because of a failure to meet the ozone air quality standard. The new designation changed the definition of a major source of NOx or VOC emissions from 100 U.S. tons (90.7 MT) per year to 50 U.S. tons per year (45.4 MT). If source emissions in the Denver metropolitan area exceed 50 U.S. tons per year (45.4 MT) of NOx or VOCs, a site-wide Title V operating permit must be acquired for that source.

The maximum potential NOx emissions for the STM Campus in 2020 are estimated to be 68.7 U.S. tons per year (62.3 MT). Because this number exceeds the 50 U.S. ton (45.4 MT) per year Title V operating permit threshold, the STM Campus must either obtain a Title V operating permit or reduce emissions. In mid-2019, NREL began evaluating compliance requirements and potential actions in expectation of this permit change. A careful evaluation of permitting alternatives resulted in a decision in early 2020 to reduce NOx air emissions and avoid Title V air permitting instead of obtaining a Title V permit. This was determined to be more in-line with NREL's mission to focus on alternative energy and reduce reliance on traditional energy sources and their associated emissions.

Avoiding a Title V air permit will require reduction of STM Campus NOx emissions by making it a "synthetic minor" source. This process will require revision of existing air permits and issuance of new permits for fossil fuel-burning equipment, which will limit annual operating hours and subsequent air emissions for 8 standby generators and 12 boilers and air heaters. An application package committing to NOx reductions for these 20 sources was submitted to the Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division (APCD) in May 2020. It is expected that permits will be issued in January 2021 that will limit NOx emissions from 68.7 to 34.7 U.S. tons (62.3 MT to 31.5 MT) per year.[6] The emission limits will take effect in January 2021. A summary of the estimated annual air pollutant emissions in 2020 is included in Table 4.

5.2 Refrigerants

Refrigerants such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are considered ozone depleting substances (ODS), and they are now only available as recycled refrigerants. Non-ODS compounds such as hydrofluorocarbons (HFC), and hydrofluoroolefins (HFOs) have been used to replace ODS refrigerants, but they are potent GHGs.

NREL uses refrigerant-containing "appliances" (i.e., sealed units that do not normally emit refrigerants) such as comfort cooling systems; research environmental chambers and experimental equipment; and small appliances such as refrigerators, coolers, and air conditioners. These appliances contain a variety of refrigerants in varying quantities. Emissions of refrigerants may occur either as a result of appliance leaks or during servicing activities. NREL follows Colorado and EPA regulations, and strives to minimize the release of refrigerants.

There is an increased interest by EPA and state regulatory agencies to reduce the use of HFC refrigerants because of their high level of use, increased release to the atmosphere during leaks, and global warming potential (which is generally much greater than that of CO_2). In 2020, Colorado enacted Rule 22, the Colorado Greenhouse Gas Reporting and Emission Reduction Requirements, which requires certain sources to report use of HFCs and to reduce the use of HFC refrigerants over time by limiting their use in new appliances. The rule does not directly affect NREL at this time, but it is expected to lead to a future decrease the laboratory's use of HFC refrigerants.

The equipment and refrigerant inventory for the laboratory includes 133 appliances, 20 of which contain 50 or more pounds of refrigerant and are subject to strict requirements. The total inventory of all refrigerants is 9,162 lb (4,156 kg); of these, 1,150 lb (522 kg) are ODS and the remaining 8,012 lb (3,634 kg) are non-ODS that are GHGs. This inventory is expected to grow in 2021 as NREL expands its research activities.

Additional information about management of NREL's air quality protection program can be found in Appendix A.

2020 Accomplishments and Highlights

- Evaluated 10 research projects and construction for air emission impacts; nine were associated with research projects and one was for the new Research and Innovation Laboratory facility on the STM Campus.
- Submitted 20 "air pollutant emissions notices" (APENs) to the Colorado APCD to limit STM Campus NOx emissions and avoid Title V permitting by designating the STM Campus as a synthetic minor air emission source.

6. NOx emissions are based on either the maximum potential to emit (24 hours per day; 365 days per year) or the permit limit.

Table 4. Estimated Annual Air Pollutant Emissions (in U.S. Tons [MT] Per Year)[a]

Year	Criteria Pollutants					GHGs			HAPs
	CO	NO_x	VOC	PM_{10}	SO_2	CO_2	CH_4	N_2O	All HAPs
2016	5.73 (5.19)	12.94 (11.74)	2.05 (1.86)	1.61 (1.46)	0.16 (0.15)	7,066 (6,410)	0.31 (0.28)	0.15 (0.14)	0.28 (0.26)
2017	5.92 (5.37)	13.63 (12.37)	2.06 (1.87)	2.30 (2.09)	0.24 (0.22)	7,685 (6,972)	0.38 (0.34)	0.19 (0.17)	0.38 (0.35)
2018	7.94 (7.25)	18.73 (17.02)	2.15 (1.95)	3.00 (2.73)	0.41 (0.37)	8,526 (7,751)	0.73 (0.66)	0.22 (0.20)	0.47 (0.43)
2019	8.25 (7.48)	20.43 (18.53)	2.19 (1.99)	3.73 (3.38)	0.50 (0.45)	9,264 (8,403)	0.31 (0.28)	0.27 (0.24)	0.58 (0.53)
2020	7.52 (6.82)	15.98 (14.49)	2.17 (1.97)	3.37 (3.06)	0.47 (0.43)	10,484 (9,511)	0.32 (0.29)	0.27 (0.24)	0.55 (0.50)

a CO: carbon monoxide; NOx: nitrogen oxides; VOC: volatile organic compounds; PM_{10}: respirable particulate matter less than 10 microns in diameter; SO_2: sulfur dioxide; CO_2: carbon dioxide; CH4: methane; N_2O: nitrous oxide; HAPs: hazardous air pollutants

Spring rains create a wetland pond each year on the Flatirons Campus. *Photo by Dennis Schroeder, NREL 56163*

6 WATER QUALITY PROTECTION

Water quality is critical to human health and the health of our natural ecosystems. Water quality protection at NREL falls within four main areas: drinking water, groundwater, surface water, and wastewater. Additional information about program management for each of these four areas can be found in Appendix A.

6.1 Drinking Water

The STM Campus and the Flatirons Campus are provided with potable drinking water by two different means. The STM Campus is serviced by a municipal public water supplier, Consolidated Mutual Water Company, whose source water is primarily stormwater runoff and snowmelt from within the Clear Creek Watershed. The Flatirons Campus is not located within the bounds of a municipal public water supply distribution system; instead, treated water is purchased from the City of Boulder and transported by truck to the campus for the employees there. The treated water originates in large part from the Boulder Creek watershed and, to a lesser degree, some watersheds on the western slope of Colorado. The trucked water is transferred to a holding tank with a capacity of 15,000 gallons (56,781 L). Water is pumped from the holding tank to a 2,000-gallon (7,580 L) day tank, where chlorine is added to boost disinfectant levels before the water is distributed to campus buildings. (See Figures 3 and 4.)

In 2020, CDPHE decreased the frequency of disinfectant byproduct sampling at the Flatirons Campus from once quarterly to once annually. Sampling occurs in August every year, when ambient air and water temperatures tend to be the highest and the likelihood of disinfectant byproduct formation is increased.

The State of Colorado permits the Flatirons Campus drinking water system. Weekly monitoring and periodic required sampling are conducted by a subcontractor to NREL that is designated as the "operator in responsible charge" (ORC). Sample analysis is performed by an analytical laboratory contracted to the ORC. Monitoring and sample collection

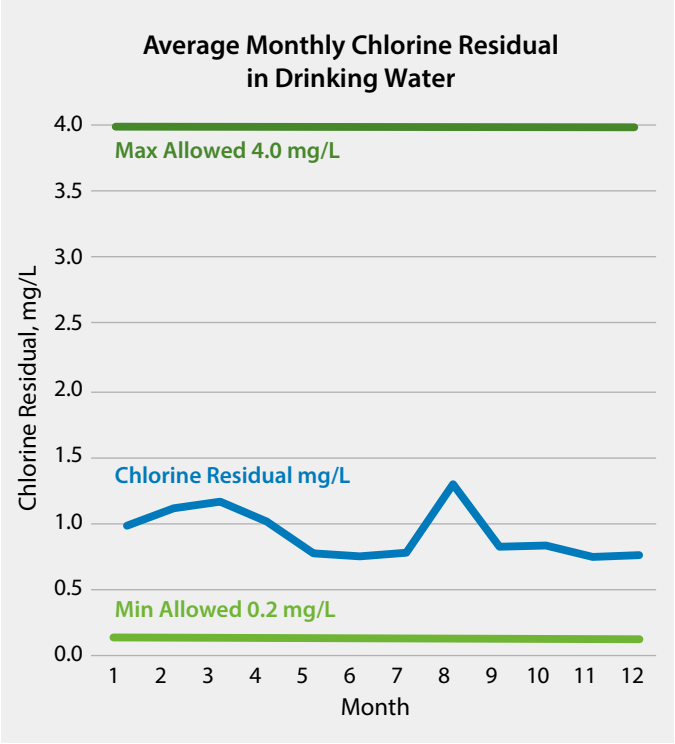


Figure 3. Results of average monthly chlorine residual monitoring in drinking water at the Flatirons Campus, 2020

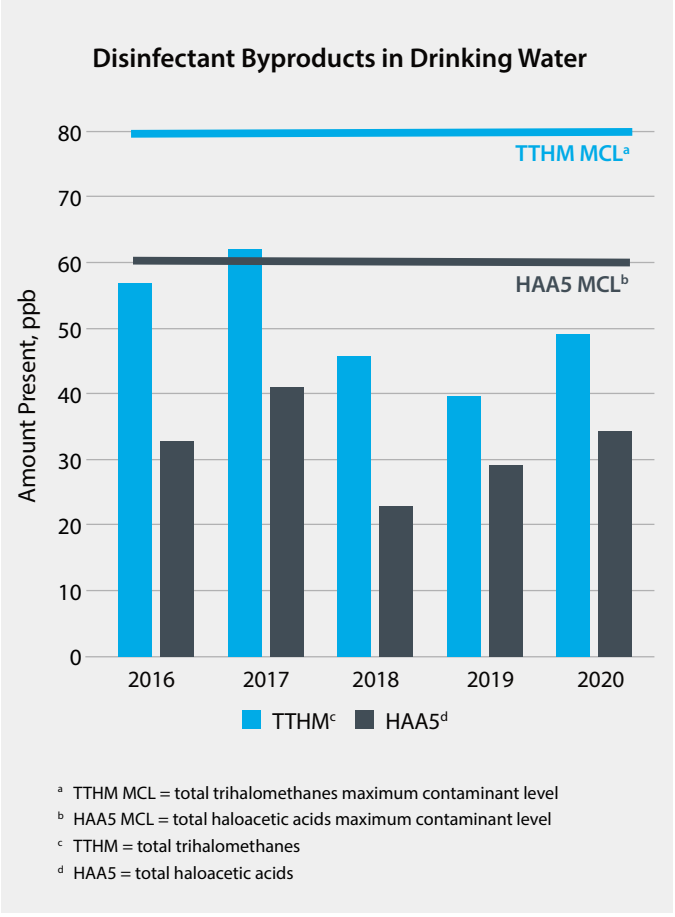


Figure 4. Results of disinfection byproducts monitoring in drinking water at the Flatirons Campus, 2016–2020

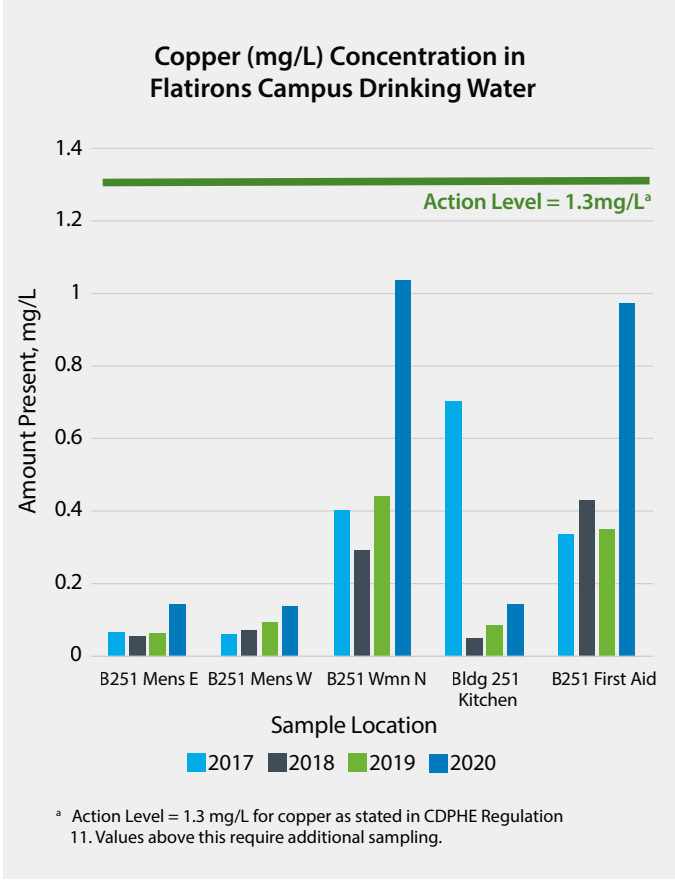


Figure 5. Results of copper monitoring in drinking water at the Flatirons Campus, 2017–2020

methods, as well as sample handling and laboratory quality control methods prescribed by the State of Colorado and the EPA, are included in the ORC subcontract with NREL and in the ORC's contract with the analytical laboratory. In 2020, monitoring results for residual chlorine, disinfectant byproducts, and copper were within allowable regulatory ranges (see Figure 3, Figure 4, and Figure 5). Lead has not been detected in Flatirons Campus drinking water samples, which are collected annually. Fecal coliform bacteria was absent from all monthly samples collected in 2020.

Because of decreased building occupancy at the STM Campus as a result of the COVID-19 pandemic, residual chlorine levels were monitored at points of use (e.g., at water faucets and drinking fountains) and were found to be close to the State of Colorado's minimum required concentration of 0.20mg/L. It was concluded this low of concentration of chlorine was a result of an insufficient amount of treated water entering the buildings. Therefore, a flushing program was instituted to bring fresh water into the buildings, which resulted in increased levels of residual chlorine. Regular monitoring will continue until normal staff occupancy returns to the buildings.

6.2 Groundwater

The Denver Basin aquifer system underlies an area of approximately 7,000 square miles (1,812,992 hectares) that extends from Greeley south to near Colorado Springs and from the Front Range urban corridor east to near Limon. The aquifer system provides groundwater to urban, rural, and agricultural users. The aquifers within the larger aquifer system, which include the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers, form a layered sequence of rock in an elongated, bowl-shaped structural depression. Both the STM Campus and the Flatirons Campus are located at the western edge of the Denver Basin aquifer system.

The STM Campus overlies the shallowest portions of the Denver, Arapahoe, and Laramie-Fox Hills aquifers. The Flatirons Campus overlies the shallowest portions of the Arapahoe and Laramie-Fox Hills aquifers. The Dawson formation is the shallowest of the Denver Basin aquifers and is the one most relied on aquifers by the groundwater users in the basin. The northern extent of the Dawson aquifer is located approximately 20 miles (33 km) south and east of the STM Campus; consequently, wells drilled at either the STM Campus or the Flatirons Campus would not intersect the Dawson aquifer, nor would a source of contamination on the affect the groundwater quality in this aquifer.

Despite the low likelihood of contaminants reaching the Dawson aquifer, NREL's groundwater management program is focused on controlling potential pollutant sources that could affect this important resource. The program includes careful evaluation of all outdoor projects to eliminate, substitute, or control potential sources of pollution.

There are currently no permitted monitoring wells at the STM Campus nor the Flatirons Campus. Two permitted closed-loop geothermal systems that were installed as part of research activities are in operation at the STM Campus: one at the Solar Radiation Research Laboratory and one near the South Site Entrance Building.

PFAS and Emerging Contaminants

Per- and polyfluoroalkyl substances (PFAS), a family of manufactured chemicals that have been used since the 1940s, are emerging contaminants of concern. PFAS are used in consumer products and industrial processes to repel oil and water, resist heat, and reduce friction. Common applications include food packaging, household products (e.g., stain and water-resistant carpets and fabrics), nonstick products, waxes, chrome plating, electronics manufacturing, and fire-fighting foam. Though many PFAS chemicals are no longer manufactured in the United States, they persist in the environment and have been detected in soil, groundwater, and drinking water supplies, prompting the federal government to begin developing PFAS standards and regulation, including the addition of several PFAS compounds to the Toxics Release Inventory under Section 313 of the Emergency Planning and Community Right-to-Know Act. The State of Colorado has developed an action plan to further minimize PFAS contamination in the environment and subsequent risks to state residents. To date, the State of Colorado has completed the following major elements of the action plan:

- Banned PFAS-containing Class B firefighting foam used for testing or training
- Facilitated sampling of approximately half of the state's public water systems, including groundwater and surface water bodies that serve as drinking water sources
- Issued a PFAS narrative policy that describes how the state will implement narrative provisions until quantitative standards are developed.

NREL previously identified one 500-gallon fire-suppression system, which contains a 3% PFAS solution, at the STM Campus. The fire-suppression system was evaluated and it was determined that if the system was activated, the PFAS foam would be contained within the building and there would be little possibility of a release to the environment. Replacing the system with a non-PFAS product would require replacing the tank and associated infrastructure; this project has been added to a list of projects for future funding.

Temporary Monitoring Wells

Three temporary groundwater monitoring wells were established in 2015 with the goal of better understanding the cause of saturated soil conditions that had resulted in seepage into the FTLB's north facade. The monitoring wells were monitored semi-annually to provide a trend analysis for the duration of the six-year program. The wells were monitored for depth below ground surface, pH, and total dissolved solids. Design and construction improvements to direct surface flows away from the building are in progress. After six years of monitoring, it was determined there was no need for further data to be collected and the wells were no longer needed. The monitoring wells were permanently closed in place in June. Currently, NREL has no groundwater monitoring wells.

2020 Accomplishments and Highlights

- Provided 375,046 gallons (1,419,704 L) of drinking water to the Flatirons Campus, which represents a decrease of approximately 137,000 gallons from 2019. This decrease is largely due to a decreased site population due to the COVID-19 pandemic.
- Instituted a flushing program to bring fresh water into the STM Campus buildings and conducted regular monitoring of fresh water during low staff building occupancy due to the COVID-19 pandemic.

Efforts to stabilize the hillside west of the Field Test Laboratory Building (FTLB) to allow for proper water drainage continues at the STM Campus. *Photo by Werner Slocum, NREL 64468*

6.3 Surface Water

Through its surface water program, NREL seeks to protect the quality of nearby waters into which the STM Campus and the Flatirons Campus drain. These receiving waters include Lena Gulch at the STM Campus and Coal Creek and Rock Creek at the Flatirons Campus. Sediment, debris, and chemicals transported to these water bodies via stormwater runoff can harm or kill fish and other wildlife either directly or by destroying aquatic and riparian habitat. High volumes of sediment can result in stream bank erosion and clogging of waterways.

Water quality protection is accomplished through compliance with federal and state stormwater permitting requirements, management of stormwater runoff flowing across active construction sites, inclusion of project design elements that promote infiltration and detention of stormwater, and management of NREL grounds to minimize erosion and support infiltration.

In December 2018, EPA Region 8 issued a Municipal Separate Storm Sewer System (MS4) permit to DOE for the STM Campus. This permit requires the development and implementation of programs to reduce the discharge of pollutants in stormwater runoff from the site to the maximum extent practicable to protect water quality in Lena Gulch, the water body to which runoff from the STM Campus flows. The programs must include the following elements, termed "minimum control measures":

- Public education and outreach
- Public involvement
- Illicit discharge detection and elimination
- Construction site runoff
- Post-construction runoff
- Good housekeeping.

Program development must be complete by the end of the first 5-year permit term. The programs will be implemented in subsequent permit terms.

2020 Accomplishments and Highlights

- Continued stabilizing the hillside adjacent to the FTLB. The building was first damaged by a water line break and was further impaired by the erosive effects of the September 2013 flood event. Most of the project was completed in 2020 and included installing retaining walls, installing a sidewalk, and stabilizing vegetation.
- Continued to implement control plans for erosion and sediment on several small construction projects (less than one acre [0.4 hectare]) at the STM Campus. This activity helped prevent sediment deposits from entering nearby surface drainages and downstream waters.
- Continued to develop MS4 permit programs intended to reduce the discharge of pollutants in stormwater runoff from the STM Campus.
- Conducted dry weather outfall screening at the STM Campus. There were no illicit/non-stormwater discharges observed.
- Applied "no dumping – drains to waterways" stencils to a subset of the storm drain inlets inventoried.
- Created a storm drain inlet inventory map for the STM Campus.

"No Dumping: Drains to Waterway" stencils were applied to approximately one-third of the storm drain inlets on the STM Campus. *Photo by Werner Slocum, NREL 64466*

6.4 Wastewater

Untreated or poorly treated wastewater can contaminate surface and groundwater used for drinking water, irrigation, industrial, commercial, and recreational purposes. Most wastewater from the STM Campus and Denver West Business Park facilities flows into the Pleasant View Water and Sanitation District's (Pleasant View's) system, and ultimately to the Metropolitan Wastewater Reclamation District's (Metro District's) central treatment plant. Wastewater from the ReFUEL Laboratory also flows to the Metro District's treatment plant.

Primary nondomestic wastewater discharge is generated at the STM Campus' Integrated Biorefinery Facility, where research related to the production of bio-based products and fuels is conducted. Acids and bases are used in pilot-scale processes for converting cellulosic biomass into various fuels and chemicals. The pH of the effluent from these processes is adjusted to fall within the target pH range of 5–11 before being discharged into the sanitary sewer system. Neutralized waste from solar cell processing equipment at the STM Campus' Science and Technology Facility is also directed to the sanitary sewer system, but only minimal discharges were made in 2020 because of the pause in research using that equipment. Boiler blowdown water from several buildings constitutes a third category of nondomestic wastewater discharge from the STM Campus. Metro District and Pleasant View system managers periodically tour the facility and review operational controls.

For facilities that lack sanitary service, three septic systems are in place, each consisting of a tank and a leach field: one is at the South Table Mountain mesa-top Solar Radiation Research Laboratory and two are on the Flatirons Campus. A preventative maintenance and inspection program is in place to confirm proper system function.

2020 Accomplishments and Highlights

- Installed a new onsite wastewater treatment system to replace the original system at the Flatirons Campus. The new system has a capacity of 2,000 gallons (7,571 L) per person per day and is expected to accommodate the anticipated increase in staff and research efforts at the site.
- Residual fluids in a solar cell processing research tool were drained in advance of infrastructure maintenance and a pending redesign of the waste neutralization component of the system. Site operations and research staff worked closely to ensure regulatory requirements were met in managing the fluids and that environmental stewardship practices were followed throughout the planning and execution of the work.

A new onsite wastewater treatment system was installed at the Flatirons Campus in 2020 to replace the original system, which was no longer adequate for the building population it served. The system was permitted through Jefferson County Public Health Department. *Photo by Brian Cox, NREL 63269*

An NREL employee inventories chemicals in a research laboratory. *Photo by Eric Schmitz, NREL 63778*

7 HAZARDOUS MATERIALS AND HAZARDOUS WASTE MANAGEMENT

Responsible acquisition, use, and disposal of materials and waste are critical to meeting regulatory compliance, preventing pollution, and caring for the environment. NREL seeks to purchase materials that are sourced responsibly, contain recycled content, and have low toxicity to reduce the environmental impact of its waste streams.

Hazardous materials used onsite are thoughtfully controlled with internal procedures designed to limit health and environmental risks. Waste is carefully managed and disposed of through fully permitted facilities. Areas of focus for the laboratory include:

- Hazardous materials management
- Hazardous waste management
- AST management
- Spill prevention and response
- Radiological materials and waste management.

Additional information about program management for each of these five areas of focus can be found in Appendix A.

7.1 Hazardous Materials Management

Various chemicals and materials, some of which are hazardous, are used in research and maintenance activities at NREL facilities. Hazardous materials are stored, used, and managed in a manner that is protective of laboratory personnel, the public, and the environment. A hazardous materials management program is in place to guide and track the acquisition, use, and disposal of these materials; doing so accomplishes environmental protection through compliance with state and federal requirements.

Table 5 summarizes the EPCRA reporting requirements that were met in 2020. The reporting requirements for each EPCRA section is defined in Section 4, Compliance Summary.

Table 5. 2020 EPCRA Reporting

EPCRA Section	Description of Reporting	Status
302	Planning notification	Not required[a]
304	Extremely hazardous substance release notification	Not required[a]
311–312	Safety data sheet/chemical inventory	Reported
313	Toxics Release Inventory reporting	Not required[a]

[a] "Not required" indicates NREL was not required to report because it did not meet the threshold or it did not have an extremely hazardous substance release.

2020 Accomplishments and Highlights

- Contingency plans were formalized for NREL's Chemical Response Team to allow for continual training and operational drills for unplanned release of hazardous material, while maintaining COVID-19 precautionary measures.
- As a result of the COVID-19 pandemic and consequent reduced onsite staffing, chemical were placed in a secure and safe state and chemical containers were inspected to address long-term storage concerns.
- A physical inventory of chemical containers began at the STM Campus and the Flatirons Campus, in which more than 25,000 containers were reviewed.
- The laboratory standardized testing of peroxide-forming chemicals to four times per year, and peroxide-forming chemicals training materials were updated to facilitate proper inspections.

Hazardous Materials Incidents

A 20 g (0.04 lb) container of a peroxide forming chemical was found to have crystal formation, indicating it was potentially unstable. Emergency responders assisted with relocating the item, and an emergency treatment permit was obtained from CDPHE to render the chemical inactive.

A large battery associated with a photovoltaic testing installation developed a leak in its secondary containment and 10 gallons of sulfuric acid/vanadium electrolyte solution leaked to the ground. Soil sampling was conducted to determine the extent of contamination and approximately 15 cubic feet (0.42 cubic meters) of soil was removed for proper disposal. The area was treated to neutralize any remaining acid in the soil. There were no impacts to groundwater or surface water.

A chiller system containing R-410a, a non-ODS refrigerant with a high global warming potential, developed a leak around a loose fitting and leaked 44 lb (20 kg) of refrigerant. The equipment was serviced and the leak stopped.

7.2 Hazardous Waste Management

Research and development activities and site-wide facility operations create a variety of waste streams, some of which contain toxic chemicals or metals. NREL typically disposes of or recycles the following categories of waste:

- Hazardous waste (as defined by environmental regulations)
- Nonhazardous waste, such as low-toxicity chemicals and containers and utensils contaminated with chemicals (does not include municipal solid waste, such as regular office trash)
- Universal waste, such as mercury-manufactured articles and lamps, batteries, aerosol cans, used oil and electronic waste, including computers, monitors, and research instrumentation containing electronic circuitry.

Figure 6 summarizes the waste generated at NREL from 2015 to 2019.

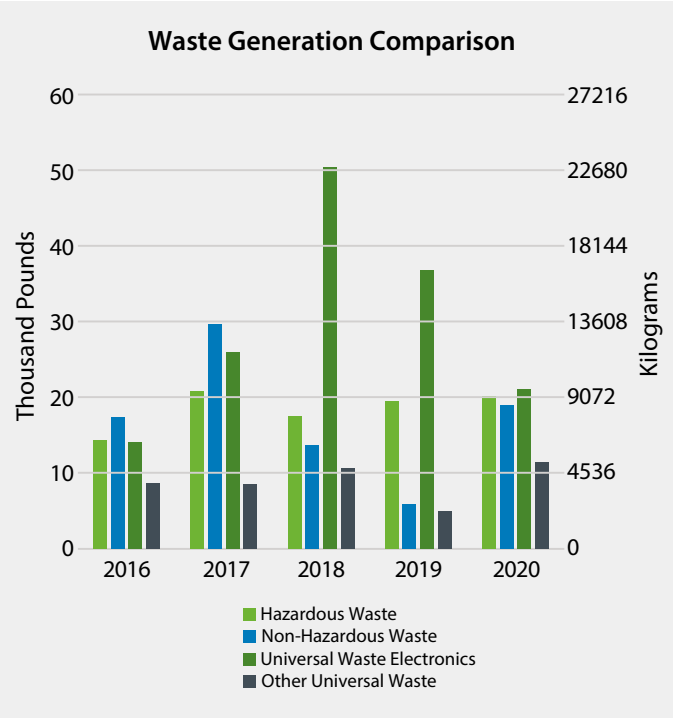


Figure 6. Comparison of four waste categories generated at NREL facilities by net weight, 2016–2020

2020 Accomplishments and Highlights

- Conducted visual inspections of hazardous waste areas to verify waste container integrity while in storage during the COVID-19 pandemic.
- Continued to collect and remove chemical waste containers from laboratories to minimize the number of containers in each space during reduced onsite staffing due to the COVID-19 pandemic.

7.3 Aboveground Storage Tank Management

Proper tank management prevents or minimizes spills and leaks that can contaminate soils, surface water, groundwater, and drinking water. Monthly, annual, and interstitial visual inspections, including determination of ullage log measurement, support the laboratory's commitments to environmental stewardship and pollution prevention.

NREL operates aboveground storage tanks (ASTs) and does not have any underground storage tanks, which decreases the risk of underground soil and water contamination. Unlike underground tanks, aboveground installations provide access for regular visual leak inspections which reduces repair and cleanup costs.

NREL operates 25 ASTs, including:

- 18 petroleum ASTs on the STM Campus with a total capacity of 7,920 gallons (29,981 L)
- One ethanol AST on the STM Campus with a total capacity of 6,000 gallons (22,712 L)
- Five petroleum ASTs on the Flatirons Campus with a total capacity of 1,289 gallons (4,879 L)
- One petroleum AST at Building 16 with a capacity of 500 gallons (1,893 L).

7.4 Petroleum Spill Prevention and Response

Spills of petroleum products can result in contamination to soil, surface water, and groundwater, potentially impacting ecosystems, wildlife habitat, and human health. Comprehensive planning using spill prevention, control, and countermeasure (SPCC) plans can reduce spills and limit impacts to the environment when spills do occur.

SPCC plans have been developed and are in place for the STM Campus, the Flatirons Campus, and the ReFUEL Laboratory. Because less than 1,320 gallons (4,997 L) of petroleum is stored at the Denver West Business Park—and no petroleum is stored

A 6000-gallon (22,712 L) ethanol AST and secondary containment basin on the STM Campus supports research in biomass development. *Photo by Werner Slocum, NREL 55981*

Some equipment found in spill kits, which are distributed throughout the STM Campus and the Flatirons Campus to aid in spill response. *Photo by Larry Durbin, NREL 56083*

at the Golden Warehouse, the Washington D.C. Office, or the Research and Testing Facility—SPCC plans are not required at those locations.

Spill reporting and response policy requires staff to internally report all spills, regardless of spill size. The purpose of this policy is to provide historical spill information, identify where spills might occur more frequently, and promote awareness of spill prevention importance. The number of spills and the quantity of spilled petroleum varies from year to year. A summary of petroleum spills is detailed in Table 6. No spills were reportable to either EPA or the State of Colorado, no spill entered a waterway, and all spills were cleaned up promptly according to SPCC procedure. NREL continues to focus on spill avoidance, response training, and spill response preparation to minimize spill events and quantities.

2020 Accomplishments and Highlights

- Added 10 additional spill kits to various locations at both campuses to facilitate a rapid response at those locations and to provide more spill resources that could be moved and deployed as needed.
- Provided annual SPCC training to all NREL workers handling petroleum-filled equipment; training was delivered virtually due to the COVID-19 pandemic.

Table 6. Petroleum Spills

Description	No. of Spills	Qty (gal, [L])
Electrical transformer failure	1	15 (56.8)
Wind turbine gearbox leak	1	2 (7.6)
Vehicle and powered industrial truck leaks	8	8.3 (31.4)
Dumpster/compactor leak	1	3 (11.4)
Other	2	0.25 (0.9)

7.5 Radiological Materials and Waste Management

The laboratory uses a small amount of depleted uranyl acetate in electron microscopy staining. Several sealed sources are also present in analytical and process equipment, check sources, and emergency exit signs. Unlike many DOE facilities, NREL does not have legacy radiological contamination issues associated with past nuclear weapons production or research.

In 2017, NREL determined there was no longer a need to use low-level radiological isotopes as biological tracers in research. As a result, in 2018, the designated laboratory space where those activities occurred was decommissioned and remediated before being returned to use for nonradiological experiments.

One of the many spill kits ready for deployment at the STM Campus. *Photo by Werner Slocum, NREL 56081*

All laboratory items (e.g., personal protective equipment, glassware, isotopic standards, chemical fume hoods, laboratory benchtops, and cabinets) removed during remediation remain onsite as preparations for final offsite shipment and disposal, in accordance with applicable state, federal, and DOE requirements, are completed.

Table 7 lists the total activity onsite and the estimated effective dose equivalent to a member of the public for the past 5 years.

Table 7. Total Activity and Effective Dose Equivalent[a]

Calendar Year	2016	2017	2018	2019	2020
Total activity (mCi)[b]	3.88	3.88	3.88	3.88	3.89
Effective dose equivalent (mrem/yr)	0.038	0.045	0.037	0.037	0.039

[a] The allowable effective dose equivalent limit for each year is 10 mrem.

[b] Millicurie is abbreviated mCi.

Equipment and Real Property Clearance

DOE orders identify the requirements that must be followed when releasing any potentially radiologically contaminated equipment or real property (i.e., land, buildings) to another DOE national laboratory, collaborating agency, or outside entity. These requirements detail the measurable radiological levels that must be verified and documented to comply with DOE-authorized limits. Furthermore, internal procedures prohibit the disposition of equipment unless it has been decontaminated to background levels. No equipment or real property was either requested or authorized for clearance to be released for reuse or disposal in 2020.

What is "Effective Dose Equivalent"?

To understand effective dose equivalent, dose and dose equivalent must first be defined:

- **Dose:** a generic term to describe the amount of radiation a person receives
- **Dose Equivalent:** a measure of the biological risk of the energy that the radiation deposited in tissue, which depends on the type of radiation and the tissues exposed; the units of dose equivalent are called rems, and a thousandth of a rem is called a millirem, which is abbreviated as mrem
- **Effective Dose** Equivalent: the total of the dose equivalent to the organ or tissue multiplied by weighting factors applicable to each of the body organs or tissues that are exposed to radiation

An average person in the United States receives about 310 mrem each year from natural sources and an additional 310 mrem from medical procedures and consumer products.

Bird diverters on power poles at the Flatirons Campus substation. The substation is part of the recent Power Generation Upgrade Project. *Photo by Werner Slocum, NREL 64460*

8 NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE

The National Environmental Policy Act of 1969 (NEPA) is a federal law that serves as the national charter for protection of the environment, including natural, social, and economic impacts. NEPA requires the federal government to evaluate and understand the potential environmental impacts of a proposed action before resources—such as federal funds, properties, facilities, employees, and equipment—are committed. NEPA mandates that federal agencies weigh the potential for environmental impacts equally among all factors when making decisions about proposed actions.

In compliance with NEPA, NREL staff evaluate potential environmental impacts from a wide range of activities before funds are authorized funds or work commences. The NEPA process represents an effective means for project managers, scientists, engineers, and other stakeholders to understand the potential environmental impacts of proposed activities and identify actions to minimize impacts. Additional information about NREL's management of its NEPA program activities can be found in Appendix A.

A key priority for the laboratory in 2020 was to develop and implement a NEPA strategy and schedule to support key NREL campus growth initiatives. To support on-time and successful project completion, integrating the NEPA process early in project planning is imperative. NEPA review activities include developing an initial list of major projects proposed, developing a project description template, creating a process for documenting and maintaining accurate project information, understanding project sequencing, and developing and maintaining project descriptions and project information over time.

In 2020, the laboratory collaborated with DOE Golden Field Office to develop a new programmatic NEPA determination. This new programmatic NEPA determination, which is expected to be finalized in 2021, will address offsite installation of research monitoring devices on existing structures and should result in more efficient reviews for certain offsite projects. The DOE Golden Field Office has issued several of these determinations for the laboratory to complete certain NEPA reviews in a more efficient manner. Each programmatic NEPA determination defines specific activities that have been reviewed by DOE Golden Field Office to have no significant environmental impacts and outlines the conditions under which each determination applies.

2020 Accomplishments and Highlights

- Developed and implemented a NEPA strategy and schedule to support campus growth initiatives.
- Initiated the development of a new programmatic NEPA determination, which will result in more-efficient reviews for certain offsite projects.

A female bobcat (*Lynx rufus*) and her three kittens are seen making themselves at home in the front entrance of the Research and Support Facility. The absence of most staff on the STM Campus during the COVID-19 pandemic has made previously populated areas more appealing to wildlife. *Photo by Dennis Schroeder, NREL 62512*

9 NATURAL AND CULTURAL RESOURCES PROTECTION

Natural resources at the STM Campus and the Flatirons Campus are managed responsibly to ensure NREL's research needs are met while protecting native wildlife, vegetation, and cultural resources. Responsible management benefits not only the environment, but also NREL employees and the surrounding community. Management focuses on these key areas:

- Wildlife management
- Endangered species and species of concern
- Vegetation management
- Wetlands and floodplains
- Cultural resources.

Additional information about program management for these five areas can be found in Appendix A.

9.1 Wildlife Management

Given the laboratory's location just east of the foothills of the Front Range, wildlife is plentiful at both the STM Campus and the Flatirons Campus.

NREL promotes responsible management of wildlife and habitat through periodic formal surveys and reviews of impacts to wildlife when designing and implementing projects. At the STM Campus, the original wildlife survey of the property was completed in 1987 and an additional study of the conservation easement property was performed in 1999; additional surveys were completed on that property in 2005 and 2011. In 2017, the STM Campus was surveyed once again.

Mammals identified in surveys of the STM Campus include mule deer *(Odocoileus hemionus),* elk *(Cervus canadensis),* coyotes *(Canis latrans),* bobcat *(Lynx rufus),* striped skunks *(Mephitis mephitis),* cottontails *(Sylvilagus* spp.*),* and various smaller mammals. More than 80 species of birds have been recorded by the formal wildlife surveys and supplemental employee observations. At least seven raptor species have

A Western Kingbird (*Tyrannus verticalis*) chases a Red-Tailed Hawk (*Buteo jamaicensis*) while flying over the Research Support Facility. Both types of birds are common to STM Campus and Flatirons Campus. *Photo by Werner Slocum, NREL 56759*

been recorded at or above the STM Campus, especially during spring migration. Two raptor species are residents at the site: the American Kestrel *(Falco sparverius)* and the Red-tailed hawk *(Buteo jamaicensis)*. Owls that occupy the STM Campus include the Great horned owl *(Bubo virginianus)* and Northern Pygmy-Owl *(Glaucidium gnoma)*. Reptiles and amphibians also inhabit the STM Campus; most notably, the Woodhouse's toad *(Anaxyrus woodhousii)* breeds in ephemeral ponds on the STM conservation easement.[7]

DOE prepared a biological characterization inventory in 1992 for the entire Rocky Flats Plant area, a former production site for nuclear weapons. The area includes the Flatirons Campus, which was part of the no-activity buffer zone of the Rocky Flats Plant at the time. Signs or tracks of bears and mountain lions were identified. Approximately 20 species of birds were sighted at or near the Flatirons Campus at that time.

Raptor surveys conducted at the Flatirons Campus in 1994 and 1995 identified seven raptor species on or in the vicinity of the campus. An avian survey was again completed in 2003 and updated in 2011.[8] A 2016 survey included mammals, reptiles, and amphibians with results duplicating the 2011 survey that showed that various mammals, including elk, mule deer, coyotes, cottontails, bobcats, several species of bats, deer mice (*Peromyscus maniculatus*), prairie voles (*Microtus ochrogaster*), and masked shrew (*Sorex cinereus*) continue to feed at and occupy the Flatirons Campus. Although seldom seen, Western (prairie) rattlesnakes (*Crotalus viridus*), bull snakes (*Pituophis catenifer*), racers, and several other reptiles are also known to occupy the Flatirons Campus. Amphibians, including Boreal chorus frogs (*Pseudacris maculata*), Woodhouse's toad, sand Northern leopard frogs (*Lithobates pipiens*), occupy ephemeral wetlands at the Flatirons Campus.

Rattlesnakes

Rattlesnakes inhabit South Table Mountain Park and the STM Campus. NREL Protective Force Officers are often called to relocate rattlesnakes found near sidewalks, doorways, and other areas where they might pose a safety concern. In 2020, officers responded more than 20 times to calls involving rattlesnakes. Of those calls, eight individual rattlesnakes were captured and given passive integrated transponder (PIT) tags. Figure 7 illustrates the frequency per month of rattlesnake captures at the STM Campus. August is typically a very active month for snakes, and most captures are males.

A Western (prairie) rattlesnake (*Crotalus viridis*) stretches out on the steps of the Energy Systems Integration Facility, during a cool evening in July. Rattlesnakes are fairly common on the STM Campus, so employees are trained on snake safety each year. *Photo by Werner Slocum, NREL 62986*

7. Two Dot Consulting, LLC. 2017. *2017 Vegetation and Wildlife Surveys at the National Renewable Energy Laboratory, South Table Mountain.* Jefferson County, Colorado.
8. Tetra Tech EC, Inc. 2011. *Avian Monitoring and Mortality Report: National Wind Technology Center.* Jefferson County, Colorado.

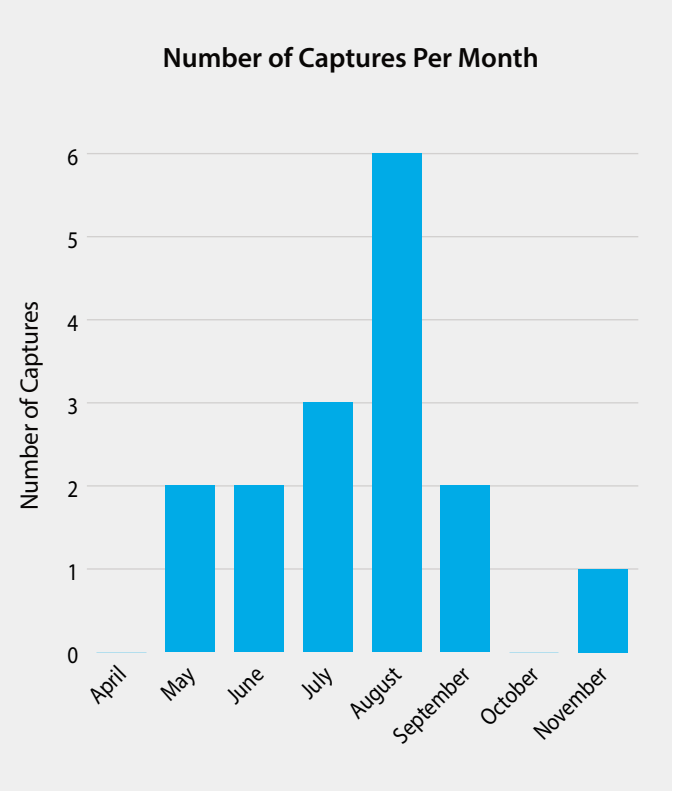


Figure 7. Number of rattlesnakes captured by month in 2020

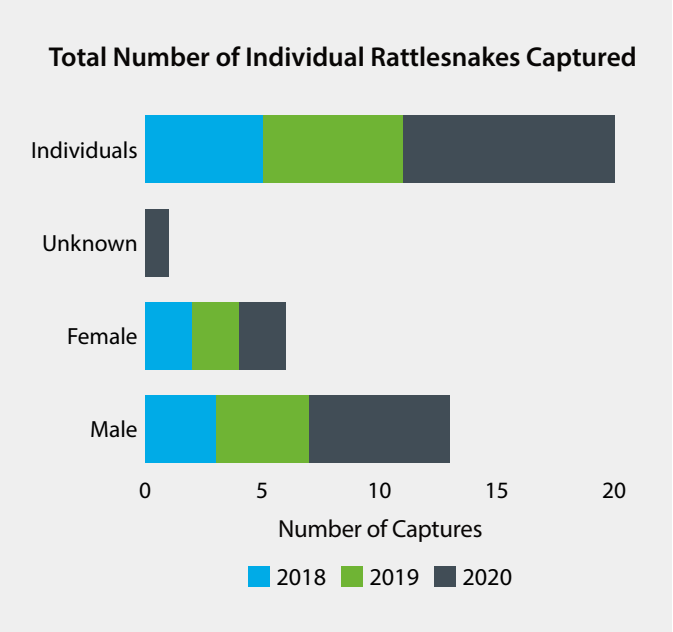


Figure 8. Number of individual rattlesnakes captured on the STM Campus, 2018–2020

NREL has been working with Adaptation Environmental Services, a local environmental firm specializing in rattlesnake safety and research. For the past 3 years, this firm has provided training sessions to NREL staff on snake ecology and taxonomy to minimize injuries to snakes and to enhance safety awareness of responders during relocation activities. Additionally, the firm conducted PIT tagging on relocated snakes to monitor snake

2020 Accomplishments and Highlights

- Encouraged a bobcat (*Lynx rufus*) family to relocate. A family of bobcats moved into the Research Support Facility main entrance courtyard where a mother and three kittens took up residence under a foot bridge in September. The area was cordoned off to protect NREL staff and bobcats. Although COVID-19 restrictions limited the number of staff on the STM Campus, it was prudent to discourage the bobcats from using the courtyard. Using a combination of predator noises and scents, the bobcat family eventually moved and were seen in other parts of the campus through December.
- Coordinated with the Jefferson County Sustainability Coordinator and Facilities Management Director to review and discuss bird-friendly solutions applied at the STM Campus. Jefferson County's intent is to apply techniques that have been successful at the STM Campus to county buildings where bird strikes have been a growing problem.
- Installed bird-friendly window film on portions of the Integrated Biorefinery Facility to minimize bird collisions.
- Captured and tagged eight rattlesnakes with passive integrated transponders at South Table Mountain Park and inside the STM Campus boundary. This brings NREL's total number of PIT-tagged snakes to 20 over the course of 3 years.
- Provided training sessions to staff on snake handling, ecology, and taxonomy to minimize injuries to snakes and enhance safety awareness of responders during snake relocation activities.
- Installed solar panel screening on the roof of the Visitor Parking Lot at the STM Campus. The space between the roof and the solar panels had become a common nesting and roosting habitat for the rock dove (*Columba livia*), also known as the domestic pigeon. Combined with other management methods, the screening has noticeably reduced the STM Campus pigeon population.
- Provided virtual nesting bird survey training to staff who frequently conduct flights of unmanned aircraft systems, commonly referred to as drones. Training focused on bird nesting awareness during field operations and how to properly "clear" an area before conducting work.
- Designed and installed two American kestrel nest boxes. The design of the new boxes incorporates a pulley system that allows one person to service the nest box that is on a tall pole. Before this design was implemented, three people were needed to service a nest box.

movements and better understand their behavior. Figure 8 presents the number of individual snakes tagged per year. A total of 19 rattlesnakes now have PIT tags.

Of the eight snakes captured in 2020, one male was recaptured three additional times after his first capture, and another was recaptured twice after its first capture. However, only one of these two snakes were captured for the first time in 2020; the other snake was initially captured in 2018 and recaptured 2 years later.

Complete lists of all wildlife species identified at both the STM Campus (Table C-1) and the Flatirons Campus (Table C-2) are found in Appendix C.

9.2 Endangered Species and Species of Concern

The federal Endangered Species Act (ESA) provides for the designation and protection of wildlife, fish, and plant species that are in danger of extinction and preserves the habitats on which these species depend. Compliance ensures the laboratory's actions do not adversely affect threatened, endangered, or candidate species that are listed under the ESA. NREL also complies with Colorado Division of Parks and Wildlife restrictions related to endangered, threatened, and species of concern for Colorado, as well as the rare plant species listed under the Colorado Natural Heritage Program.

The USFWS, which administers the ESA, lists eight species that are threatened, endangered, or a candidate for listing that could potentially be found in Jefferson County or Boulder County. Of these species, two have the potential to occur at the STM Campus or the Flatirons Campus: the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) and the Ute ladies' tresses orchid (*Spiranthes diluvialis*). According to the USFWS's Information, Planning, and Consultation System database, an additional eight bird species listed as species of special concern, along with several other species on the State of Colorado's list of Species of Greatest Conservation Concern could also exist in Jefferson County or Boulder County.

In 2017, a survey of the STM Campus did not detect any threatened species, endangered species, or species of concern. The 2016, the Flatirons Campus survey revealed three State of Colorado Species of Greatest Conservation Concern were present: the Fringed myotis (*Myotis thysanodes*), Little brown myotis (*Myotis lucifugus*), and Northern leopard frog. Note that for a bird species to be counted as occupying the STM Campus or the Flatirons Campus, the bird could not simply be flying over the site but had to be stopping over or otherwise using habitat at the site, such as by nesting or foraging.

The USFWS has designated critical habitat associated with the federally endangered Preble's meadow jumping mouse within the upper reaches of Rock Creek, including a small area at the southeastern corner of the Flatirons Campus. This area may not be disturbed without prior coordination with the USFWS.

Five species that occur in the Platte River watershed in Nebraska are listed by the USFWS as species that must be considered for Colorado and Wyoming projects that may deplete water supplies to the Platte River system. These include three birds (the Piping plover [*Charadrius melodus*], the Whooping crane [*Grus americana*], and the Least tern [*Sternula antillarum*]), a fish (the Pallid sturgeon [*Scaphirhynchus albus*]), and a plant (the Western prairie fringed orchid [*Platanthera praeclara*]). As part of the STM Campus and the Flatirons Campus NEPA environmental assessments conducted in 2014, DOE consulted with the USFWS for future activities that have the potential to deplete water in the Platte River system. In accordance with requirements agreed upon in the consultation, NREL monitors water use to ensure the established amounts are not exceeded.

9.3 Vegetation Management

Native plants have evolved over long periods of time in harmony with the local climate and surrounding soil, growing in association with microorganisms and resident wildlife to create diverse ecosystems. Through this evolution, native plants have developed natural defenses against pests and diseases specific to their locale. Non-native plants that are introduced into an environment can overcome indigenous plants, attract new types of pests and diseases, and outcompete native plants for nutrients and water. They can also deprive wildlife of nutrients and shelter. Plants such as kochia (*Bassia scoparia*), Canada thistle (*Cirsium arvense*), Russian olive (*Elaeagnus angustifolia*), diffuse knapweed (*Centaurea diffusa*), dalmation toadflax (*Linaria vulgaris*), and myrtle spurge (*Euphorbia myrsinites*) are examples of non-native plants that can have destructive effects on natural habitats.

Vegetation management incorporates four main areas:

- **Native Landscaping:** Landscaped areas near NREL buildings and common areas are designed to incorporate features such as native plantings, xeriscape principles suited to arid climates, and infiltration of stormwater to provide water and nutrients to landscape plants and recharge groundwater in the area. Adhering to such designs helps promote wildlife-friendly vegetation and reduces the introduction of non-native species and the pests and diseases that can accompany them. NREL actively manages the vegetation on its sites to maintain the native plant communities and manage wildfire risk.
- **Weed Management:** Where non-native species exist, NREL uses an integrated weed management approach that incorporates various types of weed control methods,

including mechanical practices (e.g., mowing or hand-pulling), cultural practices (e.g., reclamation of disturbed areas), prevention (e.g., limiting or eliminating driving off established roadways), biological practices (e.g., introducing state-approved insects and fungus that feed on specific weed species), and treatment using herbicides. For example, the laboratory has successfully used multiple control strategies to significantly reduce populations of diffuse knapweed and Canada thistle on the STM Campus and the Flatirons Campus. The weed control program maintains the flexibility needed to respond to changes in weed populations from year to year, and periodically assesses the effectiveness of the control methods it employs. Comprehensive site-wide weed surveys and mapping are performed approximately every 5 years. Smaller areas of NREL's main sites are assessed annually. The noxious weed species, as defined on the State of Colorado's noxious weed list, that have been identified at the STM Campus and the Flatirons Campus are listed in Table 8.

- **Wildfire Risk Management:** Part of managing native vegetation at NREL is finding a balance between preserving and manipulating the landscape to reduce wildfire risk. NREL has a fire management program that includes wildfire assessments, fire risk management, and identification of areas of wildland-urban interface. These areas are being managed to achieve and maintain defensible space around buildings and other infrastructure against wildland fires. Most of the fire management activities can be done in conjunction with other vegetation management activities, such as weed control. Annual assessments of defensible space are conducted for the STM Campus and the Flatirons Campus.
- **Imported Plant and Organism Permits:** An additional component of NREL's vegetation management program relates to the periodic use of certain animal and plant materials in research at the laboratory. Certain organisms and plants that are obtained from other states or from outside the United States are controlled by the Animal and Plant Health Inspection Service (APHIS). These might include the use of certain pathogenic organisms used in biomaterials research or plants such as sugarcane bagasse and other scrap agricultural products that are tested for their value in biofuels and biomaterial production. NREL held two active APHIS permits in 2020, both of which were issued in 2019. The permits were obtained for microorganisms imported to the STM Campus, one from within the United States and one from Japan.

Table 8. Noxious Weed Species Identified at the STM Campus and the Flatirons Campus[a]

Noxious Weed Class	Species Present at STM Campus (Common name [Scientific name])	Species Present at Flatirons Campus (Common name [Scientific name])
Class A[b]	• Myrtle spurge (*Euphorbia mysinites*)	None
Class B[c]	• Canada thistle (*Cirsium arvense)* • Common teasel (*Dipsacus fullonum*) • Dalmation toadflax – broad-leaved (*Linaria dalmatica*) • Diffuse knapweed (*Centaurea diffusa*) • Hoary cress (*Cardaria draba*) • Houndstongue (*Cynoglossum officinale*) • Jointed goatgrass *(Aegilops cylindrica*) • Leafy spurge (*Euphorbia esula*) • Musk thistle (*Carduus nutans*) • Russian olive (*Elaeagnus angustifolia*) • Scotch thistle (*Onopordum acanthium*)	• Bull thistle (*Cirsium vulgare)* • Canada thistle (*Cirsium arvense)* • Common teasel (*Dipsacus fullonum)* • Dalmation toadflax – broad-leaved (*Linaria dalmatica)* • Diffuse knapweed (*Centaurea diffusa*) • Hoary cress (*Cardaria draba*) • Leafy spurge (*Euphorbia esula*) • Moth mullein (*Verbascum blattaria*) • Musk thistle (*Carduus nutans)* • Sulfur cinquefoil (*Potentilla recta*)
Class C[d]	• Downy brome, cheatgrass (*Bromus tectorum*) • Field bindweed (*Convolvulus arvensis*) • Common mullein (*Verbascum thapsus*)	• Downy brome, cheatgrass (*Bromus tectorum*) • Field bindweed (*Convolvulus arvensis*) • Chicory (*Cichorium intybus*) • Common mullein (*Verbascum thapsus*) • Common St. John's wort **(***Hypericum perforatum*)

[a] Species identified reflect the findings of site-wide weed surveys performed in 2011 at the STM Campus and in 2016 at the Flatirons Campus

[b] Identified by the State of Colorado for eradication

[c] Identified by the State of Colorado to stop the spread

[d] Identified by the State of Colorado to more-effectively manage on private and public lands through education, research, and biological control resources

A Western honey bee (*Apis mellifera*) gathers pollen from Russian sage (*Perovskia atriplicifolia*) plants, which grow in the courtyard outside the Research Support Facility. *Photo by Werner Slocum, NREL 62981*

9.4 Wetlands and Floodplains

Wetlands are lands that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetland areas typically take the form of swamps, marshes, bogs, and groundwater seeps, and they are frequently within or adjacent to a floodplain. Floodplains are land areas adjacent to rivers and streams that are subject to recurring inundation.

Both wetlands and floodplains play a key role in providing floodwater storage, reducing flood flow rate, filtering floodwater, and recharging groundwater. The resulting enriched floodplain soils promote the growth of wetland and riparian vegetation that provides habitat for a rich diversity of terrestrial and aquatic plants and animals. NREL strives to preserve the important natural functions of its wetlands and floodplains, regardless of size or extent, to protect the physical, biological, and chemical integrity of receiving waters and riparian areas on and adjacent to the STM Campus and the Flatirons Campus.

Floodplains vary in extent from those that can contain more frequent low-volume rain event flows to those that can contain

2020 Accomplishments and Highlights

- Developed a noxious weed management plan and conducted coordination meetings as needed to facilitate effective herbicide application and revegetation efforts.
- Used a combination of spot and broadcast spraying methods to treat 128 acres at the Flatirons Campus with appropriate herbicides to control diffuse knapweed, Canada thistle, and sulfur cinquefoil.
- Treated small areas of leafy spurge growing within recently disturbed and reclaimed areas of the Flatirons Campus. These areas were surveyed again two months later, and the surviving leafy spurge was sprayed again. All treated areas will be surveyed again in 2021.
- Treated 23 acres of noxious weeds, including Canada thistle, houndstongue, and myrtle spurge at the STM Campus. Jointed goatgrass, another noxious weed recently discovered on the STM Campus, was also treated.
- Treated 46 acres of noxious weeds within the STM conservation easement, including cheatgrass, diffuse knapweed, and common mullein. The treatment will be effective for several growing seasons, promoting native warm-season grasses.
- Reviewed South Table Mountain mesa top restoration efforts with Jefferson County Open Space. Reclaimed a rubble storage area in its third season of restoration and applied herbicide to control noxious weeds and promote native grasses on the mesa top.

Seasonal ponds on the South Table Mountain mesa top provide wetland plant communities in an otherwise dry environment. *Photo by Tom Ryon, NREL 63580*

a 100-year flood event or greater; in general, stream channels at NREL sites are better characterized by the former description. There are no 100-year floodplains defined by Jefferson County or the Federal Emergency Management Agency on NREL sites.

A field investigation conducted within the Middle Drainage portion of the STM Campus identified approximately 1.7 acres (0.69 hectares) of non-jurisdictional wetlands within the study area. These areas, which comprise both palustrine emergent wetlands and palustrine scrub-shrub wetlands, are summarized in Table 9.

Table 9. STM Campus Middle Drainage Wetlands Summary

Cowardin Classification	Area (acres [hectares])
Non-Jurisdictional Areas	
Palustrine emergent wetland	0.12 (.05)
Palustrine emergent wetland and palustrine scrub-shrub wetland	1.58 (0.64)

A field investigation conducted within the Flatirons Campus identified approximately 7.53 acres (3.05 hectares) and 2,142 feet (653 meters) of jurisdictional and non-jurisdictional wetland areas. These areas, which included palustrine emergent wetlands and an ephemeral stream channel, are summarized in Table 10.

Table 10. Wetlands Summary for the Flatirons Campus

Cowardin Classification	Area (acres [hectares])	Length (feet [meters])
Jurisdictional Areas (Waters of the United States)		
Palustrine emergent wetland	2.03 (0.82)	—
Non-Jurisdictional Areas		
Palustrine emergent wetland	5.50 (2.23)	—
Ephemeral stream channel	—	2,142 (653)

2020 Accomplishments and Highlights

- Submitted a wetland delineation (conducted in 2019) to the U.S. Army Corps of Engineers (USACE) and received an approved jurisdictional determination for the Middle Drainage area within the STM Campus. This information will be used to support future planning efforts associated with the development of the STM Campus.
- Conducted a wetland delineation within the Flatirons Campus and received an approved jurisdictional determination from the USACE. The information will be used for future planning associated with the development of the Flatirons Campus.

9.5 Cultural Resources

Cultural resources are defined as any prehistoric or historic district, site, building, structure, or object considered important to a culture, subculture, or community for scientific, traditional, religious, or other reasons. Cultural resources can be divided into three major categories:

- Prehistoric and historic archaeological resources
- Architectural resources
- Traditional cultural resources.

Much of the land currently occupied by the STM Campus was once part of Camp George West, a military facility operated by the Colorado National Guard from 1903 through the early 1930s. It was later leased to the federal government for military training purposes. Therefore, several formal surveys of historic and cultural resources have been performed on the STM Campus. And three historical resources have been identified as significant cultural resources that should be preserved under the Archeological and Historic Preservation Act of 1974. These three resources, which were constructed in the 1930s and early 1940s during the Works Progress Administration era, are located at the STM Campus. They include:

- An open-air amphitheater
- A stone bridge spanning a natural drainage channel adjacent to the amphitheater
- A stone and concrete ammunition "igloo" below the amphitheater.

The projection house still stands near the bottom of the Colorado Amphitheater. The Colorado Amphitheater, built in 1935, is a natural stone amphitheater that remains on the side of South Table Mountain, north of the STM Campus. The structure is listed on the National Register of Historic Places. *Photo by Werner Slocum, NREL 56821*

Through NREL's efforts, these structures have been added to the National Register of Historic Places, with the amphitheater and stone footbridge being listed together as a single resource. Additionally, a portion of the STM Campus south of Denver West Parkway lies within the 98-acre Camp George West Historic District.

A formal survey of the Flatirons Campus conducted in 1995[9] did not identify any additional significant historical or archeological resources.

2020 Accomplishments and Highlights

- Conducted a cultural resource survey within the three proposed RAIL construction sites and found no cultural resources within the three proposed sites: An archeologist concluded the development of the three proposed sites would have no adverse effects to cultural resources, including the Camp George West Historic District, the Colorado Amphitheater, or the ammunition igloo.
- Provided an overview of NREL's cultural resource program to the DOE Cultural Resource Management Coordinators Group via webinar.

9. Labat-Anderson, Inc. 1995. *Archaeological Assessment of the National Wind Technology Center.* January 1995.

Aerial photo of the STM Campus, showing a portion of the conservation easement in the background (front side and top of mesa). *Photo by Joshua Bauer, NREL 61729*

10 CONSERVATION LANDS

In 1999, DOE granted Jefferson County a conservation easement of 177 acres (72 hectares) at the STM Campus (see Figure 9).

A baseline inventory of the property was prepared in 1999 to document the condition of the easement property and to assess its conservation value.[10] The baseline inventory includes descriptions of the geographical setting and adjacent property owners, access and use of the property by the public, and the existing environmental conditions of the property (including geology, hydrology, vegetation, wildlife, and cultural resources). Vegetation within the easement area includes grasslands interspersed with shrubland communities and trees, primarily in the drainages. Several seeps also occur throughout the area.

The easement helps preserve the natural character of the property, including its visual, biological, and recreational resources. The goals of the easement are to:

- Retain, preserve, and protect natural, scenic, ecological, and historic resources
- Protect the ecosystem and provide sustainable habitat or diverse vegetation and wildlife
- Ensure the scenic and biological integration with adjoining open space land
- Prevent further industrial, commercial, or residential development
- Preserve the property as open space.

Local policies established by Jefferson County, the City of Golden, and the City of Lakewood reflect community sensitivity about the visual qualities provided by natural resources in the area around the STM Campus. Specifically, the Jefferson County General Land Use Plan characterizes North Table Mountain and South Table Mountain as "unique landscapes" and states that "maintaining landscapes that have a unique visual quality" is key to maintaining the quality of life in Jefferson County.

10. U.S. Department of Energy. Golden Field Office. 1999. *National Renewable Energy Laboratory (NREL) Site Conservation Easement Baseline Inventory.* Golden, Colorado.

Jefferson County Open Space maintains two formal trails that cross the conservation easement property and connect Denver West Parkway (near the STM Campus east entrance) to the trails on the mesa top. NREL staff, DOE staff, and the public use these trails frequently.

Each year, at least one visual inspection of the conservation easement property is conducted to identify management activities needed to address erosion, weed management, trail conditions, or other issues that may exist.

2020 Accomplishments and Highlights

- Inspected the conservation easement property in the summer and fall. Jointed goatgrass was found along one of the hiking trails and these areas were mowed, cut, and subsequently treated in August. Siberian elms were identified and flagged for future removal.
- Hosted Jefferson County Open Space for their annual assessment of the conservation easement property. The resulting Conservation Easement Annual Monitoring Report noted that NREL has previously identified some noxious weeds on the easement property and has been working, and continues to work, to control them.

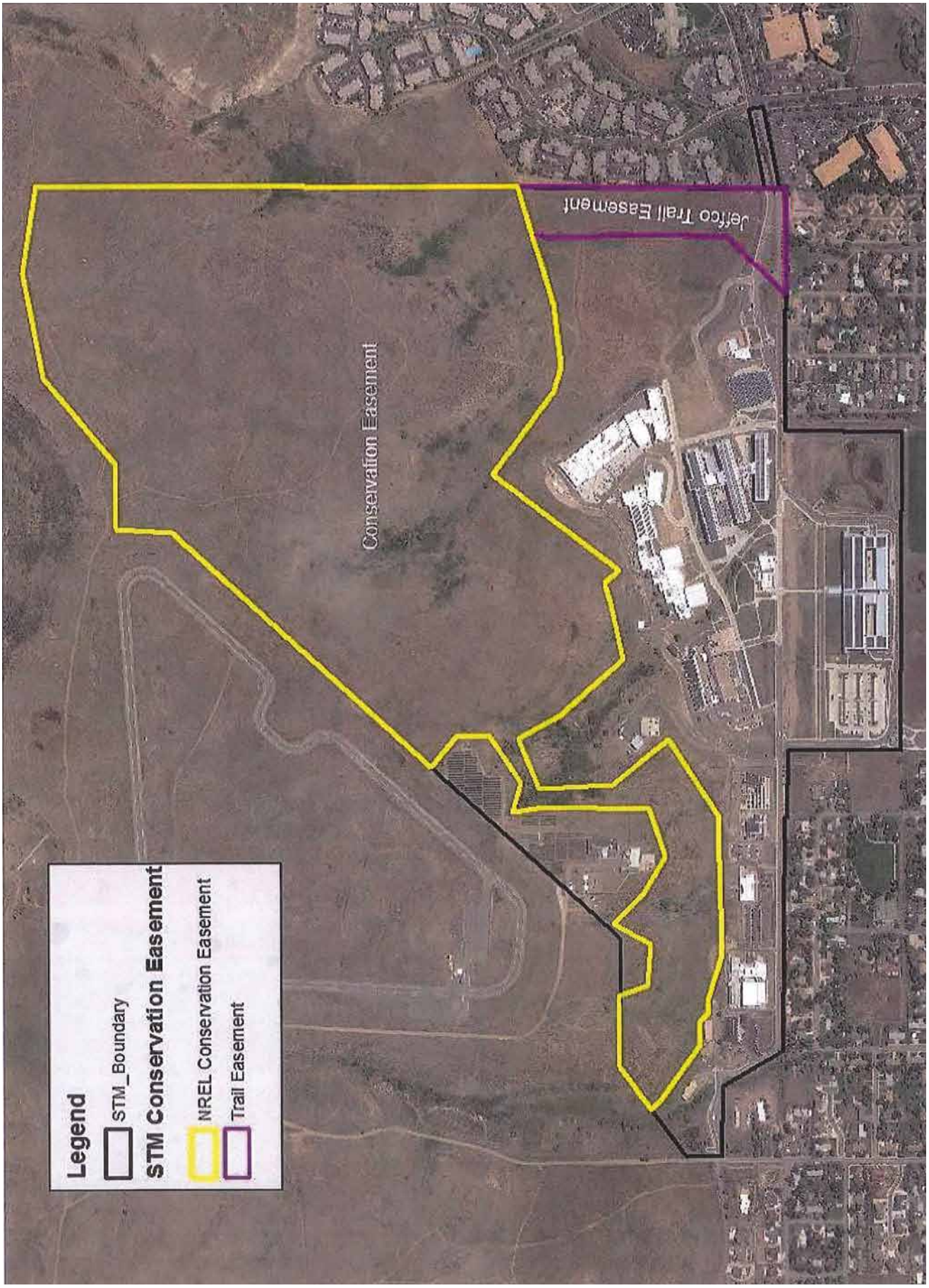


Figure 9. Conservation easement at the STM Campus

A twelve-spotted skimmer dragonfly (*Libellula pulschella*) lands on a plant near the Energy Systems Integration Facility. *Photo by Werner Slocum, NREL 62968*

APPENDIX A.
PROGRAM MANAGEMENT

Appendix A provides additional information about *how* NREL manages the environmental programs and activities described in the body of the report. For information about the laboratory's *performance* in a given area, refer to the specific section in the body of the report for that area.

Environmental Management System

NREL's EMS is implemented by:

- Establishing environmental policies and programs that guide site operations (including research and site development) and maintenance; these policies and programs undergo regular reviews and updates in pursuit of continuous improvement
- Identifying and complying with federal laws and regulations, state and local requirements, executive and DOE orders, and standards
- Identifying environmental stewardship goals and actions and regular planning to achieve them
- Verifying worker competence with regard to environmental requirements through various training programs
- Communicating within the laboratory to unify on environmental strategy and application
- Communicating with surrounding communities and regional agencies to collaborate on environmental goals
- Maintaining accurate document records and controls
- Monitoring and performing corrective actions
- Conducting internal and external program assessments
- Maintaining adherence to the ISO 14001 standard.

For details about 2020 performance in this area, see Section 2.1, Structure of NREL's Environmental Management System.

Pollution Prevention

The laboratory prevents pollution by implementing environmental and sustainability programs that cover

waste management and minimization, hazard identification and control, energy conservation, sustainable purchasing, sustainable transportation, water conservation, and sustainable building operation and maintenance.

For information about NREL's 2020 performance in this area, see Section 2.2, Pollution Prevention.

Sustainability

The sustainability program at NREL addresses multiple areas of sustainability, including GHG management and reduction, high-performance sustainable buildings, energy efficiency, renewable energy, water management, fleet management, waste management and reduction, sustainable procurement processes, climate change resiliency planning, community engagement, and changes in employee culture.

The program addresses sustainability using an integrated and holistic approach. For example, NREL is committed to the design, operation, and maintenance of high-performance sustainable buildings by employing building design and operation strategies that promote optimal performance and maximize life cycle asset value. These operational strategies can also support NREL's mission, which includes developing renewable energy projects, reducing overall laboratory energy and water usage, and improving sustainable work habits of employees. The sustainability program is able to leverage a variety of expertise and experience to integrate sustainable operations throughout the laboratory to improve performance and resilience.

In addition, the sustainability program works closely with researchers throughout the laboratory to continually develop partnerships that support NREL's mission while improving facility operations. NREL serves as both a living model of sustainability and a place to develop new clean energy ideas, technologies, and practices.

For information about NREL's 2020 performance in this area, see Section 3, Sustainability.

Resilience

NREL's resilience program is designed to (1) anticipate, prepare for, and adapt to changing conditions and (2) withstand, respond to, and recover rapidly from disruptions through adaptable and holistic planning and technical solutions. To accomplish these objectives, the laboratory has developed a list of actions to manage short- and long-term risks. Each year, the laboratory works to make progress on these action items.

For information about NREL's 2020 performance in this area, see Section 3.2, Resilience Planning.

Air Quality Protection

The objectives of NREL's air quality program are to minimize air emissions related both to research and employee commuting activities, monitor emissions from larger onsite sources, and meet all required emission standards and permitting requirements. Specific management practices relative to the types of air pollutants emitted are described in this section.

Criteria Pollutants and Hazardous Air Pollutants Permitting

The laboratory maintains an air-emission inventory to track potential emissions and identify whether future notification and permitting could be required for a particular facility or activity. Projected emissions for new sources are evaluated, and air-emission reporting and permitting are performed as required.

NREL maintains air permits issued by the State of Colorado for "minor" sources (such as standby electrical generators and pollution control systems) that are subject to minimal permit and compliance requirements.

The laboratory has a fugitive particulate emissions permit in place for the STM Campus because of construction activity over the last several years. The permit requires certain actions during earth-moving activities to minimize associated particulate emissions, such as applying water, limiting driving speeds, pausing construction activities in periods of high winds, and stabilizing stockpiled soils. To further minimize the generation of airborne particulates, NREL uses a non-sand deicer to maintain roadways. Avoiding the use of road sanding minimizes potential fugitive particulate emissions from snow removal operations, thus contributing to improved air quality for neighbors and meeting the Denver metropolitan area's requirement for controlling particulate matter emissions from onsite vehicle traffic.

For information about NREL's 2020 performance in this area, see Section 5.1, Criteria Pollutants and Hazardous Air Pollutants.

Greenhouse Gas Emissions Tracking and Permitting

Permitting and reporting of GHGs are not currently required for NREL facilities, as their emissions are below EPA permitting and reporting thresholds. EPA requires that carbon dioxide equivalent greenhouse gas emissions (CO_2e) from any source that is greater than 27,500 U.S. tons (25,000 MT) per year be reported to EPA annually. EPA also requires that a major source of criteria pollutants include CO_2e emissions in the major source permit if CO_2e emissions exceed 75,000 U.S. tons (68,000 MT) per year. Although the STM Campus is currently a major

source of criteria pollutants, it will be classified as a "synthetic minor" source by early 2021. Because CO_2e emissions for the STM and Flatirons Campuses are lower than both of the above-mentioned limits, GHG/CO_2e reporting is not required.

Certain GHGs are essential to safe operation of certain equipment. As an example, sulfur hexafluoride (SF_6), a potent greenhouse gas, is used in electrical equipment as a dielectric gas in high-voltage and high-amperage electrical equipment, such as circuit breakers, particle accelerators, some electron microscopes, and similar equipment. NREL maintains an equipment and gas inventory of equipment using SF6 and reports to DOE SF6 released to the atmosphere as a result of leaks or equipment failures.

For information about NREL's 2020 performance in this area, see Section 5.1, Criteria Pollutants and Hazardous Air Pollutants.

Refrigerant Management

The EPA and the State of Colorado regulate refrigerants to reduce emission of these compounds to the atmosphere. And the NREL refrigerant management program is intended to achieve that goal.

Management of refrigerants, including ODS, is accomplished by maintaining a detailed inventory of refrigerants and appliances containing more than one pound (0.45 kg) of any refrigerant. The inventory identifies (1) equipment that is subject to end-of-life disposal requirements and (2) larger appliances that are subject to detailed repair and documentation standards. NREL's management of refrigerants requires:

- Certification of repair technicians in accordance with EPA requirements
- Recovery of refrigerants before equipment repair and/or disposal
- Reuse or recycling of refrigerants
- Use of specific repair procedures
- Use of the smallest quantity and least harmful refrigerants possible, consistent with efficient research and facility operations.

Annual registration of the STM Campus and the Flatirons Campus as appliance repair facilities authorizes appliance repair activities at these locations. Annual registration with the State of Colorado of two STM Campus appliances is required because of the ODS refrigerant they contain.

For information about NREL's 2020 performance in this area, see Section 5.2, Refrigerants.

Drinking Water

Treated drinking water is provided to the STM Campus by Consolidated Mutual Water Company, a municipal water provider. Because of this, NREL does not have direct control over drinking water quality. However, NREL does maintain the integrity of the onsite distribution system and notifies Consolidated Mutual Water Company of any drinking water quality issues and complaints.

When treated municipal water is hauled to the Flatirons Campus, chlorine is added to achieve proper disinfectant levels at the points of use. Drinking water quality is maintained and protected through water quality testing as specified by the monitoring plan CDPHE issues each year. The plan identifies which tests are to be performed and at what frequency. Monthly tests are required for bacteria and disinfectant levels. Testing for disinfection byproducts (haloacetic acids [HAA5] and trihalomethanes [TTHM]), lead, and copper is completed annually.

For information about NREL's 2020 performance in this area, see Section 6.1, Drinking Water.

Groundwater

To protect groundwater quality, NREL carefully evaluates all outdoor projects to eliminate, substitute, or control potential sources of pollution. If any materials are used that pose a risk to groundwater, the laboratory incorporates safeguards such as secondary containment, double-walled tanks, leak detection, and collection and offsite disposal of concrete wash water.

When the laboratory conducts activities that could impact groundwater, NREL implements a monitoring program and groundwater monitoring wells are installed as needed. Occasionally groundwater wells may be installed and monitored to obtain water level data needed for construction or building maintenance purposes.

For information about NREL's 2020 performance in this area, see Section 6.2, Groundwater.

Surface Water

Surface water bodies to which NREL sites drain are protected by a management program that focuses on construction site runoff and outdoor research and maintenance activities.

For all construction projects, NREL implements an interdisciplinary planning and design process that includes NEPA review and assessment of design documents for potential impacts to stormwater and receiving waters. Design teams are encouraged to incorporate low-impact design elements that promote infiltration and evapotranspiration. NREL continues to monitor final design documents during construction for additional opportunities to reduce runoff volume and enhance runoff quality.

Erosion and sediment controls, proper chemical storage, fueling procedures, and good housekeeping practices are implemented during construction according to the stormwater management plans developed by contractors and reviewed by NREL staff. These documents are developed and reviewed for EPA-permitted sites as well as construction sites that do not require an EPA permit. Though construction projects that disturb less than 1 acre (0.40 hectare) are not regulated by the EPA, and they typically involve minimal disturbance within a short time frame, such projects still have the potential to contribute pollutants to stormwater runoff. These projects follow elements of the NREL stormwater pollution prevention program, including the development of a site-specific erosion and sediment control plan.

Contractors and staff conduct regular inspections throughout construction to verify that required controls are functioning properly. Any repairs or modifications to the plans are documented on an inspection report; prompt actions are required to correct any noncompliant conditions.

NREL manages areas outside active construction sites to minimize erosion, promote infiltration of rainwater and snowmelt, and prevent possible contamination of stormwater from exposure to materials stored outdoors. These objectives are accomplished by landscaping with native materials, revegetating site areas that have experienced a loss of vegetative cover, incorporating "low-impact development" elements in NREL design guidelines for new construction and redevelopment, and storing materials with the potential to contaminate stormwater either indoors or under cover.

The STM Campus operates under an EPA Region 8 Municipal Separate Storm Sewer System (MS4) permit that became effective in December 2018. During the first 5-year permit term, programs will be developed that are needed for compliance with the permit's six minimum control measures. The programs will be instituted in subsequent permit terms.

For information about NREL's 2020 performance in this area, see Section 6.3, Surface Water.

Wastewater

The wastewater management program is multifaceted and encompasses activities across the site, from using "green" cleaning supplies to minimizing the use harmful chemicals in laboratory operations. The program addresses the requirements of the Metro Wastewater Reclamation District, which receives and treats waste from the STM Campus, and it protects the groundwater aquifers to which the leach fields at the Flatirons Campus and STM Campus' mesa top drain.

NREL has design guidelines for construction of new buildings and refurbishment of existing buildings to minimize the possibility of a hazardous material discharge. Examples of these requirements include measures to preclude inadvertent spills to sink drains, prohibition of floor drains in laboratory areas unless a specific need can be shown, and mandatory caps for floor drains that are installed in laboratory areas. New research and operations activities, as well as ongoing activities that undergo significant modifications, are reviewed through NREL's risk assessment process for their potential effect on wastewater. Regular training on appropriate rinsing and disposal practices when dealing with hazardous chemicals is provided to laboratory staff.

For information about NREL's 2020 performance in this area, see Section 6.4, Wastewater.

Hazardous Materials Management

In addition to EPCRA reporting obligations, a cornerstone of NREL's hazardous material management program is its laboratory-wide chemical management system. The system serves as a centralized chemical inventory and is a valuable tool for managing and reporting chemicals used at the laboratory. Using an electronic barcoding system, the chemical management system tracks chemicals from point of receipt through end use and disposal. The system also contains technical data and reporting information for many of the chemicals in the chemical management system's database. Key functions of the system include:

- Providing current inventories by room, building, and campus
- Improving research efficiency and minimizing hazardous waste generation by allowing staff to determine whether needed chemicals are already available onsite before purchasing them
- Providing quick access to chemical inventories and hazard information during emergency responses
- Facilitating accurate and efficient reporting to external agencies (e.g., fire districts, state and local emergency response agencies, EPA, and DOE).

The chemical management system tracks chemical amounts, locations, and hazards, which helps NREL rigorously manage hazardous materials. Researchers and safety personnel ensure chemicals are properly stored in locations suitable for their hazards (e.g., storing flammable materials in designated flammables cabinets).

When requested by the state and local emergency response agencies or local fire departments, additional emergency response and reporting information is provided. NREL has been represented on the Jefferson County Local Emergency Planning Committee since its inception and is involved in the emergency planning concepts of EPCRA. NREL currently has two active members on the committee.

Emergency response plans are also in place in the event of a spill or release of a hazardous material; these plans are coordinated with state and local emergency planning and response agencies and first responders such as West Metro Fire Rescue, Rocky Mountain Fire Rescue, and the Jefferson County Local Emergency Planning Committee.

For information about NREL's 2020 performance in this area, see Section 7.1, Hazardous Materials Management.

Hazardous Waste Management

Waste management and minimization efforts begin in the planning stages of all experimental and operational activities. Processes are evaluated based on the quantities and toxicities of products that will be brought onsite before an activity begins, and evaluations continue until material use is complete and materials are ready for disposal. Hazardous materials proposed for use are also assessed for the potential substitution of less hazardous products to lessen the hazardous waste stream.

The laboratory is committed to the appropriate management of regulated waste generated through its daily operations. These wastes are handled, stored, and disposed of responsibly and in accordance with regulatory requirements to minimize the potential for health and environmental impacts that could result from a release or improper disposal.

Implementation of regulatory requirements includes:

- A documented waste management and minimization program
- Annual training for all staff members who generate or handle regulated waste
- Regular inspection and tracking of all waste containers
- Storage, packaging, shipment, and tracking of wastes until final disposition at a properly permitted waste disposal or recycling facility
- Active monitoring of waste volumes to determine generator status
- Maintenance of records that are generated through "cradle-to-grave" waste management activities.

For select unregulated materials that still pose a potential hazard, NREL follows a conservative waste management policy wherein nonhazardous materials are collected and disposed of as nonhazardous materials at properly permitted disposal facilities. For example, nonhazardous nanomaterial-bearing wastes are not federally regulated but, because they pose a potential health risk, they are managed and disposed of using the same management methods used for hazardous waste. Waste streams are accumulated onsite for time frames that are well within regulatory limits before being shipped for final disposal. In a general order-of-management preference, hazardous waste items are shipped offsite for final disposal via incineration, treatment, or landfill. Universal wastes are recycled or reclaimed.

For information about NREL's 2020 performance in this area, see Section 7.2, Hazardous Waste Management.

Aboveground Storage Tank Management

The AST management program applies to petroleum fuel tanks and is intended to ensure compliance with requirements and minimize releases from tanks. The program consists of inspections, tank maintenance, training, and spill preparedness. Personnel who operate and manage ASTs are trained annually on program requirements, including inspection and response requirements, the spill history of each site, lessons learned, and recent changes to rules and regulations.

Several important mechanical and procedural safeguards have been incorporated into NREL's AST management program to prevent an accidental release of diesel or E-85 fuel from the storage tanks. Mechanical safeguards include overfill and spill protection, double-walled tanks equipped with sensors that result in an alarm if the inner tank wall is leaking, and secondary containment for single-walled tanks. Procedural safeguards include written operating and tank-filling procedures, monthly and annual inspections, and recordkeeping of inspection results. ASTs with more than 60 gallons (227 L) of capacity are visually inspected monthly, and all double-walled ASTs are inspected annually to confirm the absences of the interstitial liquid.

For information about NREL's 2020 performance in this area, see Section 7.3, Aboveground Storage Tank Management.

Petroleum Spill Prevention and Response

The laboratory prepares for and continually improves spill response procedures. Formal SPCC plans have been developed and are periodically updated for the Flatirons Campus, the STM Campus, and the ReFUEL Laboratory. The plans are designed to minimize the number and size of spills, as well as facilitate the efficient cleanup of spilled materials. SPCC plans are updated every 3 years or whenever regulations, operations, or equipment changes significantly. The laboratory's aggressive approach to spill prevention and control exceeds the EPA's requirement that SPCC plans be updated at least every 5 years.

Emergency notification and hazardous materials procedures are in place to provide additional support for spill response. Proper preventive planning and training minimizes the potential for spills, and advance preparation for spill response protects water and ecological resources.

SPCC training occurs annually for individuals who are responsible for oil-containing equipment and AST operation and maintenance. Training covers inspection and response

requirements, location and use of spill response equipment, identification of spill control locations, and notification and spill reporting protocols.

The laboratory typically does not experience spills that require notification to federal or state agencies. Small, incidental hydraulic system leaks, lubricant leaks, and fuel transfer spills might occasionally occur. NREL policy is that spills, regardless of their size, are to be reported to appropriate internal responders; this policy makes clear that reporting of and responding to any spill are important to NREL and DOE. Lessons learned from spill incidents and clean-up activities are used to improve management and spill response planning.

Spill response kits containing sorbent materials are strategically placed at each NREL facility near where spills might occur. Spill kits are periodically evaluated as laboratory activities change over time.

For information about NREL's 2020 performance in this area, see Section 7.4, Petroleum Spill Prevention and Response.

Radiological Materials

Through its radiation safety program, NREL has established strict protocols for radiation-generating devices, equipment containing sources of radiation, and the use of radioisotopes in laboratory experiments. These protocols include:

- Confining work with radioisotopes to a small number of specific laboratories
- Limiting the types and quantities of radioisotopes onsite
- Monitoring equipment and facilities for removable contamination or sealed-source leakage.

No radioactive air emission monitoring is conducted at the laboratory because of the extremely low use of radioactive materials. In lieu of monitoring, NREL demonstrates compliance with radiological air emission standards by using an EPA computer model (COMPLY Version 1.6) to determine the effective dose equivalent to the public.

Current laboratory procedures prohibit any activity that might result in a radioactive waste that is federally regulated under the Resource Conservation and Recovery Act and is categorized as "mixed waste." Therefore, all radioactive waste generated is classified solely as low-level radioactive waste. Waste is temporarily stored onsite until disposal is arranged at an offsite facility permitted to accept low-level radioactive waste.

For information about NREL's 2020 performance in this area, see Section 7.5, Radiological Materials and Waste Management.

NEPA

Once a project is proposed, the NEPA process is initiated, and it must be completed before the proposed project or activity begins. In accordance with regulations, all NREL activities (both on and offsite) must undergo a NEPA review to evaluate and understand the potential environmental impacts of a project. The outcome of such a review is the NEPA determination. A final NEPA determination must be signed before federal funds are expended, before a contract award can be made, and before project activities begin.

NREL and DOE Golden Field Office use site-wide environmental assessments to streamline the environmental review process. These documents represent comprehensive analyses of potential environmental impacts associated with NREL's current and future actions over 5–10 years at both the STM Campus and the Flatirons Campus. The environmental assessments serve as planning tools that aid ongoing and future operational and development decisions related to NREL's sites. The site-wide environmental assessments for the STM Campus and the Flatirons Campus provide a baseline environmental analysis that streamlines future environmental reviews, improves and coordinates site and agency planning, and maximizes cost savings.

NREL and the DOE Golden Field Office have developed several programmatic NEPA determinations to further streamline the environmental review process for recurring activities that have minimal environmental impacts. These activities generally involve business and administrative actions, information gathering and technical advice, and bench-scale research and development. The programmatic NEPA determinations are based on the existing site-wide environmental assessments or DOE categorical exclusions and are reviewed annually for applicability and appropriateness.

Using the site-wide environmental assessment and programmatic NEPA determinations, DOE and NREL analyze administrative, operational, and research activities, and they place each in one of three categories to streamline the environmental review process:

- Require No Further NEPA Review: Actions under this category have been assessed by DOE and NREL and have been determined to have negligible environmental impacts.
- Require a NEPA Sufficiency Review: These actions might have minimal potential for environmental impacts and might require a sufficiency review by the NREL NEPA Coordinator.
- Require Further NEPA Review and Documentation by DOE: Actions in this category have a greater potential for environmental impacts, involve actions with a federal agency or foreign government, or require the application of a categorical exclusion. DOE must complete the NEPA review.

If a proposed activity has not already been evaluated in an existing site-wide environmental assessment or programmatic NEPA determination, further environmental analysis must be

conducted. Potential environmental impacts of an activity are evaluated and measures are taken as needed to avoid or minimize those impacts. The level of review conducted is appropriate to the potential impacts of the proposed activity. For example, a proposed construction project would receive a more rigorous review than routine office or laboratory work.

For information about NREL's 2020 performance in this area, see Section 8, National Environmental Policy Act Compliance.

Wildlife Management

The wildlife management program was developed to implement measures to meet or exceed regulatory requirements and minimize or avoid impacts to wildlife species and their habitats. Regulatory requirements include those of the Migratory Bird Treaty Act, a U.S. Fish and Wildlife Service (USFWS) statute prohibiting the harassment of wildlife (including damaging/destroying dens or nests), a memorandum of understanding between DOE and the USFWS to promote the conservation of migratory bird populations, and a presidential memorandum to promote the health of bees and other pollinators.

Several laboratory activities help achieve the program's intent, including the following:

- Monitoring: The laboratory conducts nesting bird surveys before any ground- or vegetation-disturbing activities are conducted between mid-March and mid-September every year. If nests are found in an area, it is closed and a buffer area is established until nestlings fledge. Staff also periodically conduct site-wide surveys to document biological conditions.
- Project Reviews: Biologists conduct project reviews to assess and reduce potential impacts to wildlife.
- Coordination: Biologists coordinate with local, state, and federal agencies to improve wildlife management in concert with surveys for threatened and endangered species and habitats. Because habitat is as much of a concern as the wildlife species themselves, program activities often overlap with vegetation management.

Other program goals include maintaining wildlife movement through the STM Campus by retaining access to the adjacent conservation easement north of the site and to Pleasant View Community Park and Lena Gulch to the south. At the Flatirons Campus, ecologically sensitive areas and linkages with surrounding open space areas are preserved.

When control of pest wildlife species is needed, a graded approach is used to humanely control pests and minimize other potential impacts. Building design features and administrative controls are the first line of defense against pests. When these are not fully effective, additional controls are used. Native wildlife pests are relocated whenever possible. When pests must be destroyed, mechanical methods are preferred over poisoning. When needed, pesticides are selected that pose the least-harmful effects to nontarget wildlife.

For information about NREL's 2020 performance in this area, see Section 9.1, Wildlife Management.

Endangered Species and Species of Concern

NREL conducts periodic surveys at the Flatirons Campus and STM Campus to determine the presence or absence of species that are listed under the ESA as threatened or endangered. These include the Preble's meadow jumping mouse (*Zapus hudsonius preblei*), and the Ute ladies' tresses orchid (*Spiranthes diluvialis*). The USFWS has designated critical habitat associated with the Preble's meadow jumping mouse within the upper reaches of Rock Creek, including a small area at the southeastern corner of the Flatirons Campus. This area may not be disturbed without coordination with the USFWS.

Species of special concern listed by the USFWS on the Information for Planning and Consultation website,[11] as well as species listed by the State of Colorado as rare plants, species of special concern, or species of greatest conservation concern are surveyed. These baseline surveys, which are typically conducted every 5 years, are a vital part of the laboratory's NEPA program by which impacts to natural resources from mission activities are assessed.

In accordance with the ESA, the USFWS lists five species in the Platte River watershed in Nebraska that must be considered for projects in Colorado and Wyoming that may deplete water supplies to the Platte River system. For any NREL activities that may deplete water in the Platte River system, consultation with the USFWS must be completed to determine potential impacts.

For information about NREL's 2020 performance in this area, see Section 9.2, Endangered Species and Species of Concern.

11."IPaC Information for Planning and Consultation," U.S. Fish and Wildlife Service, https://ecos.fws.gov/ipac/

Vegetation Management

The focus of NREL's vegetation management program is to:

- Conserve existing ecosystems in their natural state as much as possible
- Strive to replace disturbed vegetation with native species, or with adapted but noninvasive species when necessary
- Implement a program of weed management to prevent the spread of noxious weeds and implement measures to control these species.

To maintain existing native vegetation and to ensure the success of revegetated areas, the laboratory has developed sustainable landscape management practices that:

- Provide supplemental water during seedling growth and establishment, and minimize water use thereafter
- Reduce the need for and use of pesticides and fertilizers
- Reduce maintenance costs
- Maximize ground cover to reduce soil erosion
- Establish a variety of habitats to support diverse wildlife
- Create an aesthetically pleasing landscape.

When removal of native vegetation cannot be avoided, reseeding is done using mixes of grass and forb seed that is native to the local area. A suite of native flowering plants, shrubs, and trees has been identified for use on both the STM Campus and the Flatirons Campus to enhance ecosystem diversity and integrity. NREL staff continually evaluate and modify revegetation techniques as needed to promote healthy plant establishment.

NREL participated in a Sustainable Sites Initiative two-year pilot program (2010–2012) established by the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center at the University of Texas at Austin, the United States Botanic Garden, and a diverse group of other stakeholders. The pilot program was intended to develop the first national rating system for sustainable landscapes. Certification under the program demonstrates that the stewardship activities needed for sustaining healthy ecosystems are being implemented. NREL developed and submitted a plan for implementing sustainable landscape practices and received a rating of three out of four stars. The plan is now integrated into NREL's landscape maintenance plan and other relevant site-wide procedures. Integrated components of the plan include plant stewardship, invasive species management, organic materials management, soil stewardship, irrigation and water use, stormwater management, materials management, snow and ice management, and monitoring. The Sustainable Sites Initiative also serves as a critical foundation that supports NREL's objective in creating adaptive and resilient sites to meet the challenge of dynamic climate changes.

NREL uses an integrated weed management approach that incorporates various types of weed control methods, including:

- Mechanical practices (e.g., mowing or pulling weeds by hand)
- Cultural practices (e.g., reclaiming disturbed areas)
- Prevention (e.g., limiting or eliminating driving of vehicles off established roadways)
- Biological practices (e.g., introducing living organisms such as fungus or insects that have a preference for certain weed species)
- Treatment using herbicides.

The use of multiple strategies for control has been successful in significantly reducing populations of diffuse knapweed (*Centaurea diffusa*) and Canada thistle (*Cirsium arvense*). The weed control program maintains the flexibility needed to respond to changes in weed populations from year to year. Periodic mapping of weed infestation areas helps target weed control efforts.

The laboratory continues to address the control of these species using the integrated weed management approach described above, and periodically assess the effectiveness of these control methods. At the STM Campus and the Flatirons Campus, comprehensive weed surveys and mapping are performed approximately every 5 years and smaller areas are assessed annually.

For information about NREL's 2020 performance in this area, see Section 9.3, Vegetation Management.

Wildfire Risk Management

Because wildfires have the potential to affect DOE property and impact operational activities, NREL has developed a fire protection program that addresses wildfire. To protect buildings, infrastructure, and outdoor research from wildfire, NREL evaluates the wildland-urban interface on DOE properties. Areas within the interface are actively managed to reduce fuel sources. Management activities include mowing vegetation, herbicide application in graveled areas, and shrub and tree removal where applicable. At both the STM Campus and the Flatirons Campus, vegetation management is balanced with maintaining native vegetation and wildlife habitat.

For information about NREL's 2020 performance in this area, see Section 9.3, Vegetation Management.

Imported Plants and Organisms

The vegetation management program also addresses the use of certain animal (i.e., pathogen) and plant species brought to the laboratory for research purposes, primarily for biofuels and biomaterials investigations. Some of the plants and pathogens obtained from other states or from outside the United States are controlled by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS), and they require permitting to protect against their release into either the immediate work area or to the outside environment. In addition to the required management practices identified in APHIS-issued permits, management of these materials is also controlled through NREL's Biosafety Program. This program provides guidance to researchers on various aspects of working with biological materials, such as the identification of materials that can and cannot be used at NREL, when approvals are required by NREL's Institutional Biosafety Panel, and good laboratory practices.

For information about NREL's 2020 performance in this area, see Section 9.3, Vegetation Management.

Wetlands and Floodplains

Functional wetlands, whether regulated (jurisdictional) or unregulated (non-jurisdictional), are considered valuable features that serve many ecological functions, and the laboratory seeks to protect these to the maximum extent practicable from site development.

NREL protects its wetlands and floodplains by:

- Periodically surveying vegetation and conducting wetland delineations
- Mapping wetland areas potentially affected by proposed construction
- Identifying and minimizing potential impacts
- Coordinating with other jurisdictions on the control of floodwaters leaving the STM Campus or the Flatirons Campus.

Wetland delineations are periodically conducted and submitted to the U.S. Army Corps of Engineers (USACE) to ensure regulated and unregulated wetlands are properly identified. For information about NREL's 2020 performance in this area, see Section 9.4, Wetlands and Floodplains.

Cultural Resources

Cultural resources are protected by:

- Integrating cultural resource management into site activities, and minimizing and mitigating impacts to historic properties and features
- Implementing procedures to manage historic features and protect undiscovered cultural resources and artifacts
- Periodically conducting surveys to document the presence or absence of cultural or historic resources and working with the Colorado Office of Archaeology and Historic Preservation to determine how to proceed should any evidence of cultural resources be discovered in surveys or ground-disturbing activities; for example, workers are to stop all work in the vicinity of a potential find until a qualified archaeologist evaluates its significance.

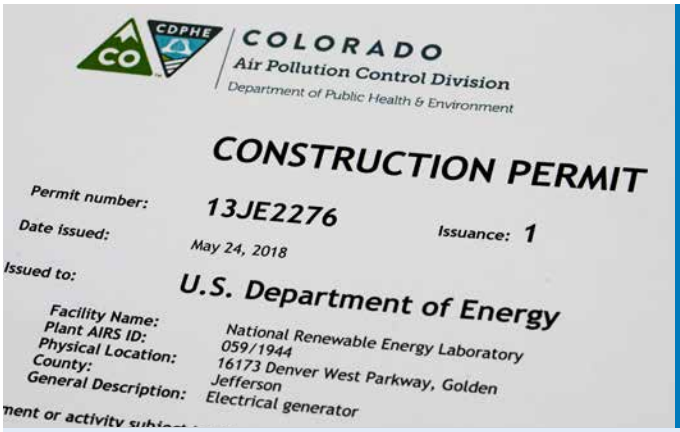
For information about NREL's 2020 performance in this area, see Section 9.5, Cultural Resources.

Conservation Lands

Approximately 177 acres (72 hectares) at the STM Campus have been granted by DOE to Jefferson County as a conservation easement. This area is maintained by NREL as a natural landscape. Each year, at least one visual inspection of the conservation easement property is conducted to identify management activities needed to address erosion, weed management, trail conditions, or other potential issues.

At the Flatirons Campus, approximately 60 acres (24 hectares) of land are managed as a conservation area. Development is limited in this area, and the land is managed to conserve specific features, including seeps, ephemeral drainages, ponds, wetlands, native grassland habitat, areas supporting ancient soils (i.e., a soil structure in association with plant species forming a stable ecological community that is resistant to weed invasion), a small area designated as critical habitat for the Preble's meadow jumping mouse, and a rocky outcropping supporting ponderosa pine and shrublands.

For information about NREL's 2020 performance in this area, see Section 10, Conservation Lands.



APPENDIX B. ENVIRONMENTAL PERMITS, REGISTRATIONS, AND NOTIFICATIONS

NREL obtains numerous permits and registrations to ensure environmental compliance. *Photo by Werner Slocum, NREL 56778*

Table B-1. Environmental Permits, Registrations, and Notifications in 2020

Location: Description	Category	Issuing Agency	ID	Permit or Registration Status
Air				
Laboratory-wide: servicing of CFC-containing equipment	Notification	APCD	647	Completed
STM Campus: Solar Energy Research Facility: 2 CFC-containing stationary sources	Registration	APCD	647	Completed
STM Campus: FTLB: waste gas combustor	Permit	APCD	99JE0400	Active
STM Campus: Renewable Fuel Heat Plant: wood waste boiler	Permit	APCD	07JE0277	Active
STM Campus: fugitive dust from construction activities	Permit	APCD	08JE0889L	Active
STM Campus: Research Support Facility 1: diesel-fired standby electrical generator	Permit	APCD	10JE1400	Active
STM Campus: Research Support Facility 2: diesel-fired standby electrical generator	Permit	APCD	11JE1303	Active
STM Campus: FTLB: diesel-fired standby electrical generator	Permit	APCD	10JE1630	Active
Flatirons Campus: Site 4.0: diesel-fired standby electrical generator	Permit	APCD	10JE1712	Active
STM Campus: Energy Systems Integration Facility: diesel-fired standby electrical generator	Permit	APCD	11JE3542	Active
STM Campus: Energy Systems Integration Facility: research electrical generator #3	Permit	APCD	13JE2829	Active
STM Campus: Integrated Biorefinery Facility: ammonia scrubber and baghouse	Permit	APCD	11JE1798	Active
STM Campus: Energy Systems Integration Facility: research electrical generator #1	APEN	APCD	12JE1734 XP	Active

Location: Description	Category	Issuing Agency	ID	Permit or Registration Status
STM Campus: Energy Systems Integration Facility: research electrical generator #2	APEN	APCD	12JE1735 XP	Active
STM Campus: Integrated Biorefinery Facility: standby electrical generator	Permit	APCD	13JE2276	Active
Flatirons Campus STL: standby electrical generator	APEN	APCD	13JE2271 XP	Active
Flatirons Campus Building 251: standby electrical generator	APEN	APCD	13JE2272 XP	Active
Flatirons Campus CoMET: facility composite demonstration facility	APEN	APCD	16JE0934 XP	Active
Flatirons Campus Site 4.4: diesel-fired standby electrical generator	APEN	APCD	13JE2270 XP	Active
STM Campus: Science and Technology Facility: standby electrical generator	APEN	APCD	13JE2274 XP	Active
STM Campus: Solar Energy Research Facility: standby electrical generator	APEN	APCD	13JE2275 XP	Active
Alcohol				
STM Campus: Integrated Biorefinery Facility: alcohol fuel production	Permit	Alcohol and Tobacco Tax and Trade Bureau (U.S. Department of the Treasury)	AFP-CO-00255	Active
Laboratory-wide: tax-free alcohol use	Permit	Alcohol and Tobacco Tax and Trade Bureau (U.S. Department of the Treasury)	US-TF-20125	Active
Animals, Plants				
STM Campus: controlled import permit to import *Agrobacterium tumefaciens* from within the United States	Permit	APHIS	P526-19-02851	Active
STM Campus: controlled import permit to import *Sphingobium* . from Japan	Permit	APHIS	P526P-18-02318	Active
Drinking Water				
Flatirons Campus: drinking water system ID number	Registration	CDPHE Water Quality Control Division	CO0230860	In effect; does not expire
Groundwater				
STM Campus: FTLB: groundwater monitoring well MW-FTLB-1	Permit	State of Colorado Division of Water Resources	301322	Terminated
STM Campus: FTLB: groundwater monitoring well MW-FTLB-2	Permit	State of Colorado Division of Water Resources	301323	Terminated
STM Campus: FTLB: groundwater monitoring well MW-FTLB-3	Permit	State of Colorado Division of Water Resources	301324	Terminated

Location: Description	Category	Issuing Agency	ID	Permit or Registration Status
Hazardous materials				
STM Campus: Waste Handling Facility: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
STM Campus: Solar Energy Research Facility: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
STM Campus: Science and Technology Facility: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
STM Campus: FTLB: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
STM Campus: Integrated Biorefinery Facility: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
STM Campus: Shipping and Receiving: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
Denver West Business Park: Building 16: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
STM Campus: Energy Systems Integration Facility: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
ReFUEL Laboratory: hazardous material storage and use permit	Permit	Denver Fire Department	197016	Completed
Hazardous waste				
Denver West Business Park: Building 16: RCRA hazardous waste generator status EPA ID	Notification	CDPHE Hazardous Materials and Waste Management Division	CO4890000017	Completed
STM Campus: RCRA hazardous waste generator status EPA ID	Notification	CDPHE Hazardous Materials and Waste Management Division	CO3890090076	Completed
Joyce Street Facility: RCRA hazardous waste generator status EPA ID	Notification	CDPHE Hazardous Materials and Waste Management Division	COD980805162	Completed (pending closure)
Flatirons Campus: RCRA hazardous waste generator status EPA ID	Notification	CDPHE Hazardous Materials and Waste Management Division	COD983902448	Completed
ReFUEL Laboratory: RCRA hazardous waste generator status EPA ID	Notification	CDPHE Hazardous Materials and Waste Management Division	COR000207563	Completed

Location: Description	Category	Issuing Agency	ID	Permit or Registration Status
Historic resource				
STM Campus: amphitheater	Registration	National Park Service	93000378	In effect; does not expire
STM Campus: stone bunker	Registration	National Park Service	93000379	In effect; does not expire
Stormwater				
STM Campus: Solar Energy Research Facility and Science and Technology Facility: landscape /site improvements	Permit	EPA	COR10F00K	Active
Flatirons Campus: site improvements, power generation upgrade, and secondary feeder	Permit	EPA	COR10F028	Terminated
STM Campus: Municipal separate storm sewer system (MS4)	Permit	EPA	COR042009	Active

Acronyms used in the table:

APCD Air Pollution Control Division (CDPHE)

APEN Air Pollutant Emission Notice

APHIS Animal and Plant Health Inspection Service (U.S. Department of Agriculture)

AST aboveground storage tank

CDPHE Colorado Department of Public Health and Environment

CFC chlorofluorocarbon

CoMET Composites Manufacturing Education and Technology

EPA Environmental Protection Agency (United States)

FTLB Field Test Laboratory Building

RCRA Resource Conservation and Recovery Act

ReFUEL Renewable Fuels and Lubricants (Laboratory)

STM South Table Mountain

A Red-tailed Hawk (*Buteo jamaicensis*) perches on a wire near the Integrated Biorefinery Research Facility. Hawks are just one of the several types of birds and other wildlife that are frequently sighted at the STM Campus. *Photo by Werner Slocum, NREL 63046*

APPENDIX C.
WILDLIFE SPECIES OBSERVED AT THE STM AND FLATIRONS CAMPUSES

This appendix lists the wildlife species observed at the STM Campus and the Flatirons Campus. Species listed for the STM Campus (Table C-1) were observed by staff and/or were observed in surveys completed in 1987, 2005, 2011, and 2017.[12] Species listed for the Flatirons Campus (Table C-2) were identified in surveys completed in 1996, 2003, 2011, and 2016.[13]

Table C-1. Wildlife Species at the STM Campus

Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Birds				
American Coot	*Fulica americana*			X
American Crow	*Corvus brachyrhynchos*	X	X	X
American Goldfinch	*Carduelis tristis*		X	X
American Kestrel	*Falco sparverius*	X	X	X
American Pipit	*Anthus rubescens*		X	X
American Redstart	*Setophaga ruticilla*		X	X
American Robin	*Turdus migratorius*	X	X	X
American Tree Sparrow	*Spizella arborea*	X	X	
American White Pelican	*Pelecanus erythrorhynchos*		X	
Bald Eagle[a]	*Haliaeetus leucocephalus*			
Barn Swallow	*Hirundo rustica*		X	X
Black-billed Magpie	*Pica hudsonia*	X	X	X
Black-capped Chickadee	*Poecile atricapilla*	X		X

12. For 1987 survey results, refer to NREL (National Renewable Energy Laboratory). 2016. *Environmental Performance Report 2016: Annual Site Environmental Report per the U.S. Department of Energy Order 231.B Chg 1*. Golden, CO: National Renewable Energy Laboratory. NREL/MP-1900-68671. https://www.nrel.gov/docs/fy17osti/68671.pdf.

13. For the 1996 survey results, refer to NREL. 2016. *Environmental Performance Report 2015: Annual Site Environmental Report per the U.S. Department of Energy Order 231.B.* Golden, CO: National Renewable Energy Laboratory. NREL/MP-1900-65807. https://www.nrel.gov/docs/fy16osti/65807.pdf.

Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Black-crowned Night Heron	*Nycticorax nycticorax*	X		
Black-headed Grosbeak	*Pheucticus melanocephalus*		X	
Blue-gray Gnatcatcher	*Polioptila caerulea*		X	
Blue Jay	*Cyanocitta cristata*	X	X	
Blue-winged Teal[a]	*Spatula discors*			
Brewer's Blackbird	*Euphagus cyanocephalus*		X	
Brewer's Sparrow	*Spizella breweri*		X	X
Broad-tailed Hummingbird	*Selasphorus platycercus*		X	X
Broad-winged Hawk	*Buteo platypterus*		X	
Brown-headed Cowbird	*Molothrus ater*	X	X	X
Bullock's Oriole	*Icterus bullockii*	X	X	X
Bushtit	*Psaltriparus minimus*		X	
California Gull	*Larus californicus*	X		
Canada Goose	*Branta canadensis*	X	X	
Cedar Waxwing	*Bombycilla cedrorum*		X	
Cassin's Kingbird	*Tyrannus vociferans*		X	X
Chestnut-collared Longspur	*Calcarius ornatus*		X	
Chipping Sparrow	*Spizella passerina*		X	X
Clay-colored Sparrow	*Spiella pallida*			X
Cliff Swallow	*Petrochelidon pyrrhonota*		X	X
Common Grackle	*Quiscalus quiscula*		X	X
Common Nighthawk	*Chordeiles minor*	X	X	X
Common Raven	*Corvus corax*	X	X	X
Common Yellowthroat	*Geothlypis trichas*			X
Cooper's Hawk	*Accipiter cooperii*	X	X	
Dark-eyed Junco	*Junco hyemalis*	X	X	X
Double-crested Cormorant	*Phalacrocorax auritus*		X	X
Eastern Kingbird	*Tyrannus tyrannus*		X	
Eurasian Collared-Dove	*Streptopelia decaocto*			X

Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
European Starling	*Sturnus vulgaris*	X	X	X
Golden Eagle	*Aquila chrysaetos*	X		
Grasshopper Sparrow	*Ammodramus savannarum*		X	
Gray Catbird	*Dumetella carolinensis*			X
Great Blue Heron	*Ardea herodias*	X	X	
Great Horned Owl	*Bubo virginianus*			X
Greater Roadrunner[a]	*Geococcyx californianus*			
Green-tailed Towhee	*Pipilo chlorurus*		X	
Hammond's Flycatcher	*Empidonax hammondii*			X
Hepatic Tanager	*Piranga flava*		X	
Hermit Thrush	*Catharus guttatus*		X	
Horned Lark	*Eremophila alpestris*		X	
House Finch	*Carpodacus mexicanus*	X	X	X
House Sparrow	*Passer domesticus*	X	X	X
House Wren	*Troglodytes aedon*		X	X
Killdeer	*Charadrius vociferous*	X	X	
Lark Bunting	*Calamospiza melanocorys*	X		
Lark Sparrow	*Chondestes grammacus*		X	X
Lazuli Bunting	*Passerina amoena*		X	
Lesser Goldfinch	*Carduelis psaltria*		X	X
Lincoln's Sparrow	*Melospiza lincolnii*			X
Loggerhead Shrike	*Lanius ludovicianus*	X		
MacGillivray's Warbler	*Oporornis tolmiei*	X		
Mallard	*Anas platyrhynchos*	X		
Mountain Bluebird	*Sialia currucoides*	X		X
Mountain Chickadee	*Poecile gambeli*		X	
Mourning Dove	*Zenaida macroura*	X		X
Northern Flicker	*Colaptes auratus*	X		X
Northern Goshawk	*Accipiter gentilis*		X	

Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Northern Harrier	*Circus cyaneus*	X		X
Northern Mockingbird	*Mimus polyglottos*			X
Northern Pygmy-Owl	*Glaucidium californicum*			X
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*			X
Northern Saw-whet Owl[a]	*Aegolius acadicus*			
Orange-crowned Warbler[a]	*Oreothlypis celata*			
Osprey	*Pandion haliaetus*	X		X
Peregrine Falcon	*Falco peregrinus*		X	
Pine Siskin	*Carduelis pinus*		X	
Prairie Falcon	*Falco mexicanus*	X		X
Red-breasted Nuthatch	*Sitta canadensis*	X		X
Red-tailed Hawk	*Buteo jamaicensis*	X		X
Red-winged Blackbird	*Agelaius phoeniceus*			X
Rock Dove	*Columba livia*	X		X
Rock Wren	*Salpinctes obsoletus*	X		
Ruby-crowned Kinglet	*Regulus calendula*		X	
Sage Thrasher	*Oreoscoptes montanus*		X	X
Say's Phoebe	*Sayornis saya*	X		X
Sharp-shinned Hawk	*Accipiter striatus*		X	X
Spotted Towhee	*Pipilo maculates*	X		X
Swainson's Hawk	*Buteo swainsoni*	X		
Tree Swallow	*Tachycineta bicolor*	X	X	X
Turkey Vulture	*Cathartes aura*	X		X
Vesper Sparrow	*Pooecetes gramineus*	X		X
Virginia's Warbler	*Oreothlypis virginiae*		X	
Violet-green Swallow	*Tachycineta thalassina*		X	X
Western Kingbird	*Tyrannus verticalis*	X		X
Western Meadowlark	*Sturnella neglecta*	X		X
Woodhouse's (Western) Scrub-Jay	*Aphelocoma californica*	X		X

Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
White-crowned Sparrow	*Zonotrichia leucophrys*	X		X
White-faced Ibis	*Plegadis chihi*		X	
White-throated Swift	*Aeronautes saxatalis*		X	
Wilson's Snipe	*Gallinago delicata*	X		
Yellow Warbler	*Setophaga petechia*			X
Yellow-breasted Chat	*Icteria virens*		X	X
Yellow-rumped Warbler	*Dendroica coronata*		X	
Mammals				
Big brown bat[a]	*Eptesicus fuscus*			
Black bear[a]	*Ursus americanus*			
Black-tailed jackrabbit	*Lepus californicus*		X	
Bobcat[a]	*Lynx rufus*			
Bushy-tailed woodrat[a]	*Neotoma cinerea*			
Common muskrat[a]	*Ondatra zibethicus*			
Coyote	*Canis latrans*	X	X	
Deer mouse	*Peromyscus maniculatus*		X	
Elk[a]	*Cervus canadensis*			
Fox squirrel	*Sciurus niger*	X		
Hoary bat	*Lasiurus cinereus*			X
Long-tailed weasel	*Mustela frenata*	X		
Mexican woodrat	*Neotoma mexicana*	X	X	
Mountain cottontail	*Sylvilagus nuttalli*	X	X	X
Mule deer	*Odocoileus hemionus*	X	X	X
Prairie vole	*Microtus ochrogaster*	X		
Raccoon	*Procyon lotor*	X	X	
Red fox	*Vulpes*		X	
Striped skunk	*Mephitis*		X	
Western harvest mouse	*Reithrodontomys megalotis*	X	X	
Western spotted skunk	*Spilogale gracilis*		X	

Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
White-tailed jackrabbit	*Lepus townsendii*	X		
Reptiles and Amphibians				
Boreal chorus frog	*Pseudacris maculata*		X	X
Bull snake	*Pituophis catenifer*		X	
Plains garter snake	*Thamnophis radix*	X		
Prairie lizard	*Sceloporus consobrinus*		X	
Six-lined racerunner	*Cnemidophorus sexlineatus*	X		
Wandering garter snake[a]	*Thamnophis elegans*			
Tiger salamander	*Ambystoma tigrinum*	X	X	X
Western (Prairie) rattlesnake	*Crotalus viridus*	X	X	
Woodhouse's toad	*Anazyrus woodhousii*		X	
Yellow-bellied Racer	*Coluber constrictor*		X	

[a] Species observed at a time other than during a survey

Table C-2. Wildlife Species at the Flatirons Campus

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Birds				
American Crow	*Corvus brachyrhynchos*		X	
American Goldfinch	*Spinus tristis*	X	X	
American Kestrel	*Falco sparverius*	X	X	X
American Pipit	*Anthus rubescens*		X	
American Robin	*Turdus migratorius*	X	X	X
American Tree Sparrow	*Spizella arborea*		X	
Bald Eagle	*Haliaeetus leucocephalus*		X	
Barn Swallow	*Hirundo rustica*	X	X	X
Black-billed Magpie	*Pica hudsonia*	X	X	X
Black-capped Chickadee	*Poecile atricapillus*	X	X	
Blue-gray Gnatcatcher	*Polioptila caerulea*	X		X
Blue Jay	*Cyanocitta cristata*		X	
Brewer's Blackbird	*Euphagus cyanocephalus*	X	X	X
Brewer's Sparrow	*Spizella breweri*		X	

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Broad-tailed Hummingbird	*Selasphorus platycercus*	X	X	X
Broad-winged Hawk[a]	*Buteo platypterus*			
Brown-headed Cowbird	*Molothrus ater*	X	X	
Bullock's Oriole	*Icterus bullockii*		X	X
Canada Goose	*Branta canadensis*		X	X
Cedar Waxwing	*Bombycilla cedrorum*		X	
Chipping Sparrow	*Spizella passerina*	X	X	
Cliff Swallow	*Petrochelidon pyrrhonota*	X		
Common Grackle	*Quiscalus quiscula*	X	X	
Common Nighthawk	*Chordeiles minor*	X		X
Common Raven	*Corvus corax*	X	X	X
Cooper's Hawk[a]	*Accipiter cooperii*			
Dark-eyed Junco	*Junco hyemalis*		X	
Double-crested Cormorant	*Phalacrocorax auritus*	X		X
Downy Woodpecker	*Picoides pubescens*		X	
Eurasian Collared-Dove	*Streptopelia decaocto*		X	
European Starling	*Sturnus vulgaris*	X	X	X
Ferruginous Hawk	*Buteo regalis*	X	X	
Franklin's Gull	*Larus pipixcan*		X	
Golden Eagle[b]	*Aquila chrysaetos*	X	X	
Grasshopper Sparrow	*Ammodramus savannarum*	X	X	X
Gray Catbird	*Dumetella carolinensis*		X	X
Great Blue Heron	*Ardea herodias*	X	X	X
Great Horned Owl	*Bubo virginianus*		X	X
Green-tailed Towhee	*Pipilo chlorurus*	X		X
Hairy Woodpecker	*Picoides villosus*		X	
Horned Lark	*Eremophila alpestris*	X	X	
House Finch	*Carpodacus mexicanus*	X	X	X
House Wren	*Troglodytes aedon*			X
Killdeer	*Charadrius vociferus*		X	X
Lark Bunting	*Calamospiza melanocorys*		X	
Lark Sparrow	*Chondestes grammacus*	X		X

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Loggerhead Shrike	*Lanius ludovicianus*		X	
Long-billed Curlew	*Numenius americanus*		X	
Mallard	*Anas platyrhynchos*	X	X	
Mountain Bluebird	*Sialia currucoides*	X	X	
Mountain Chickadee	*Poecile gambeli*		X	
Mourning Dove	*Zenaida macroura*	X	X	X
Northern Flicker	*Colaptes auratus*	X	X	
Northern Harrier	*Circus cyaneus*	X	X	
Peregrine Falcon	*Falco peregrinus*	X	X	
Prairie Falcon	*Falco mexicanus*	X		
Red-headed Woodpecker	*Melanerpes erythrocephalus*		X	
Red-tailed Hawk	*Buteo jamaicensis*	X	X	X
Red-winged Blackbird	*Agelaius phoeniceus*	X	X	X
Rough-legged Hawk	*Buteo lagopus*	X	X	
Ruby-crowned Kinglet	*Regulus calendula*		X	
Sandhill Crane	*Grus canadensis*		X	
Savannah Sparrow	*Passerculus sandwichensis*		X	
Say's Phoebe	*Sayornis saya*	X	X	X
Song Sparrow	*Melospiza melodia*		X	X
Spotted Towhee	*Pipilo maculatus*		X	X
Swainson's Hawk	*Buteo swainsoni*		X	
Townsend's Solitare	*Myadestes townsendi*		X	
Tree Swallow	*Tachycineta bicolor*		X	
Turkey Vulture	*Cathartes aura*	X	X	
Vesper Sparrow	*Pooecetes gramineus*	X	X	X
Western Kingbird	*Tyrannus verticalis*	X	X	X
Western Meadowlark	*Sturnella neglecta*	X	X	X
Western Wood Peewee	*Contopus sordidulus*			X
Wilson's Snipe	*Gallinago delicata*		X	X
Wilson's Warbler	*Wilsonia pusilla*	X		
Yellow-rumped Warbler	*Dendroica coronata*	X		

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Mammals				
Big brown bat	*Eptesicus fuscus*		X	X
Black-tailed prairie dog[a]	*Cynomys ludovicianus*	X		
Bobcat	*Felis rufus*			X
Coyote	*Canis latrans*		X	X
Deer mouse	*Peromyscus maniculatus*		X	X
Desert cottontail	*Sylvilagus audubonii*		X	X
Eastern red bat	*Lasiurus borealis*		X	X
Elk	*Cervus canadensis*		X	X
Fringed myotis[b]	*Myotis thysanodes*		X	X
Hoary bat	*Lasiurus cinereus*		X	X
Little brown myotis[b]	*Myotis lucifuaus*		X	X
Masked shrew	*Sorex cinereus*		X	X
Meadow vole	*Microtus pennsylvanicus*		X	X
Mexican woodrat	*Neotoma mexicana*		X	X
Mountain lion	*Puma concolor*			X
Mule deer	*Odocoileus hemionus*		X	X
Myotis bat	*Myotis sp.*		X	X
Prairie vole	*Microtus ochrogaster*		X	X
Silver-haired bat	*Lasionycteris noctivagans*		X	X
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*		X	
Western harvest mouse	*Reithrodontomys megalotis*		X	X
Western small-footed myotis	*Myotis ciliolabrum*		X	X
White-tailed deer	*Odocoileus virginiana*			X
Yellow-bellied marmot[a]	*Marmota flaviventris*			
Reptiles and Amphibians				
Boreal chorus frog	*Pseudacris maculata*		X	X
Bull snake	*Pituophis catenifer*		X	X
Northern leopard frog[b]	*Lithobates pipiens*			X
Tiger salamander	*Ambystoma tigrinum*			X
Western (Prairie) rattlesnake	*Crotalus viridus*	X	X	X
Woodhouse's toad	*Anazyrus woodhousii*		X	X

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Terrestrial Arthropods[c]				
Aphrodite fritillary	*Speyeria aphrodite*		X	
Cabbage white	*Pieris rapae*		X	
Checkered white	*Pontia protodice*		X	
Common wood nymph	*Cercyonis pegala*		X	
Dainty sulphur	*Nathalis iole*		X	
Gray hairstreak	*Strymon melinus*		X	
Orange sulphur	*Colias eurytheme*		X	
Western white	*Pontia occidentalis*		X	

[a] Species were observed at a time other than during a survey.

[b] Colorado State Species of Highest Conservation Need, Tier 1, 2015

[c] Terrestrial arthropods were surveyed in 2011 and only at Flatirons Campus.

Blue flax (*Linum lewisii*) are some of the many flowers that grow on the hillside of the conservation easement north of the STM Campus. *Photo by Werner Slocum, NREL 56755*

APPENDIX D.
PLANT COMMUNITIES AT THE STM AND FLATIRONS CAMPUSES

Vegetation surveys are periodically completed for the STM and the Flatirons Campuses, with the most recent surveys occurring at the STM Campus in 2017 and at the Flatirons Campus in 2016. In those recent surveys, plant communities and species were identified for each site, and changes from previous surveys are noted below.

STM Campus Plant Communities

Most vegetation at the STM Campus belongs to the grassland community type. Within that association, there are two distinct community types: short grassland on the mesa top and mixed grassland on the mesa slopes and toe areas. Other mapped vegetation communities at the STM Campus include ravine shrubland, tall shrubland, short shrubland, and wetlands. The plant communities are described below and mapped as illustrated in Figure D-1.

Short Grassland

Short grassland is found on the flat top of the mesa. The dominant grass species are blue grama (*Chondrosum gracile*), a native prairie species, and cheatgrass (*Anisantha tectorum*), a noxious weed. Populations of diffuse knapweed (*Acosta diffusa*) and Dalmatian toadflax (*Linaria genistifolia subsp. Dalmatica*) are scattered throughout the whole community; these two noxious weeds comprise approximately 1% of the short grassland.

Alyssum (*Alyssum parviflorum*), an introduced species, is the dominant forb. Several species of prickly pear cactus (*Opuntia fragilis, O. macrorhiza, O. phaeacantha, and O. polyacantha*) occur throughout the short grassland on the mesa top, as does hen and chicks (*Echinocereus viridiflorus*) and pincushion cacti (*Coryphantha missouriensis* and *C. vivipara var. vivpara*). Well-draining hillocks often support thick stands of needle-and-thread grass (*Hesperostipa comata*) and yucca (*Yucca glauca*). Some short shrubs such as rubber rabbitbrush (*Chrysothamnus nauseosus* subsp.), chokecherry (*Padus virginiana*), and skunkbrush (*Rhus aromatica* subsp. *Trilobata*) appear infrequently in the short grassland area and concentrate along the rimrock areas. Several large hackberry trees (*Celtis reticulata*) are clustered at the very edge of the mesa top.

Historically, the short grassland on the mesa top was most likely dominated by blue grama grass and other short-grass species such as buffalo grass (*Buchloë dactyloides*), intermixed with the other species associations described above. However, the entire mesa top area has become dominated by cheatgrass, an aggressive noxious weed. This weed is changing the appearance and general species composition of the area by outcompeting native plants.

Mixed Grassland

On the STM Campus, the mesa slopes and toe areas also support blue grama and cheatgrass but are dominated by a mixed-grass species association of needle-and-thread grass and western wheatgrass (*Pascopyrum smithii*), with smaller amounts of big bluestem (*Andropogon gerardii*), sideoats grama (*Bouteloua curtipendula*), three-awn (*Aristida purpurea*), and green needlegrass (*Nassella viridula*). As in the short grassland areas, a large number of forbs are also found in the mixed grasslands.

A few patches of anomalous vegetation occur within the mixed grasslands where subsurface water appears to be close to the surface. These areas support wide swaths of mat muhly (*Muhlenbergia richardsonis*). One such area is on a south-facing slope near the eastern property boundary. The other is on a southwest-facing slope of the ravine north of the NREL Education Center; this area is notable for a large population of poison ivy (*Toxicodendron rydbergii*), which grows in thickets of tall (>3 feet [>1 m]) plants that have a woody, shrub-like growth form. A small number of plains cottonwood (*Populus deltoides*) saplings, skunkbrush, chokecherry, and snowberry occur in this patch as well.

The mixed-grass areas grade into both the upland and ravine shrublands and contribute most of the understory in these areas. Some mixed-grass areas also blend into disturbed areas, where reclamation species, such as crested wheatgrass (*Agropyron cristatum*) and smooth brome (*Bromus inermis*), have been planted and have subsequently spread into the mixed-grass community.

Upland Shrublands

Upland shrubland habitat occurs along the upper sides of ravines and on the steeper mesa slopes, and it becomes more prominent as elevation increases up to the top of the mesa. The upland shrubland habitat, which excludes the shrublands in the ravine bottoms, comprises tall shrubland and short shrubland communities that are very similar in overall composition but distinguished by the dominant species.

Tall Shrubland

The tall shrubland areas are defined by stands of mountain mahogany (*Cercocarpus montanus*) that occur along the rim of the mesa, usually where volcanic cap rock is exposed, and on the upper mesa slopes below rimrock areas. The understory, with a large amount of bare soil, is notably sparse throughout this community. Cheatgrass is the most common herbaceous species in these areas, and it is intermixed with needle-and-thread grass, yucca, and many cacti.

Short Shrublands

The short shrublands occur on elevated flat areas amidst the surrounding grasslands, some of which appear to have experienced surficial disturbance in the past. These areas are distinctive because of the dominance of rubber rabbitbrush. The other common location for short shrublands is on the outer slopes of the ravines. Skunkbrush defines these and other short shrublands along the upper portions of the steepest slopes of the mesa. These communities usually grade into the ravine shrublands along the drainage bottoms and the tall shrublands near the top of the mesa slopes. The short shrubland community also has a sparse understory of the same grasses and forbs as the tall-shrub community.

Ravine Shrublands

Ravine shrublands are limited to the lower sides and bottoms of the drainages that cut down through the mesa slopes. These communities support a variety of shrubs such as skunkbrush, chokecherry, and wild plum (*Prunus americana*), which often grow in dense, impassible thickets. A few plains cottonwoods and peachleaf willow (*Salix amygdaloides*) trees occur at the top of the ravine channels and in other portions of the channel where the water table appears to be higher. A diverse herbaceous component is found in these drainages. In one instance near the southeastern boundary, a ravine shrubland grades into an ephemeral drainage at the toe of the mesa. This drainage is vegetated with grassland species and conveys only occasional surface water runoff.

Wetlands Vegetation

Five small communities on the STM Campus have been identified as supporting wetland vegetation. These have been roughly quantified as measuring less than 0.5 acre (0.2 hectare in total.

One is in a shallow swale at the mouth of the ravine at the southwestern corner of the site boundary where surface water and/or subsurface drainage have created a pocket of saturated soil. Species here include sedges (*Carex* spp.), rushes (*Juncus*

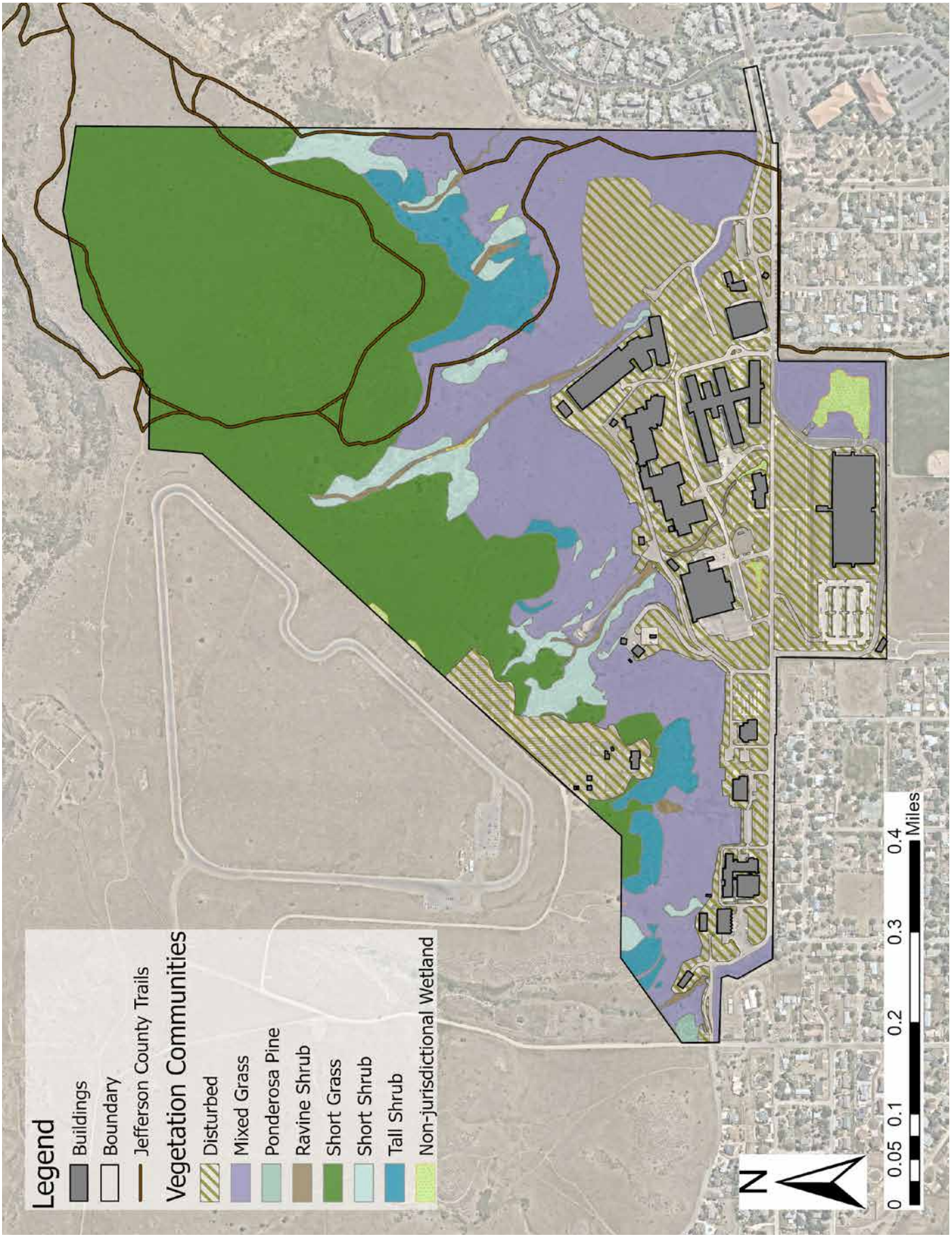


Figure D-1. STM Campus land cover types surveyed in 2017

spp.), bulrush (*Schoenoplectus* spp.), and peachleaf willow. The area at the mouth of the ravine may no longer experience the hydrology that originally allowed these plants to establish there. In 2002, this plant community supported populations of cattails that were not observed in the 2011 survey.

The second area may have been formed as a result of past construction activities. This linear depression supports wetland vegetation along the central portion of the western site boundary, northeast of the photovoltaic array. Perhaps situated where equipment was once staged, this area appears to hold seasonal water for enough consecutive growing seasons to support some wetland vegetation, including Arctic rush (*Juncus arcticus*), American speedwell (*Veronica americana*), and broadleaf cattail (*Typha latifolia*).

Three small seeps are located on the hillslope between the Education Center and the public trail on the far eastern boundary of the STM Campus. These seeps are dominated by sedges, rushes, and Canada thistle (*Cirsium arvensis*).

A sixth community that was once observed[14] no longer appears to support wetland vegetation.

In 2002, cattail species near an old stock tank in the eastern-most drainage area appeared to have been supported by a pipe draining an area within the hillside. Although the stock tank was observed in the 2011 survey, it appears the cattails have not persisted in the intervening years.

Disturbed/Reclaimed Land

This habitat type comprises all the areas at the site that have experienced surface disturbance to vegetation caused by human activities. These activities mostly occur on the perimeter of the buildings, roads, parking lots, and soil stockpile areas. Most of these areas appear to have been revegetated and support a combination of native grassland plants, planted ornamental revegetation species, and native and introduced weeds.

Flatirons Campus Plant Communities

Most of the vegetation at the Flatirons Campus belongs to the mixed-grass prairie association of the grassland formation. Mixed-grass prairie is defined by the presence of grass species typical of the tallgrass or true prairie such as big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and prairie dropseed (*Sporobolus heterolepis*), with species more typical of the short-grass prairie such as blue grama (*Chondrosum gracile*) and buffalo grass (*Buchloë dactyloides*). Intermediate grasses (mid-grasses), such as the needle grasses (*Hesperostipa and Nassella* spp.), wheat grasses (*Pascopyron, Agropyron, Elytrigia, Elymus,* and *Thinopyrum* spp.), and blue grasses (*Poa* spp.), are also important constituents of mixed-grass prairie.

The grasslands at the Flatirons Campus fall into the xeric mixed-grassland community type that are identified and classified primarily on available soils and soil moisture, and which are reflected in xeric mixed-grassland plant species assemblages.

Several changes in vegetation patterns noted since the Flatirons Campus was previously mapped are discussed below, by specific plant community. In addition, the plant communities are described and mapped as illustrated in Figure D-2.

Mixed Grassland

This community is distinguished from the non-native grassland community by the higher cover of native grasses and forbs. Native species typically make up 50%–60% of the vegetative cover. Common grasses in this community include smooth brome, Kentucky bluegrass, Canada bluegrass, big bluestem, little bluestem, switchgrass, and purple three-awn. Common forbs in this community include scurfpea, fringed sage (*Artemisia frigida*), prairie sage (*Artemisia ludoviciana*), and hairy golden aster (*Heterotheca villosa*).

Non-Native Grassland

The non-native grassland community is the most common community type at the Flatirons Campus. It is dominated by introduced pasture grasses, including smooth brome, Kentucky bluegrass, and Canada bluegrass. Non-native species make up 65%–90% of the vegetative cover in this community. Commonly observed forb species include alyssum (*Alyssum simplex*), Canada horseweed (*Conyza canadensis*), fringed sage, prairie sage, scurfpea, and hairy golden aster. Native grasses within this community, particularly big bluestem and switchgrass, occur most frequently along roadside depressions, possibly because additional soil moisture from precipitation runoff is captured there.

Disturbed Native Grassland

This community occurs along the northern fence line of the Flatirons Campus. Total vegetative cover in this community ranges from 30% to 70%, and exposed soil in this community consists of coarse gravel. The proximity of this community to machinery and buildings, the abundance of exposed ground, and the gravelly soil texture indicate this area has been significantly disturbed by human activity. However, this community has the highest vegetative cover of native grasses

14. Unpublished report (*2017 Vegetation and Wildlife Surveys at the National Renewable Energy Laboratory, South Table Mountain, Jefferson County, Colorado*) prepared for NREL by Two Dot Consulting.

within the Flatirons Campus. This community is dominated by purple three-awn, big bluestem, and switchgrass. Other commonly observed species in this community include non-native grasses such as smooth brome and ruderal weed species, including common sunflower (*Helianthus annuus*), prickly lettuce (*Lactuca serriola*), common mullein (*Verbascum thapsus*), and bigbract verbena (*Verbena bracteata*).

Non-Native Yucca Grassland

This community is very similar in composition to the non-native grassland community, but it is distinguished by the presence of stands of yucca (*Yucca glauca*) shrubs. Yucca typically occurs as scattered individuals throughout the grassland communities at the Flatirons Campus. In the areas identified as non-native yucca grassland, yucca occurs at a higher density than in the surrounding grassland, and the structural change from the surrounding grasslands warrants its inclusion as a separate community. Dominant grass species in this community include downy brome (*Bromus tectorum*), smooth brome, Kentucky bluegrass, and intermediate wheatgrass (*Thinopyrum intermedium*).

Degraded Grassland

The degraded grassland community has been heavily influenced by human disturbance and is dominated by non-native and noxious grass species with minimal native vegetation (typically less than 10%). The dominant species in this community are downy brome and intermediate wheatgrass. Downy brome is a List-C Noxious Weed in Colorado. An area near the southwest corner of the Flatirons Campus contains significant bare soil that is dominated by annual and biennial weed species, including kochia (*Bassia scoparia*), downy brome, and common sunflower. The soil in this area has a distinctive reddish color that is visible in recent aerial imagery. The degraded grassland community along the western boundary of the Flatirons Campus is possibly influenced by historical and ongoing disturbance that may originate from offsite activities.

Ponderosa Pine Woodland

This community occurs along a granite outcrop located in the northwestern corner of the Flatirons Campus. Dominant tree and shrub species include ponderosa pine (*Pinus ponderosa*), skunkbrush sumac (*Rhus trilobata*), wax currant (*Ribes cereum*), and wild plum (*Prunus americana*). Understory vegetation consists of native and non-native grass and forb species. Common species include smooth brome, crested wheatgrass (*Agropyron cristatum*), junegrass (*Koeleria macrantha*), sulfur cinquefoil (*Potentilla recta*), golden banner (*Thermopsis rhombifolia*), harebell (*Campanula rotundifolia*), and James' nailwort (*Paronychia jamesii*).

Mixed Shrubland

The mixed shrubland community occurs on the southeastern end of the same granite outcrop that supports the ponderosa pine woodland. The southeastern end of this outcrop is lower and less exposed than where the ponderosa pine woodland occurs. Dominant shrub species include wax currant, skunkbrush sumac, chokecherry, and western serviceberry (*Amelanchier alnifolia*). This community supports higher cover and diversity of native grasses and forbs than the surrounding non-native grassland community. Common grasses in this community include smooth brome, Kentucky bluegrass, big bluestem, junegrass, and sideoats grama (*Bouteloua curtipendula*). Common forbs include scurfpea, prairie sage, golden banner, hairy golden aster, and sulphur flower (*Eriogonum umbellatum*). An isolated group of hawthorn (*Crataegus erthyropoda*) shrubs occurs along the western site boundary within the Flatirons Campus site boundary. These trees are at the top of the slope, directly east of an active area of construction disturbance that is outside the Flatirons Campus boundary.

Palustrine Emergent Wetlands

Palustrine emergent wetlands have been identified at the Flatirons Campus.[15] Dominant species in these communities include broadleaf cattail (*Typha latifolia*), Arctic rush (*Juncus arcticus*), common spikerush (*Eleocharis palustris*), and Nebraska sedge (*Carex nebrascensis*). Other commonly observed species include foxtail barley (*Hordeum jubatum*), Torrey's rush (*Juncus torreyi*), cloaked bulrush (*Scirpus pallidus*), and willowherb (*Epilobium*) species. Patches of smooth brome, Kentucky bluegrass, big bluestem, and western wheatgrass (*Pasocpyrum smithii*) occur on the fringes of these wetland communities.

A large palustrine emergent wetland occurs south of the solar array in Row 1 of the array. The southernmost road separates this large wetland from a second smaller wetland along the southern fence line of the Flatirons Campus. These wetlands are hydrologically connected and supported by seepage from a reservoir south of the property boundary. Capture of surface water runoff provides additional hydrology to these wetlands. Hydrological support has evidently increased since 2011, as the area was dominated by obligate wetland species and surface water was present throughout the area in the 2016 field surveys.

15. Cowardin, Lewis M., Virginia Carter, Edward T. LaRoe, and Francis C. Golet. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* Washington, D.C.

Another palustrine emergent wetland occurs south of the solar array in Row 3 of the array. This wetland consists of a large stand of cattails (*Typha* spp.) and foxtail barley surrounded by sandbar willow (*Salix exigua*) and plains cottonwood (*Populus deltoides*) trees.

Headwater—Riparian Emergent Wetland

Headwater or riparian emergent wetland communities occur within the two prominent drainages in the eastern half of the Flatirons Campus (Figure D-2), both of which show evidence of an ephemeral channel; both drainages are tributaries to Rock Creek. Dominant species within these wetlands include Arctic rush, foxtail barley, Nebraska sedge, and prairie cordgrass (*Spartina pectinata*). Significant patches of Canada thistle, bull thistle (*Cirsium vulgare*), and common teasel (*Dipsacus fullonum*), all List-B noxious weeds, occur within the northernmost drainage. Other observed species include shortbeak sedge (*Carex brevior*), swordleaf rush (*Juncus ensifolius*), longstyle rush (*Juncus longistylis*), Torrey's rush, common spikerush, and switchgrass. Occasional plains cottonwood trees and sandbar willow shrubs occur along these drainages.

Disturbed/Non-Habitat

These cover types reflect surface disturbance that is due to human activities on the site. These areas include roadsides, pad sites, parking lot perimeters, construction sites, and storage areas. Some of these areas have been revegetated and now include a combination of species from surrounding natural plant communities, reclamation species, and adventive (non-native) or ruderal (native or adventive, disturbance colonizer) species. Dominant species noted include smooth brome cheatgrass. (These areas are not specifically called out in Figure D-2.)

Ornamental Trees/Shrubs

Disturbed areas around buildings have been planted with a combination of native and ornamental trees and shrubs. Planted trees include multiple species of junipers (*Sabina* spp.) and pines (*Pinus* spp.), interspersed with ornamental deciduous trees. Shrubs in these areas are mainly chokecherry and rose (*Rosa* spp.) bushes. (These areas are not specifically called out in Figure D-2.)

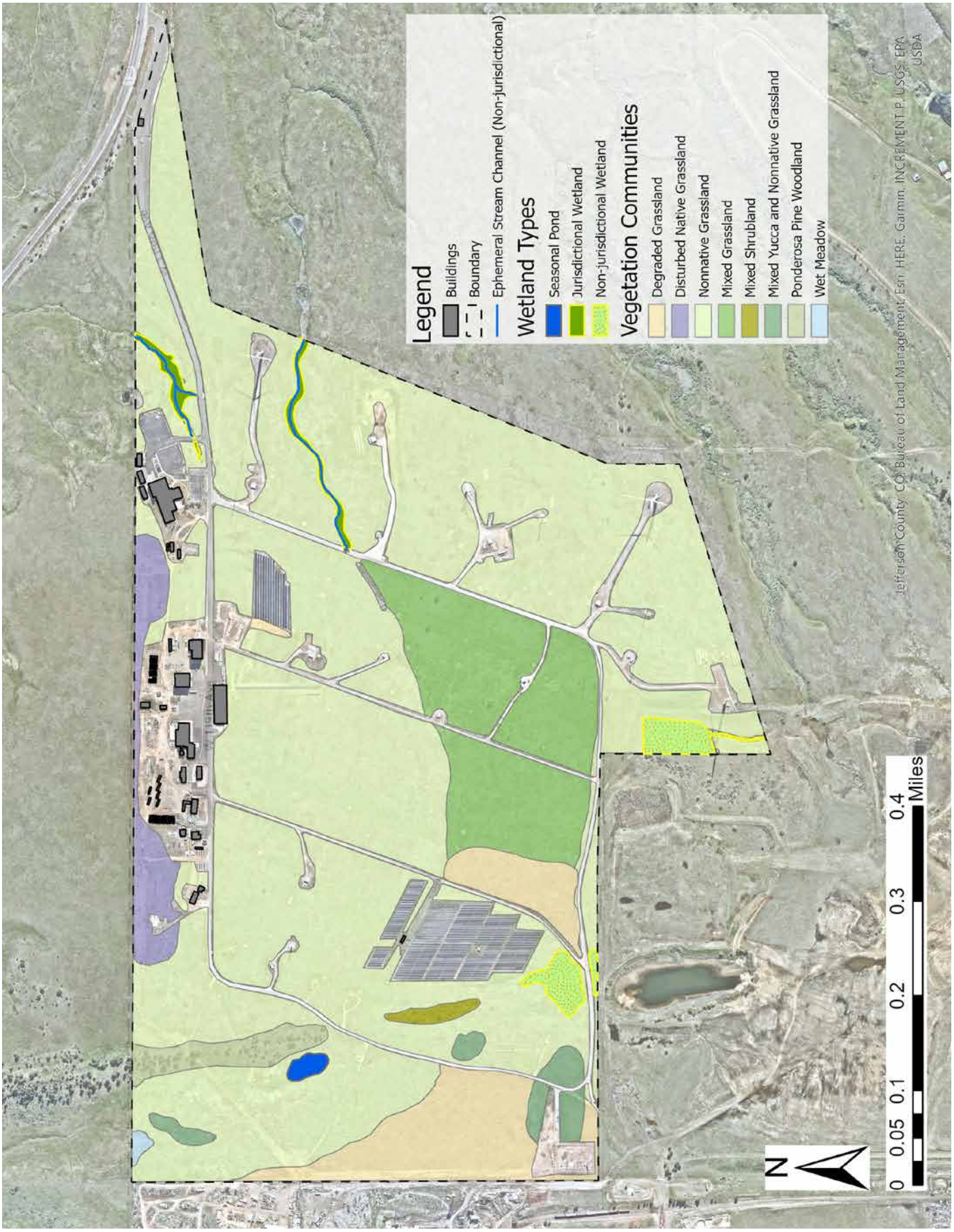


Figure D-2. Flatirons Campus land cover types surveyed in 2016

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