

ENVIRONMENTAL PERFORMANCE REPORT 2021

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

Cover Photo: A photovoltaic array at the NREL Flatirons Campus is in the foreground with Flatirons above Boulder, Colorado, in the background. *Photo by Werner Slocum, NREL 67730.*

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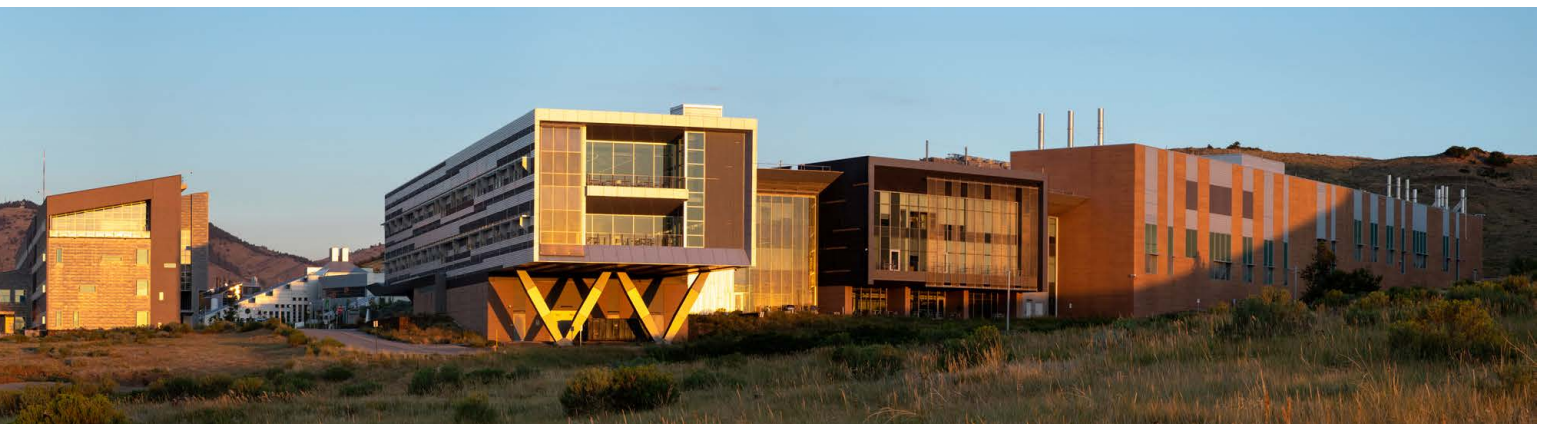
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NOMENCLATURE

APEN	air pollutant emission notice	GHG	greenhouse gas
APHIS	Animal and Plant Health Inspection Service	HAA5	haloacetic acids
AST	aboveground storage tank	HAP	hazardous air pollutants
CCR	Colorado Code of Regulations	in	inch
CDPHE	Colorado Department of Public Health and Environment	ISO	International Organization for Standardization
CFR	Code of Federal Regulations	kBtu	kilo-British thermal unit
cm	centimeter	kg	kilogram
CO	carbon monoxide	km	kilometer
CO₂	carbon dioxide	L	liter
CO₂e	carbon dioxide equivalent	LEED	Leadership in Energy and Environmental Design
COVID-19	coronavirus disease 2019	m	meter
DOE	U.S. Department of Energy	mCi	millicurie
EMS	Environmental Management System	MCL	maximum contaminant level
EO	executive order	mg/L	milligram per liter
EPA	U.S. Environmental Protection Agency	mrem	millirem
EPCRA	Emergency Planning and Community Right-to-Know Act of 1986	MS4	municipal separate storm sewer system
EPEAT	Electronic Product Environmental Assessment Tool	MT	metric ton
ESA	Endangered Species Act	N₂O	nitrous oxide
ESH&Q	Environment, Safety, Health, and Quality Office	NEPA	National Environmental Policy Act
ft	foot	NO_x	nitrogen oxides
FY	fiscal year	NREL	National Renewable Energy Laboratory
		PFAS	per- and polyfluoroalkyl substances

PIT	passive integrated transponder
RCRA	Resource Conservation and Recovery Act
ReFUEL	Renewable Fuels and Lubricants Laboratory
SPCC	spill prevention control and countermeasures
STM	South Table Mountain
TTHM	trihalomethanes
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
yr	year



A female northern flicker (*Colaptes auratus*) peeks her head out of a nesting birdbox near the Outdoor Testing Facility at the STM Campus. Northern flickers are a member of the woodpecker (*Picidae* spp.) family and are commonly spotted on the campus. *Photo by Werner Slocum, NREL 67731*

EXECUTIVE SUMMARY

Purpose

The National Renewable Energy Laboratory's (NREL)'s *Environmental Performance Report 2021* describes the laboratory's environmental management activities in 2021. It includes information on environmental and sustainability performance; environmental compliance activities and statuses; 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. Summaries are 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 2021 to enhance

sustainability and environmental performance and made, and it continues to make significant progress toward them.

Sustainability is integral to both NREL's research and its 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 2021:

- Developed a core resiliency team and initiated an update to NREL's vulnerability and resilience assessments originally developed in 2015.
- Obtained new or revised air permits for 20 items of fuel-burning equipment and achieved a "synthetic minor" source determination for the STM Campus. For the 20 items, a run-time emissions database was used to collect and tabulate data to provide accurate emissions for operating compliance.
- Completed a multiyear effort to stabilize the hillside adjacent to the Field Test Laboratory Building. The building was first damaged by a water line break and was further impaired by the erosive effects of a flood event in September 2013. Efforts to stabilize the hillside were deemed successful in 2021.
- Continued to develop municipal separate storm sewer system (MS4) permit programs intended to reduce the discharge of pollutants in stormwater runoff from the STM Campus.
- Started a project to develop a wastewater treatment feasibility study for the Flatirons Campus. The study is intended to include innovative yet practical solutions to onsite wastewater treatment systems that also afford researchers the opportunity to assist in early-stage advance technologies for use in the public domain, on federal lands, in Arctic communities, and on native tribal reservations.
- Continued a physical inventory of approximately 7,000 chemical containers at the STM Campus.
- Observed bobcats (*Lynx rufus*) at the western end of the STM Campus that were likely the same family of bobcats that denned within the Research Support Facility courtyard in 2020. To prevent the bobcats from denning in the courtyard again, natural animal deterrent was sprayed in 2021.
- Incorporated bird-friendly window glass into the design of a new STM Campus building. A fritted pattern within the window glass was selected to provide a durable solution and minimize the potential for bird strikes.
- Provided training sessions to 12 interested staff on snake handling, ecology, and taxonomy to minimize injuries to snakes and enhance safety awareness of responders during snake relocation activities.
- Sowed native wildflower forb seed mixes at the STM Campus at three separate locations to create "forb islands" where the area from previous construction activities remained denuded. These seed islands are intended to provide additional pollinator food sources on campus.
- Developed new seed mixes with the assistance of a local plant ecologist. These new mixes are campus-specific to either the STM Campus or the Flatirons Campus. They are also position-specific, depending on if they are located either near or away from buildings.
- Reestablished native grasses and plants after applying a broad-spectrum herbicide in 2018 and 2020 to reduce smooth brome (*Bromus inermis*) plots at the Flatirons Campus.

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 2021. 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 2021 for its environmental and sustainability accomplishments:

- 2021 Community Award from Jefferson County Sustainability Commission in recognition of the laboratory's commitment to educate, promote, and implement sustainable practices within the county
- Four-star Electronic Product Environmental Assessment Tool (EPEAT) purchases award from the Green Electronics Council in recognition of NREL's excellence in the procurement of sustainable electronics
- Colorado Environmental Leadership Program Gold-Level Leader status in recognition of the laboratory exceeding regulatory requirements and for continued partnership with the Colorado Department of Public Health and Environment since 2004.

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 2021. No violation notices were received from any regulatory agency. 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.

The laboratory continued to improve its environmental management and performance in 2021, 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.



NREL collaborates with many different government and business partners. Here, representatives of a global green energy and product company committed to producing zero-emission hydrogen from renewable resources tour the Flatirons Campus. *Photo by Werner Slocum, NREL 66854*

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 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) 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 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 sun rises and begins to illuminate the STM Campus in mid-October. *Photo by Stephanie Harding, NREL 67231*



A wind turbine is reflected in a photovoltaic array at the Flatirons Campus. Photo by Werner Slocum, NREL 66364

1 INTRODUCTION

This report summarizes NREL's environmental management activities in 2021, including:

- Environmental protection programs
- Environmental and sustainability performance
- Environmental compliance activities and their statuses
- 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 Mission

NREL's mission focuses on advancing the energy goals of DOE and the 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 portfolios, including:

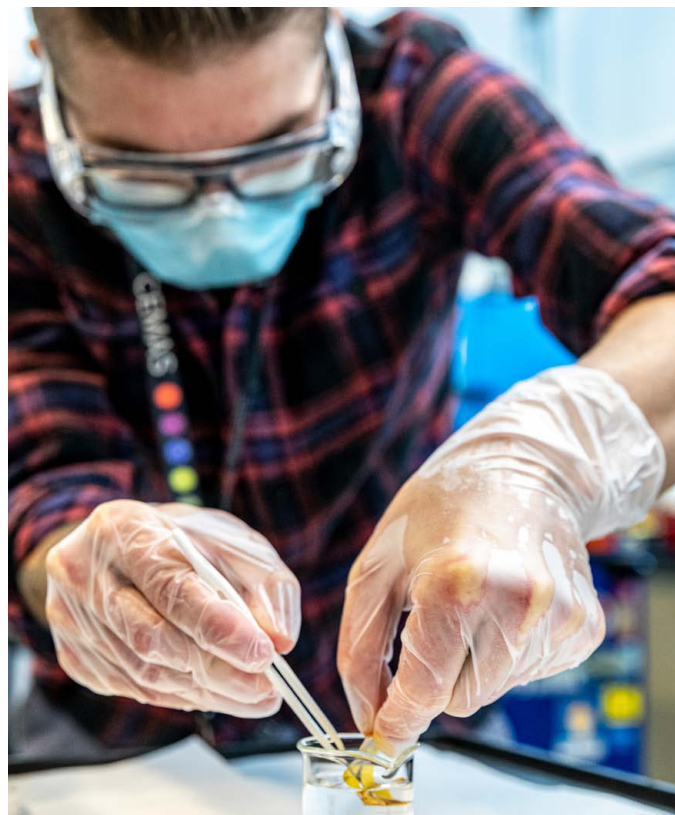
- **Advanced Manufacturing:** Scientific and engineering research focuses on reducing energy requirements associated with the most energy-intensive manufacturing industries and accelerating those innovations to commercialization of next-generation technologies and processes.
- **Bioenergy:** Bioenergy 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 U.S. and the world.
- **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 Science:** Computational science staff work to solve energy challenges using high-performance computing; computational science; applied mathematics; and scientific data management, data visualization, and informatics. NREL is home to the world's largest high-performance and most energy-efficient data center dedicated to advancing renewable energy and energy efficiency technologies.
- **Geothermal Energy:** NREL works to develop new techniques to increase the production of geothermal energy and explores the benefits of integrating geothermal and other renewable energy systems. The laboratory collaborates with industry, government agencies, and other partnering entities to advance the use of geothermal energy worldwide.
- **Hydrogen and Fuel Cells:** NREL conducts research focused on developing, integrating, and demonstrating hydrogen production and delivery, hydrogen storage, and fuel cell technologies for transportation, stationary, and portable applications.
- **Integrated Energy Solutions:** NREL supports the transition to renewable energy portfolios at the city, state, national, and international levels through technical and economic evaluations of renewable energy opportunities that address technology, policy, social, and market systems.
- **Materials Science:** Materials science research at NREL 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.



A materials and process researcher uses a fermenter to convert liquid carbon monoxide to ethanol after first converting it from carbon dioxide at the Integrated Biorefinery Research Facility. *Photo by Werner Slocum, NREL 66466*

- **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.



A postdoctoral materials science researcher demonstrates thin-film solar cells during an industry partnership visit. *Photo by Werner Slocum, NREL 66159*



A senior scientist installs a small perovskite accelerator for solar panels at the Outdoor Test Facility at the STM Campus. *Photo by Werner Slocum, NREL 67121*

- **Photovoltaics and Solar Power:** Photovoltaics work at NREL includes 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.
- **Transportation:** NREL researchers collaborate with industry experts to develop advanced vehicles and transportation systems. The laboratory 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 tool kits 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's Flatirons Campus 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 seven separate locations in Alaska, Colorado, and Washington, D.C., including:

Federally-owned facilities:

- Flatirons Campus, Arvada, Colorado
- South Table Mountain (STM) Campus, Golden, Colorado

Leased facilities:

- 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.

Flatirons Campus

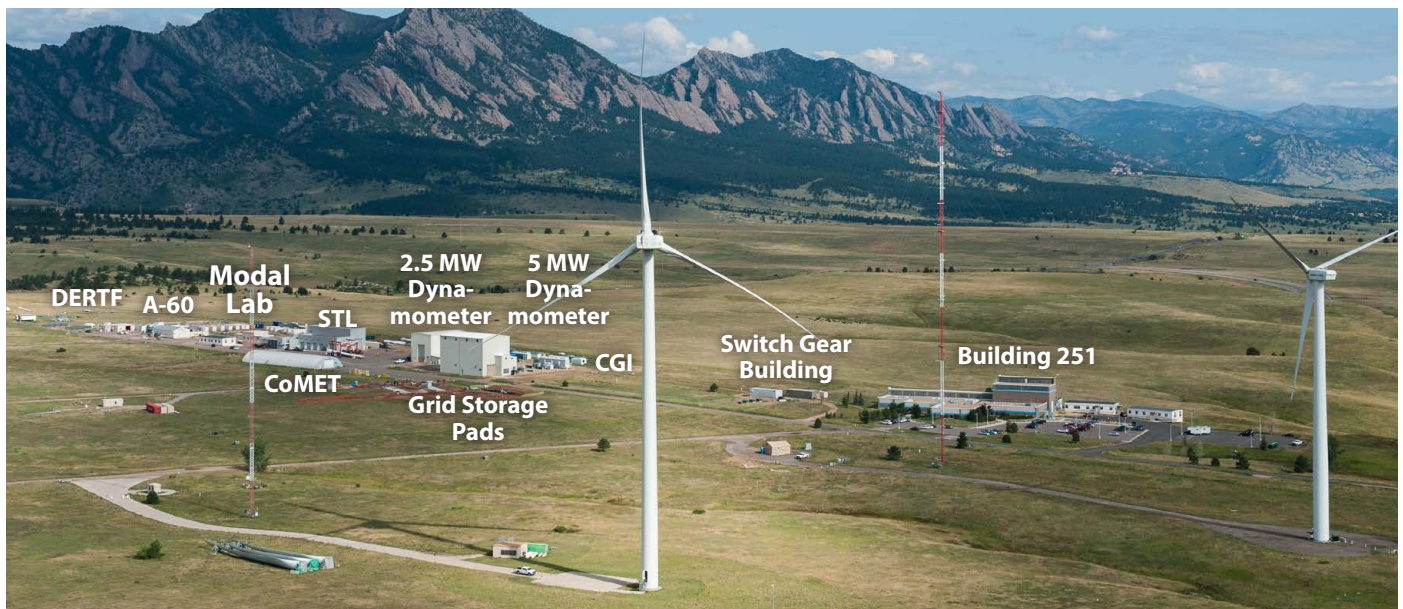
The Flatirons Campus is the main facility for NREL's wind turbine technology, water power, and grid integration research. Located at the Jefferson County-Boulder County border just east of the foothills of the Front Range, the Flatirons Campus has abundant wind resources that are critical for the variety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

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 of the Flatirons Campus (on the refuge's property), and an expanded shale and clay lightweight aggregate production operation is located along the southern portion of the western boundary of the campus. A propellant fracturing company also has a small installation along the northern part of the campus's western 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



Aerial view of the northern portion of 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 (*Pinus ponderosa*), 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](#).

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 Campus and the Flatirons Campus](#).

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.

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>.



An aerial view of NREL's STM Campus. Photo by Dennis Schroeder, NREL 30709

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 (ft) (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 that is 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 campus. 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 some existing utility easements and recreational trails to be established by Jefferson County Open Space. For details, see [Section 8, National Environmental Policy Act Compliance](#).

Geology, Soils, and Hydrogeology

South Table Mountain was formed as weak sedimentary rocks surrounding lava were eroded, 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 campus, including the area designated for major development, has a deep well-drained soil referred to locally as Denver clay loam that consists of clayey material

containing some calcium carbonate. Also, two smaller soil areas within the southwestern part of the campus that consist of cobbly clay loam and very stony clay loam are similar in character to other soils within the campus.

Surface Water

About 90% of the surface drainage from the STM Campus, both from the mesa top and across the lower portions, 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](#).

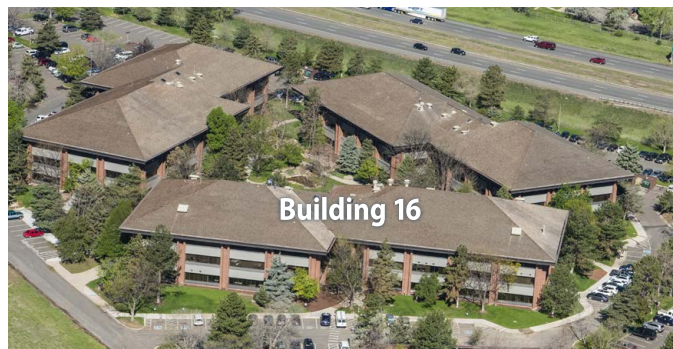
Wildlife

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 9.1, Wildlife Management](#), and [Appendix C. Wildlife Species Observed at the STM Campus and the Flatirons Campus](#).

Building 16

Building 16 is a leased office building within the Denver West Business Park, which is 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

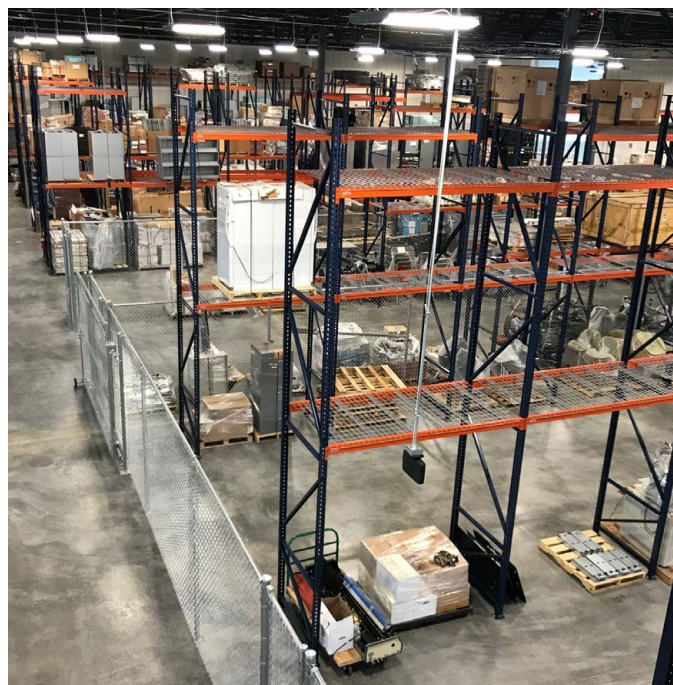
West Business Park is a fairly flat, landscaped office complex, consisting of several four-story office buildings, parking lots, and common areas. Building 16 is bordered on the south by commercial areas (on West Colfax strip) and on the west by the Camp George West facility and the STM Campus. In addition 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

NREL's leased 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 storage space.



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

Renewable Fuels and Lubricants Research Laboratory

Renewable Fuels and Lubricants Research Laboratory (ReFUEL) is a leased facility 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 ReFUEL 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 District's bus and light-rail train systems. The area around the facility consists of commercial and light industrial development. The ReFUEL lies on predominantly 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 facility or in the immediate vicinity. Trees and shrubs line the South Platte River adjacent to the facility's southern, eastern, and northeastern boundaries.

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 (in) (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 in (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.

Research and Testing Facility

NREL leases the Research and Testing Facility at the Cold Climate Housing Research Center in Fairbanks, Alaska. This LEED (Leadership in Energy and Environmental Design) 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 access to the Arctic environment provides a new dimension to NREL's energy systems integration specifically as it is applied to extreme climates.

Climate of Alaska Facility

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 -50°F to 80°F (-46°C to 27°C).

Washington, D.C. Office

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

Climate of Washington, D.C. Facility

The Washington, D.C. Office is located in the District of Columbia in a humid, subtropical zone. Winters are typically cool with little 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.



A transit bus being tested at the ReFUEL. Photo by Dennis Schroeder, NREL 17948



A snowy view of the Cold Climate Housing Research Center in Fairbanks, Alaska. *Photo courtesy of the Cold Climate Housing Research Center, NREL 63776*



2 ENVIRONMENTAL MANAGEMENT SYSTEM

A female great horned owl (*Bubo virginianus*) perches behind a solar panel on the top level of STM Campus parking garage. The mother owl raised three owlets in a nearby tree earlier in the year. Photo by Werner Slocum, NREL 64253

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 (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 prioritize activities in the EMS 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 (Figure 3).
- **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 is 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,



Figure 1. NREL's Continual Improvement Cycle

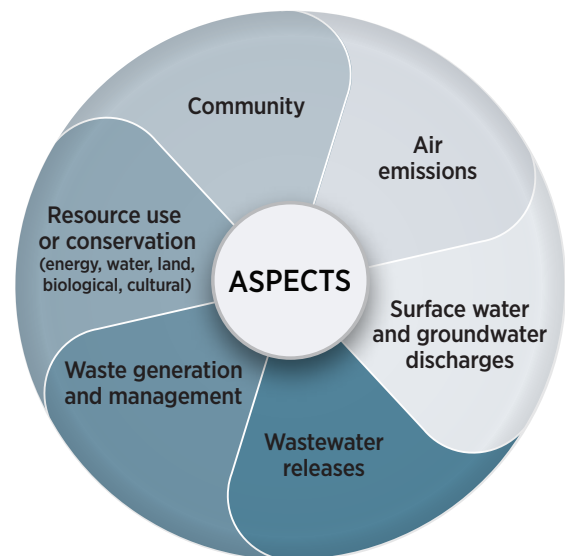


Figure 2. NREL's Environmental Aspects



Figure 3. NREL's Integrated Safety Management System

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.

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.
- **Assessments:** 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, Assessment and Improvement](#).

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 formally committed to preventing pollution 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.



During an NREL Earth Day event, employees drop off electronic items to be properly recycled. *Photo by Dennis Schroeder, NREL 56177*

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. Table 1 includes examples of achievements this year that are related to the laboratory's goal of providing a comprehensive, effective, and responsive environmental management program.

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 us 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 2021 allowed NREL to enhance program effectiveness and make substantial environmental performance improvements:

- **Internal Assessments:** Separate internal assessments were completed for NREL's EPCRA process and Groundwater Protection and Maintenance program. No major issues were identified and actions to address the minor nonconformities and opportunities for improvement have been completed or are in progress.
- **External Assessments:** NREL underwent a maintenance assessment to verify conformance to the ISO 14001:2015 standard. A team of external auditors conducted the virtual assessment, including 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.

Table 1. Environmental Goals and Achievements in 2021

Goal	Examples of Achievements	Status
Provide a comprehensive, effective, and responsive environmental management program	<p>Demonstrated a shared commitment to efficiency, excellence, and compliance with requirements:</p> <ul style="list-style-type: none"> • Initiated the transition to a new chemical management software system which is intended to enhance chemical tracking, use authorization, reporting, and to properly address the life cycle of chemical use and disposal • Completed two internal audits: NREL's Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) process and NREL's Groundwater Protection and Maintenance program • Conducted reviews of environmental aspects associated with the proposed construction of the Flatirons Campus waterline project including threatened and endangered species, cultural resources, and water quality • Began mapping environmental features on the STM Campus and Flatirons Campus to further expand the laboratory's capabilities for environmental analysis • Revised SPCC plans for the STM Campus, Flatirons Campus, and ReFUEL; revisions included updating oil-containing equipment information, spill history, and cleanup resources • Continued to develop MS4 permit programs intended to reduce the discharge of pollutants in stormwater runoff from the STM Campus. <p>Shared successes, best management practices, expertise, and lessons learned to promote excellence and collaboration in environmental performance:</p> <ul style="list-style-type: none"> • Corresponded with U.S. Department of Agriculture Animal and Plant Health Inspection Service staff to continue to develop guidance for NREL researchers on bioprospecting permitting requirements and to ensure compliance • Participated in a DOE refrigerant committee to provide comments to EPA regarding proposed refrigerant regulations • Published a report about bobcat behavior and biology (<i>Lynx rufus</i>) for use by NREL staff • Provided training sessions to 12 interested staff on snake handling, ecology, and taxonomy to minimize injuries to snakes and enhance safety awareness of responders during snake relocation activities. 	Goal met

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 is 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 also proactively engages 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.

2.5 Awards and Recognition

In 2021, NREL received several awards and recognition of its environmental and sustainability achievements, including those described in this section.

Jefferson County Sustainability Award

Jefferson County's Sustainability Commission recognized NREL's commitment to educating, promoting, and implementing sustainable practices within the county by awarding NREL with its 2021 Community Award. The laboratory was recognized for integrating its sustainability best practices on the STM Campus including green buildings, water conservation, wildlife management, and green transportation.

Green Electronics Council Award

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. In 2021, NREL received the Five-Star EPEAT Purchaser Award from the Green Electronics Council for 2020 EPEAT purchases.

Colorado Environmental Leadership Program Gold-Level Leader Recognition

NREL maintained its status as a Colorado Environmental Leadership Program Gold-Level Leader, the highest level awarded by the program. The Colorado Environmental

⁴ NREL recognized Earth Day 2021 by offering a week of activities hosted virtually due to the ongoing COVID-19 pandemic. The theme of Earth Week 2021 was "Restore Our Earth" where activity offerings included virtual tours that emphasized the laboratory's dedication to sustainability and climate resiliency through xeriscaping, water conservation, landscape restoration and wildlife management, composting and recycling, energy efficient appliances, sustainable transportation, green chemistry, sustainable procurement, on-site renewable energy generation, and net zero energy building design.

Leadership Program is a voluntary partnership of the Colorado Department of Public Health and Environment and is intended to recognize environmental leadership and performance. The Colorado Environmental Leadership Program⁵ 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 3-year goals focusing on measurable results.

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

2.6 Integrated Environmental Stewardship in Construction Management

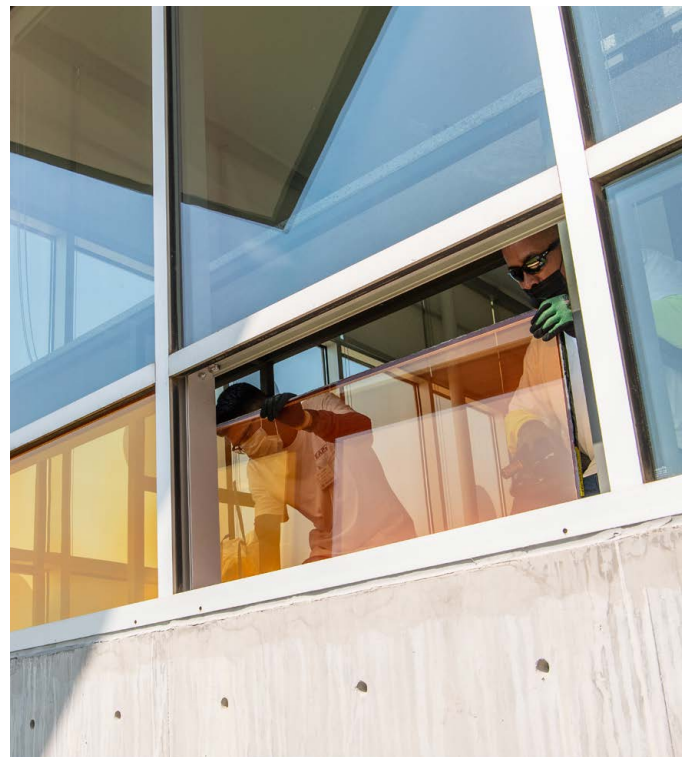
NREL designs, builds, and refurbishes facilities using an integrated approach that allows the laboratory to achieve its mission needs while addressing environmental, safety, health, and community considerations.

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 2021, NREL took the following notable actions to address environmental concerns during the planning, design, and construction of projects:

- Conducted reviews of environmental aspects associated with the proposed construction of the Flatirons Campus waterline project including threatened and endangered species, cultural resources, and water quality
- Supported an initial environmental assessment for a



NREL frequently tests its energy efficient building projects on its facilities. Here, glazers install quantum dot windows for testing at the STM Campus Café. Quantum dot laminated glass absorbs sunlight trapped in the glass by internal reflection and guides the light to solar cells at the window edges to generate electricity. *Photo by Dennis Schroeder, NREL 65022*

potential tall wind turbine tower project at the Flatirons Campus with an industry partner

- Hosted consistent and frequent NEPA strategy meetings and collaboration reviews to address environmental components of upcoming projects
- Continued to address NREL's MS4 permit conditions by coordinating with legal, site operations, and procurement departments to develop stormwater and erosion enforcement criteria for inclusion in building subcontractor requirements and training materials
- Supported review of contractor proposals for a new building on the STM Campus which included reviewing chemical waste storage, bird deterrents, potential generator emissions, impacts to cultural resources, and outlined options to reduce emissions
- Provided wastewater input for the design and repair of the acid waste neutralization system at the STM Campus' Science and Technology Facility
- Created "areas of conservation and other sensitive resources" maps for the STM Campus and the Flatirons Campus to aid in

⁵ Learn more about this voluntary program at the state's Environmental Leadership Program website ("Environmental Leadership Program Legacy," Colorado Department of Public Health and Environment (CDPHE), <https://www.colorado.gov/pacific/cdphe/environmental-leadership-program>).

development plans and assist with environmental reviews

- Incorporated bird-friendly window glass into the design of a new STM Campus building; the design is a fritted pattern within the window glass to provide a durable solution and minimize the potential for bird strikes.

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.

2021 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 the laboratory’s commitment to environmental stewardship.
- Conducted separate internal assessments for NREL’s EPCRA reporting process and Groundwater Protection and Maintenance program. No major issues were identified and actions to address the minor nonconformities and opportunities for improvement have been completed or are in progress.

Benefits of the EMS to the Environment

- **Improved Overall Compliance Management:** NREL follows 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, the laboratory regularly reviews compliance with these requirements 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 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.
- **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.



President of the U.S., Joseph Biden, speaks at the Flatirons Campus about NREL's long-term research mission, vision, and critical objectives and how they align with the current administration's decarbonization goals and national energy priorities. *Photo by Werner Slocum, NREL 65441*



Research bays at the Energy Systems Integration Facility at the STM Campus are used to test the performance of high-power electric vehicle chargers and the potential for integrating building and electrical vehicle charging systems. *Photo by Dennis Schroeder, NREL 62132*

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, sustainable materials, 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 into 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
- Sustainable purchasing
- 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 2021 is presented in Table 2. It provides a high-level summary of NREL's current and planned efforts in sustainability as they pertain to specific DOE goals.

Each goal is evaluated by considering five categories of risk:

- **Technical:** The availability of technology and/or systems in current facilities
- **Management:** Adequacy of policies or procedures as they relate to management systems, policies, and/or support
- **Mission:** Major initiatives, construction, and/or changes to mission that have the potential to impact sustainability goals
- **Financial:** The viability of funding availability in current or forecasted years and performance contracts
- **Supply Chain:** The potential for interruptions to flow of material, purchased goods, and services

NREL evaluates each goal and assigns it a risk level:

- **High:** Risk is such that the goal will likely not be achieved
- **Medium:** Risk is sufficient enough that the goal may not be achieved
- **Low:** Risk is such that the goal will likely be achieved

Table 2. Sustainability Goals and Performance Summary

DOE Goal	Risk Level	Performance
Multiple Categories		
Reduce Scope 1 and Scope 2 greenhouse gas (GHG) emissions ^a	High	In Fiscal Year (FY) 2021, NREL increased Scope 1 and 2 GHG emissions 16% from FY 2020.
Reduce Scope 3 GHG emissions ^b	High ^c	In FY 2021, NREL reduced Scope 3 emissions 38% from FY 2020.
Energy Management		
Reduce energy use intensity (measured in 1,000 British thermal units per gross square foot, kBtu/GSF) in goal-subject buildings	High	In FY 2021, energy use intensity increased 17% from FY 2020 to 124 kBtu/GSF.
Evaluate energy and water systems per Section 432 of the Energy Independence and Security Act, ^d continuous, 4-year cycle	Low	Conducted energy and water audits at the Energy Systems Integration Facility, Science and Technology Facility, Solar Energy Research Facility, and Field Test Laboratory Building on the STM Campus in FY 2021.
Meter individual buildings for electricity, natural gas, steam, and water use, where cost-effective and appropriate	Medium	<p>91% of relevant buildings have electricity meters, all of which are advanced meters.^e</p> <p>75% of relevant buildings have chilled water meters, all of which are advanced meters.</p> <p>75% of relevant buildings have hot water meters, all of which are advanced meters.</p> <p>94% of relevant buildings have natural gas meters.</p> <p>94% of relevant buildings have potable water meters and 28% of relevant buildings have advanced potable water meters.^e</p>

DOE Goal	Risk Level	Performance
Water Management		
Reduce potable water-use intensity (measured in gallons per gross square foot, gallons/GSF)	High	In FY 2021, potable water intensity increased by 8% from FY 2020 to 23.4 gallons/GSF.
Reduce non-potable freshwater consumption (measured in gallons) for industrial, landscaping, and agricultural	N/A	NREL does not use industrial, landscaping, or agricultural non-potable freshwater.
Waste Management		
Reduce nonhazardous solid waste sent to treatment and disposal facilities	Medium	In FY 2021, NREL had a 55% diversion (composted or recycled) rate of nonhazardous solid waste.
Reduce construction and demolition materials and debris sent to treatment and disposal facilities	Medium	In FY 2021, NREL had a 59% diversion (composted or recycled) rate of construction and demolition waste.
Fleet Management		
Reduce petroleum consumption	High	In FY 2021, NREL had a 9% decrease from FY 2020 in total petroleum fuel consumption.
Increase alternative fuel consumption	Medium	In FY 2021, NREL had a 17% decrease from FY 2020 in alternative fuel consumption.
Acquire alternative fuel and electric vehicles	High	NREL continued to increase alternative fuel vehicles in its fleet.
Renewable Energy		
Increase consumption of clean and renewable electric energy	High	In FY 2021, NREL had a 10% decrease from FY 2020 in consumption of clean and renewable electric energy.
Increase consumption of clean and renewable nonelectric thermal energy	High	In FY 2021, NREL had a 12% decrease from FY 2020 in consumption of clean and renewable nonelectric thermal energy.
Sustainable Buildings		
Increase the number of owned buildings that are compliant with the Guiding Principles for Sustainable Buildings ^f	High	In FY 2021, 57% of the gross square footage of eligible facilities met the guiding principles.
Acquisition and Procurement		
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred ^g and bio-based provisions and clauses are included in all applicable contracts	Low	As of FY 2021, 100% of NREL's contracts contain sustainability provisions.

DOE Goal	Risk Level	Performance
Measures, Funding, and Training		
Implement life cycle cost-effective efficiency and conservation measures with appropriated funds and/or performance contracts	High	In FY 2021, NREL helped the DOE Golden Field Office select an energy service company (companies that develop, design, build, and arrange financing for projects that save energy, reduce energy costs, and decrease operation and maintenance costs at their customers' facilities) and began steps to award energy-savings contracts and energy service performance contracts for the STM Campus and the Flatirons Campus.
Electronic Stewardship		
Achieve electronics stewardship from acquisition, to operations, to end-of-life diversion or reuse	Low	In FY 2021, 100% of electronics were reused or recycled.
Increase energy and water efficiency in high-performance computing and data centers	Medium	<p>The STM Campus' Research Support Facility data center achieved a power usage effectiveness^h rating of 1.31.</p> <p>The STM Campus' Energy System Integration Facility High Performance computing data center achieved a power usage effectivenessⁱ of 1.03 liters (L) per kilowatt hour and water usage effectivenessⁱ of 0.92 L per kilowatt hour.</p>
Organizational Resilience		
Implement climate adaptation and resilience measures	High	In FY 2021, the laboratory conducted microgrid feasibility discussions within NREL research community.

- a Scope 1 emissions (direct GHGs) 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 GHGs) 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.
- b Scope 3 emissions (other indirect GHGs) 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.
- c Though a 38% reduction in Scope 3 emission was achieved, this reduction occurred largely because of curtailment of commuting, business travel, and campus occupation associated with the COVID-19 pandemic. Scope 3 emissions are expected to increase when operations return to normal, and the risk of nonattainment for this goal is expected to be high.
- d Section 432 of the Energy Independence and Security Act of 2007 requires that, at a minimum, buildings representing at least 75% of a facility's total energy consumption undergo energy and water audits every 4 years. DOE sites are responsible for ensuring facilities are audited on a 4-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 To advance sustainable building principles and practices the Council on Environmental Quality issued a guidance document on how Federal agencies could best design, locate, construct, maintain, and operate Federal buildings in a sustainable manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, ensures the health of occupants, protects the environment, generates cost savings, and mitigates risks to assets, consistent with Agency and Department missions.
- g 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.
- h Power usage effectiveness is the ratio of the total quantity of power used by a computer data center facility to the power delivered to computing equipment. Data centers focusing on efficiency typically achieve effectiveness rating values of 1.2 or less.
- i Water usage effectiveness is the ratio of the annual site water usage (liters) to the information technology equipment energy usage (kilowatt hours).

3.2 Resilience Planning

NREL is proactively engaged in the development and implementation of 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.

2021 Accomplishments and Highlights

- Started a preliminary assessment for energy-savings performance contract awards at the STM Campus and the Flatirons Campus. 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 a microgrid-interactive efficient building to ensure continuity of operations in an emergency.
- Continued to provide the Flatirons Campus with trucked-in water. This source of water was identified as a vulnerability in the 2015 resilience risk assessment. In 2021, NREL initiated a project to install a water pipeline to provide a more reliable water source for the Flatirons Campus.
- Developed a core resiliency team and initiated an update to NREL's vulnerability and resilience assessments originally developed in 2015.



A 1-megawatt battery energy storage system is used at the Flatirons Campus to validate large-scale storage solutions for renewable power systems. The battery is integrated with other campus grid assets to simulate system dynamics and demonstrate advanced solutions for power grid management. *Photo by Werner Slocum, NREL 65137*



4 COMPLIANCE SUMMARY

NREL employees volunteer to help with a trail maintenance project on South Table Mountain in Golden, Colorado. *Photo by Werner Slocum, NREL 65293*

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 strong 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		
<p>Executive Order 13990, Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis, was established January 20, 2021, and Executive Order 14057, Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability, was established December 8, 2021. These two executive orders established new federal level sustainability goals. They require federal agencies to meet statutory requirements in a manner that increases the sustainability of federal supply chains in order to achieve net-zero emissions by 2050 and makes federal agencies more adaptive and resilient to the impacts of climate change. DOE has established goals that accomplish those objectives.</p> <p>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.</p>	<p>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.</p> <p>NREL's EMS is certified to the ISO 14001:2015 standard for environmental management systems since 2011. Annual assessments verify that NREL meets the ISO standard and is continually improving performance.</p>	<p>Executive Order 13990: Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis</p> <p>Executive Order 14057: Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability</p> <p>DOE Order 436.1: Departmental Sustainability</p>
Resilience Planning		
<p>Executive Order 14008, Tackling the Climate Crisis at Home and Abroad, and the America the Beautiful initiative set a goal of conserving 30% of land and water by 2030, among other goals. The White House Council on Environmental Quality asked federal agencies, including DOE, to support it by preparing conservation action plans detailing programs and projects across several discrete areas of early focus.</p> <p>DOE Order 436.1 requires facilities to annually develop a site sustainability plan that facilitates identifying and addressing opportunities for resiliency.</p>	<p>Efforts to connect the Flatirons Campus to a nearby municipal water supply continued in 2021.</p> <p>The laboratory supports the Council on Environmental Quality's conservation initiative at the STM Campus and the Flatirons Campus. The STM Campus conservation easement protects 177 acres. The Flatirons Campus protects 60 acres managed for conservation purposes. Areas under management include native grasslands, wetlands and drainages, seeps, cultural resources, and sensitive resources.</p> <p>A Site Sustainability Plan is developed each year to report on past performance and set goals for the coming year.</p>	<p>Executive Order 13990: Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis</p> <p>Executive Order 14057: Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability</p> <p>Executive Order 14008: Tackling the Climate Crisis at Home and Abroad and the America the Beautiful initiative</p> <p>DOE Order 436.1: Departmental Sustainability</p>

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Air Quality		
<p>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.</p> <p>On October 1, 2021, EPA implemented hydrofluorocarbon phasedown requirements authorized by the American Innovation and Manufacturing Act of 2020 which will reduce hydrofluorocarbons use in manufacturing to 15% of a 2011–2013 baseline by 2036.</p> <p>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) (23 kilograms [kg]), of all regulated refrigerants, including chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, and hydrofluoroolefins. Appliances containing 5 lb (2.3 kg) or more of these refrigerants are subject to end-of-life refrigerant recovery, recycling, and documentation requirements.</p> <p>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 (CO₂e) per year. The purpose of this reporting is to better identify the actual emissions of such gases across the U.S. 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.</p> <p>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 CO₂e emissions are greater than 100,000 U.S. tons (90,718 MT) per year.</p> <p>The EPA has designated the Denver metropolitan area's ozone nonattainment status as "serious," and major source permitting thresholds for nitrogen oxides (NO_x) and volatile organic compounds (VOCs) are 50 U.S. tons (45.4 MT) per year.</p> <p>The Air Pollution Control Division of Colorado Department of Public Health and Environment (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 (HAP), ozone-depleting substances, and greenhouse gases (GHGs).</p>	<p>Program activities were in compliance with all requirements except the submission of a "self-certification" package related to the January 2021 issuance of one "permit to construct" for the 12 STM boilers and heaters. This matter was resolved in early 2022 and did not result in a "notice of violation". NREL did not exceed any air permit standard or other air regulatory requirement at any facility.</p> <p>HAP emissions for each individual facility were 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.</p> <p>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 or "synthetic minor" sources, and actions were taken to avoid Title V permitting at the STM Campus.</p> <p>Laboratory CO₂e and GHG emissions were below the federal reporting and permitting threshold of 27,500 U.S. tons (25,000 MT).</p> <p>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.</p> <p>Twenty items that burn fuel at the STM campus (eight standby generators and twelve natural gas-fired boilers and heaters) were issued either revised or new air permits to reduce NO_x emissions. This reduction allowed the STM campus to become a "synthetic minor" source and avoid the need for a Title V air permit. One "permit to construct" was issued in January 2021 and a final "permit to operate" was received in May 2022 for the twelve boilers and heaters. Eight modified "permits to operate" were also issued in January 2021 for the eight standby generators.</p> <p>The STM Campus, which is within the Denver metropolitan area's "serious" nonattainment zone, has limited NO_x emissions to less than 50 U.S. tons (45.4 MT) per year and is classified as a "synthetic minor" source of NO_x emissions by limiting NO_x emissions from 20 fuel-burning equipment items.</p>	<p>H.R. 133 Consolidated Appropriations Act, 2021 Section 103 in Division S: American Innovation and Manufacturing Act of 2020</p> <p>EPA 40 Code of Federal Regulations (CFR) Part 40: Mandatory Greenhouse Gas Reporting</p> <p>EPA 40 CFR Part 50: National Primary and Secondary Ambient Air Quality Standards</p> <p>EPA 40 CFR Part 51: Requirements for Preparation, Adoption, and Submittal of Implementation Plans</p> <p>EPA 40 CFR Part 52: Approval and Promulgation of Implementation Plans</p> <p>EPA 40 CFR Part 60: Standards of Performance for New Stationary Sources</p> <p>EPA 40 CFR Part 63: National Emission Standards for Hazardous Air Pollutants for Source Categories</p> <p>EPA 40 CFR Part 70: State Operating Permit Programs</p> <p>EPA 40 CFR Part 71: Federal Operating Permit Programs</p> <p>EPA 40 CFR Part 82: Protection of Stratospheric Ozone</p> <p>EPA 40 CFR Part 98: Mandatory Greenhouse Gas Reporting</p> <p>CDPHE 5 Colorado Code of Regulations (CCR) 1001-3: Stationary Source Permitting and Air Pollutant Emission Notice Requirement</p> <p>CDPHE 5 CCR 1001-15: Control of Emissions of Ozone Depleting Compounds</p>

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Air Quality <i>(continued)</i>		
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 those occurring for more than 6 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.	<p>NREL maintains an STM Campus air permit allowing fugitive dust emissions from construction activities.</p> <p>NREL 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.</p>	CDPHE 5 CCR 1001-16: Street Sanding Emissions
Drinking Water Quality		
<p>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.</p> <p>The Water Quality Control Division of CDPHE implements the federal Safe Drinking Water Act in Colorado under authority delegated by the EPA.</p>	<p>Program activities were in compliance with requirements.</p> <p>All monitored water quality parameters met requirements.</p> <p>Annual sampling of lead and copper levels in drinking water was performed as required by the state. All lead sample results were below the maximum allowable concentration in drinking water of 0.015 milligram per liter (mg/L). Only one sample was detected at 0.003 mg/L, which was just above the analytical method detection limit of 0.001 mg/L. Copper levels ranged from 0.115 mg/L to 1.698 mg/L. The calculated 90th percentile value of 1.089 mg/L fell below the regulatory action level of 1.3 mg/L. These results were reported to the Water Quality Control Division of CDPHE, as required.</p> <p>A total of 354,168 gallons (1,328,623 L) of drinking water were provided to the Flatirons Campus.</p>	<p>EPA 40 CFR Part 141: National Primary Drinking Water Regulations</p> <p>EPA 40 CFR Part 142: National Primary Drinking Water Regulations Implementation</p> <p>EPA 40 CFR Part 143: National Secondary Drinking Water Regulations</p> <p>EPA 40 CFR Part 149: Sole Source Aquifers</p> <p>CDPHE 5 CCR 1002-11: Colorado Primary Drinking Water Regulations</p>
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, and they include well installations.	<p>Program activities were in compliance with requirements.</p> <p>There were no spills or releases that impacted groundwater.</p> <p>There are currently no permitted groundwater monitoring wells at either the STM Campus or the Flatirons Campus.</p> <p>There are two permitted closed-loop geothermal systems at the STM Campus.</p>	<p>CDPHE 2 CCR 402-2: Rules and Regulations for Water Well Construction, Pump Installation, Cistern Installation, and Monitoring and Observation Hole/Well Construction</p> <p>CDPHE 2 CCR 402-10: Rules and regulations for Permitting the Development and the Appropriation of Geothermal Sources Through the Use of Wells</p> <p>CDPHE 5 CCR 1002-41: The Basic Standards for Ground Water</p>

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Storm and Surface Water Quality		
<p>The Energy Independence and Security Act of 2007 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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>Surface water quality is protected by the federal Clean Water Act, the Energy Independence and Security Act of 2007, and the Colorado Water Quality Control Act.</p>	<p>Program activities were in compliance with requirements.</p> <p>Periodic stormwater inspections were performed at locations where earth-disturbing activities occurred. Inspections and required maintenance of 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.</p> <p>Several programs required by the MS4 permit continued to be developed. These programs are intended to reduce the discharge of pollutants in stormwater runoff from the STM Campus.</p> <p>Coverage under the EPA Construction General Permit for a landscaping improvement project at the STM Campus' Solar Energy Research Facility and the Science and Technology Facility was extended and will remain active through December 31, 2022.</p> <p>Obtained coverage under the EPA Construction General Permit for the STM Campus' Research and Innovation Laboratory.</p>	<p>Public Law 110-140: Energy Independence and Security Act of 2007</p> <p>EPA 40 CFR 122.26: Storm Water Discharges</p> <p>EPA 40 CFR 122.34: Permit Requirements for Regulated Small MS4 Permits</p> <p>CDPHE 5 CCR 1002-38: Classifications and Numeric Standards South Platte River Basin Laramie River Basin Republication River Basin Smoky Hill River Basin</p> <p>CDPHE 5 CCR 1002-61: Colorado Discharge System Permit Requirements</p> <p>CDPHE 5 CCR 1002-65: Regulation Controlling Discharges to Storm Sewers</p> <p>CDPHE 5 CCR 1002-93: Colorado's Section 303(D) List of Impaired Waters and Monitoring and Evaluation List</p>

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Wastewater Quality		
<p>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.</p> <p>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.</p> <p>The Metro Water Recovery manages wastewater at its treatment plant per federal and state requirements. Domestic and nondomestic wastewater flows are delivered to Metro Water Recovery's plant via conveyance systems owned, operated, and regulated by numerous sanitation districts.</p> <p>Nondomestic wastewater discharges must comply with Metro Water Recovery rules and regulations, which incorporate requirements of the Clean Water Act.</p>	<p>Program activities were in compliance with requirements.</p> <p>Two applications were submitted to Metro Water Recovery for sanitary sewer discharge of wastewater associated with research projects.</p>	<p>EPA 40 CFR 122: EPA Administered Permit Programs, The National Pollutant Discharge Elimination System</p> <p>EPA 40 CFR 123: State Program Requirements</p> <p>EPA 40 CFR 125: Criteria and Standards for the National Pollutant Discharge Elimination System</p> <p>EPA 40 CFR 127: National Pollutant Discharge Elimination System Reporting</p> <p>EPA 40 CFR 129: Toxic Pollutant Effluent Standards</p> <p>EPA 40 CFR 130: Water Quality Planning and Management</p> <p>EPA 40 CFR 131: Water Quality Standards</p> <p>EPA 40 CFR 133: Secondary Treatment Regulation</p> <p>EPA 40 CFR 136: Guidelines Establishing Test Procedures for the Analysis of Pollutants</p> <p>CDPHE 5 CCR 1002-62: Regulations for Effluent Limitations</p> <p>CDPHE 5 CCR 1002-63: Pretreatment Regulations</p>

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Hazardous Materials Management		
<p>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 of 1986 (EPCRA). It 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 by federal, state, and local governments. NREL facilities are subject to Sections 302, 304, 311, 312, and 313 of EPCRA.</p> <p>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.</p> <p>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.</p> <p>EPCRA Section 311 requires a one-time submittal of safety data sheets to state and local emergency response agencies and local fire departments for chemicals stored onsite in quantities greater than regulatory thresholds.</p> <p>EPCRA Section 312 requires an annual report of EPCRA Section 311 information.</p> <p>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.</p> <p>Hazardous materials permits are required by the local fire jurisdiction for the STM Campus, Building 16 at the Denver West Office Park, and ReFUEL.</p>	<p>Program activities were in compliance with requirements.</p> <p>Section 302 notification was not required.</p> <p>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.</p> <p>An EPCRA Section 311 submission was not required.</p> <p>EPCRA Section 312 Tier II hazardous materials reports were submitted for two facilities. Chemicals reported included diesel fuel, petroleum oil, sulfuric acid, and lead contained in sealed lead-acid batteries.</p> <p>An EPCRA Section 313 Toxic Release Inventory report was not required.</p> <p>Hazardous materials permits were acquired for facilities as appropriate.</p> <p>No reportable hazardous material spills occurred.</p>	<p>EPA 40 CFR 355: Emergency Planning and Notification</p> <p>EPA 40 CFR 370: Hazardous Chemical Reporting, Community Right-To-Know</p> <p>EPA 40 CFR 372: Toxic Chemical Release Reporting, Community Right-To-Know</p> <p>DOE Order 151.1D: Comprehensive Emergency Management System</p>

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Hazardous Waste Management		
<p>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.</p> <p>Per state and federal regulations, annual generator notifications are delivered and applicable fees are paid to the state based on monthly volumes of hazardous waste generated at each facility.</p> <p>EPA has three hazardous waste generator classifications:</p> <ul style="list-style-type: none"> • Large quantity generator • Small quantity generator • Very small quantity generator. 	<p>Program activities were in compliance with requirements.</p> <p>Applicable staff received annual hazardous and universal waste training in accordance with state and federal regulations.</p> <p>NREL maintains unique EPA identification numbers for four of its seven facilities: the STM Campus, Building 16, the Flatirons Campus, and ReFUEL.</p> <p>All regulatory notifications were completed and applicable waste generator fees were paid. The waste generator status for each NREL facility is:</p> <ul style="list-style-type: none"> • STM Campus: small quantity generator, episodically large quantity generator • Flatirons Campus: very small quantity generator • Building 16: very small quantity generator • ReFUEL: 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. <p>The lease for the Joyce Street Facility was terminated and the facility vacated in 2018. The EPA identification number was terminated December 10, 2021.</p> <p>A two-liter container of nitroglycerin at the STM Campus was found to be potentially unstable. The container was destroyed via an emergency treatment permit issued by CDPHE.</p>	<p>EPA 40 CFR 260-273: Hazardous Waste</p> <p>EPA 40 CFR 279: Standards for the Management of Used Oil</p> <p>CDPHE 6 CCR 1007-3: Hazardous Waste Regulations</p> <p>Alaska Department of Environmental Conservation 18 Alaska Admin Code 60.020: Hazardous Waste</p>
Aboveground Storage Tank Management		
<p>Aboveground storage tanks (ASTs) are regulated in Colorado by the Colorado Department of Labor and Employment’s Division of Oil and Public Safety under the Colorado AST regulation.</p> <p>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.</p>	<p>Program activities were in compliance with requirements.</p> <p>All tanks were inspected to confirm continued adherence to State of Colorado regulations.</p>	<p>Colorado Department of Labor and Employment 7 CCR 1101-14: Storage Tank Regulations</p>

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Petroleum Spill Prevention and Response		
<p>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 the Division of Oil and Public Safety.</p> <p>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 U.S. 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.</p> <p>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.</p>	<p>Program activities were in compliance with requirements.</p> <p>No reportable spills occurred.</p> <p>SPCC plans are maintained for the STM Campus, Flatirons Campus, and ReFUEL.</p> <p>Applicable staff received annual SPCC training in accordance with state and federal regulations.</p>	<p>EPA 40 CFR Part 112: Oil Pollution Prevention</p> <p>EPA Clean Water Act, Section 319: Nonpoint Source Management Program</p> <p>Colorado Department of Labor and Employment 7 CCR 1101-14: Storage Tank Regulations</p> <p>Colorado Water Quality Control Commission Colorado Revised Statutes 25-8-205: Control Regulations</p>
Radiological Materials and Waste Management		
<p>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.</p> <p>DOE Order 458.1, Radiation Protection of the Public and the Environment, establishes radiation emission limits for DOE facilities, which 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.</p> <p>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.</p> <p>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.</p>	<p>Program activities were in compliance with requirements.</p> <p>Small quantities (less than 2.0 cubic yards [1.5 cubic meter]) of low-level radioactive waste are in storage awaiting offsite disposal.</p> <p>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.</p> <p>In accordance with a federal regulation and DOE order, NREL submitted its annual Radionuclide Air Emissions Annual Report to the EPA to confirm that the laboratory is in compliance with air emissions standards. For 2021, the effective dose equivalent of radiation to the public was 0.043 mrem, which is far below the 10 mrem per year limit.</p> <p>No property was either requested or authorized for clearance to be released for reuse or disposal.</p>	<p>EPA 40 CFR 61, Subpart H: Emissions of Radionuclides Other Than Radon from Department of Energy Facilities</p> <p>DOE Order 458.1: Radiation Protection of the Public and the Environment</p> <p>DOE Order 435.1 Chg 1: Radioactive Waste Management</p>

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
National Environmental Policy Act		
<p>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.</p> <p>DOE regulations and orders establish how NEPA is implemented for DOE, and the Council on Environmental Quality reviews and approves federal agency NEPA procedures.</p> <p>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.</p>	<p>Program activities were in compliance with requirements.</p> <p>A total of 185 documented environmental evaluations were completed; 174 actions were covered by a NEPA programmatic determination or existing environmental assessment; and 11 actions were submitted to DOE for review.</p>	<p>40 CFR 1500-1508: Regulations for Implementing the Procedural Provisions of NEPA (Council on Environmental Quality)</p> <p>DOE 10 CFR 1021: NEPA Implementing Procedures</p>
Wildlife Management		
<p>The Migratory Bird Treaty Act 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.</p> <p>The Migratory Bird Treaty Act and its amendments implement several treaties between the U.S., Canada, Mexico, Japan, and Russia. The act 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.</p> <p>Under the memorandum of understanding between DOE and the USFWS Regarding Implementation of Executive Order 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.</p> <p>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.</p>	<p>Program activities were in compliance with requirements.</p> <p>Potential wildlife impacts are considered for proposed projects and routine maintenance activities.</p> <p>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 Migratory Bird Treaty Act.</p> <p>To help reduce bird collisions with structures, a variety of methods are evaluated for use such as applying films or adhesives to window glass, using fritted window glass, adding bird diverters to power pole guy wires, adding motion sensors to interior and exterior lighting, down-shielding exterior lighting, and turning off interior lights at night.</p> <p>NREL held one active Scientific Collection Permit for salvage in 2021. The permit is acquired for the collection of deceased bats to determine bat species.</p>	<p>USFWS 16 U.S.C. 703-712: The Migratory Bird Treaty Act</p> <p>Memorandum of Understanding between DOE and the USFWS</p> <p>Executive Order 13186: Responsibilities of Federal Agencies to Protect Migratory Birds</p> <p>Colorado Division of Parks and Wildlife Colorado Revised Statutes 33-6-128: Damage or Destruction of Dens or Nests, Harassment of Wildlife</p>

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Endangered Species and Species of Concern		
<p>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.</p> <p>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.</p> <p>Additional federal and state laws and regulations, such as the Bald and Golden Eagle Protection Act, protect wildlife.</p> <p>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.</p> <p>The Colorado Division of Parks and Wildlife maintains a list of endangered, threatened, and wildlife species of concern for Colorado.</p>	<p>Program activities were in compliance with requirements.</p> <p>No activities were conducted in designated critical habitat for the federally threatened Preble's meadow jumping mouse (<i>Zapus hudsonius preblei</i>).</p> <p>No threatened or endangered plant species were identified at either the STM Campus or the Flatirons Campus.</p> <p>Water usage at the STM Campus and Flatirons Campus were below the thresholds identified through the DOE and USFWS formal consultation.</p>	<p>USFWS 50 CFR 17: Endangered and Threatened Wildlife and Plants</p> <p>Colorado Division of Parks and Wildlife 2 CCR 406-10, Article 2: Endangered Wildlife</p> <p>Colorado Division of Parks and Wildlife 2 CCR 406-10, Article 3: Threatened Wildlife</p>
Vegetation Management		
<p>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.</p> <p>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.</p> <p>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.</p> <p>Executive Order 13112, Invasive Species, requires the control of invasive species at federal facilities.</p> <p>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.</p> <p>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.</p>	<p>Program activities were in compliance with requirements.</p> <p>Herbicides were applied to control Class A-, B-, and C-listed weeds in conjunction with other management methods, such as mowing and hand pulling on the STM Campus, STM Campus conservation easement, and the Flatirons Campus. When applying herbicides, a spot-spraying method is used to protect the health of bees (<i>Anthophila</i> spp.) and other pollinators.</p> <p>NREL acquired certified weed-free seed mixes to minimize the introduction of invasive weed species at its campuses.</p> <p>NREL held three active APHIS permits in 2021, one of which was terminated and one of which was transferred to a different research staff member under a different permit number. The permits were obtained for microorganisms imported to the STM Campus from within the U.S. and from Japan.</p>	<p>Executive Order 13112: Invasive Species</p> <p>Presidential Memorandum: Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators</p> <p>EPA 40 CFR 162: State Registration of Pesticide Products</p> <p>EPA 40 CFR 171: Certification of Pesticide Applicators</p> <p>Colorado Water Quality Control Commission 25-8-205: Noxious Weed Management, Municipal Authority</p> <p>U.S. Department of Agriculture 7 U.S. Code Ch. 61: Noxious Weeds</p> <p>U.S. Department of Agriculture Public Law 106-224: Agricultural Risk Protection Act of 2000</p> <p>EPA 7 U.S. Code 136 et seq.: Federal Insecticide, Fungicide, and Rodenticide Act</p>

Regulatory Program Description	Compliance Status	Regulator Requirement: Regulation Title
Wetlands and Floodplains		
<p>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 and the EPA.</p> <p>Executive Order 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.</p> <p>Under Executive Order 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.</p> <p>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.</p> <p>In Colorado, Jefferson County requires approval of development proposed in floodplains within its jurisdiction.</p>	<p>Program activities were in compliance with requirements.</p> <p>A wetland delineation was conducted for the proposed Flatirons Campus water system project.</p>	<p>U.S. Army Corps of Engineers Clean Water Act Section 404: Permit Program</p> <p>Executive Order 11988: Floodplain Management</p> <p>Executive Order 11990: Protection of Wetlands</p> <p>DOE 10 CFR 1022: Compliance with Floodplain and Wetland Environmental Review Requirements</p>
Cultural Resources		
<p>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.</p> <p>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.</p>	<p>Program activities were in compliance with requirements.</p> <p>A cultural resource survey was conducted on the STM Campus in advance of proposed construction activities.</p>	<p>National Park Service 36 CFR 60: National Register of Historic Places</p> <p>National Park Service 36 CFR 63: Determinations of Eligibility for Inclusion in the National Register of Historic Places</p> <p>National Park Service 36 CFR 79: Curation of Federally Owned and Administered Archaeological Collections</p> <p>National Park Service 36 CFR 800: Protection of Historic Properties</p> <p>16 U.S.C. 470: National Historic Preservation Act</p> <p>State Historic Preservation Office 8 CCR 1504-7: Historical, Prehistorical, and Archaeological Resources</p>



5 AIR QUALITY PROTECTION

A small standby generator and fuel tank help power building operations on the Flatirons Campus. Emissions from all NREL generators are tracked by staff to ensure adherence to air quality protection requirements. *Photo by Werner Slocum, NREL 56896*

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 an individual's 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:

- Minimizing air emissions from research and operations activities and employee commuting
- Tracking air emissions from the onsite sources
- Meeting federal and state air emissions and permitting requirements. Emitted air pollutants include criteria pollutants (e.g., carbon monoxide, NO_x, 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 laboratory facilities and those in the greater 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.

The Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division issued permits to NREL in January 2021 limiting NO_x emissions at the STM Campus from 68.7 to 34.7 U.S. tons (62.3 MT to 31.5 MT) per year⁶; the STM Campus is now considered a “synthetic minor” source. A summary of the estimated annual air pollutant emissions in 2021 is included in Table 4.

In late 2021, EPA and Colorado stated plans to change the ozone nonattainment status of northeastern Colorado from

“serious” to “severe” which would change the major source definition for NO_x and VOC emissions from 50 U.S. tons (45.4 MT) per year to 25 U.S. tons (22.7 MT) per year. Such a change would require NREL to further evaluate emissions and sources at the STM Campus to determine the proper course of action to comply with that change. Possible courses of action include further reduction of NO_x emissions or entry into Title V permitting for the STM Campus.

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 ₂ O	All HAPs
2017	5.92 (5.37)	13.63 (12.36)	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 (0.34)
2018	7.94 (7.20)	18.73 (17.00)	2.15 (1.95)	3.00 (2.72)	0.41 (0.37)	8,526 (7,735)	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 (8,404)	0.31 (0.28)	0.27 (0.24)	0.58 (0.53)
2020	7.52 (6.82)	15.98 (14.50)	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)
2021	7.65 (6.94)	15.43 (14.00)	0.70 (0.64)	3.14 (2.85)	0.42 (0.38)	10,389 (9,425)	0.34 (0.31)	0.25 (0.23)	0.52 (0.47)

a CO: carbon monoxide; NO_x: nitrogen oxides; VOC: volatile organic compound; PM₁₀: respirable particulate matter less than 10 micrometers in diameter; SO₂: sulfur dioxide; CO₂: carbon dioxide; CH₄: methane; N₂O: nitrous oxide; HAPs: hazardous air pollutants

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

5.2 Refrigerants

Refrigerants such as chlorofluorocarbons and hydrochlorofluorocarbons are considered ozone depleting substances, and they are now only available as recycled refrigerants. Non-ozone depleting compounds such as hydrofluorocarbons and hydrofluoroolefins have been used to replace ozone depleting refrigerants; most of these compounds 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 various refrigerants in varying quantities. Emissions of refrigerants may occur either because 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 hydrofluorocarbon refrigerants because of their high level of use, increased releases to the atmosphere during leaks, and global warming potential (which is generally much greater than that of CO₂). In November 2021, the U.S. Congress enacted legislation that limits the use of hydrofluorocarbons in manufacturing. This legislation, now enacted as a rule by EPA, mandated progressive reduction in hydrofluorocarbon use effective in 2022 and further reducing use to 15% of the baseline amount by 2036. This reduction in use does not require the retirement of existing appliances

using hydrofluorocarbon refrigerants; however, the availability of these refrigerants is expected to decrease, and costs are expected to increase over the phase-out period. The rule is expected to lead to a future decrease in the laboratory’s use of hydrofluorocarbon refrigerants.

The equipment and refrigerant inventory for the laboratory includes 133 appliances, 20 of which contain 50 or more lb (23 kg) of refrigerant and are subject to strict requirements. The total inventory of all refrigerants is 9,162 lb (4,156 kg); of this amount, 1,150 lb (522 kg) are ozone depleting substances and the remaining 8,012 lb (3,634 kg) are non-ozone depleting substances that are GHGs. This inventory is expected to increase in 2022 as NREL modifies existing equipment and constructs new research facilities at the STM Campus and the Flatirons Campus.

Additional information about management of NREL’s air quality protection program can be found in [Appendix A. Program Management](#).

2021 Accomplishments and Highlights

- Obtained new or revised air permits for 20 items of fuel-burning equipment and received a “synthetic minor” source determination for the STM Campus. For these 20 items, a run-time emissions database collected and tabulated data to provide accurate emissions for operating compliance.



The Central Arroyo Detention Basin at the STM Campus was constructed to manage stormwater runoff. The basin also provides habitat for various types of wildlife. *Photo by Werner Slocum, NREL 64471*

6 WATER QUALITY PROTECTION

Water quality is critical to human health and the health of 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. Program Management](#).

6.1 Drinking Water

The STM Campus and the Flatirons Campus are provided with potable drinking water by two different means.

STM Campus

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.

Due to 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 at or near the State of Colorado's minimum required concentration of 0.20 mg/L. It was concluded this low concentration of chlorine resulted from an insufficient amount of treated water entering the buildings. A flushing program was instituted in mid-2020 to bring fresh water into the buildings to increase levels of residual chlorine and regular monitoring and flushing continued until May 2021; at that time, it was determined that enough staff had returned to campus and sufficient water use was occurring to restore residual chlorine levels comfortably above the minimum state-required concentration.

Flatirons Campus

The Flatirons Campus is not located within the bounds of a municipal public water supply distribution system; consequently, treated water is purchased from the City of Boulder and transported by truck to the campus. The treated water originates in large part from the Boulder Creek

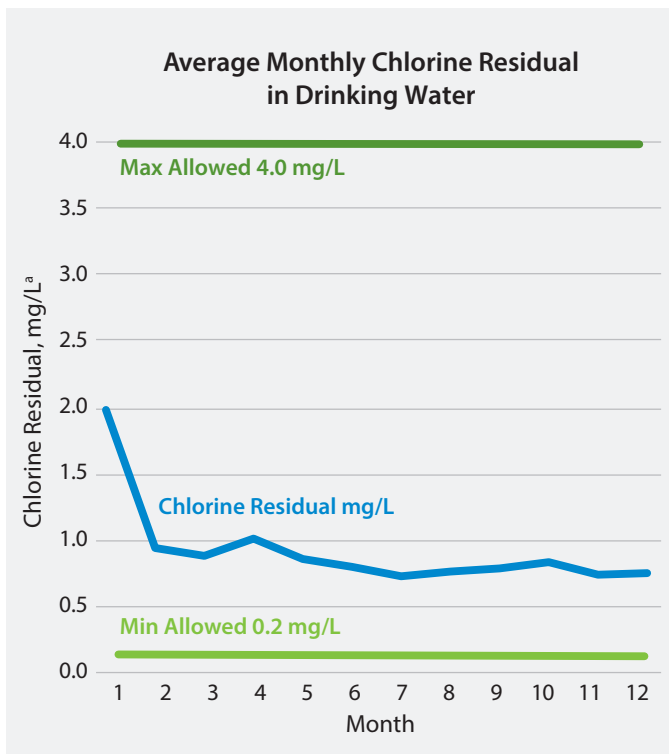


Figure 4. Results of Average Monthly Chlorine Residual Monitoring in Drinking Water at the Flatirons Campus, 2021

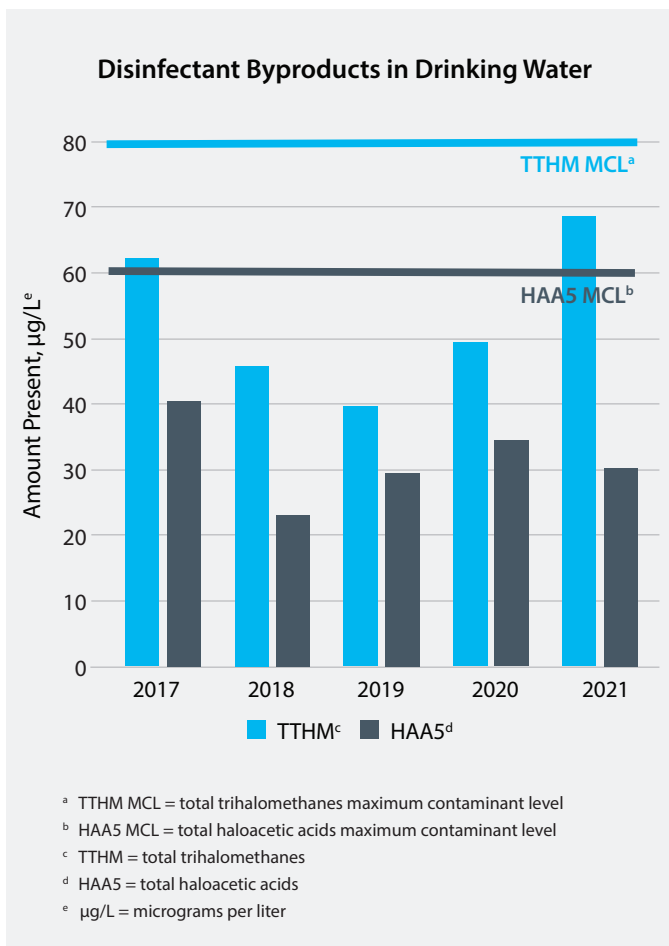


Figure 5. Results of Disinfection Byproduct Concentrations in Drinking Water at the Flatirons Campus, 2017–2021

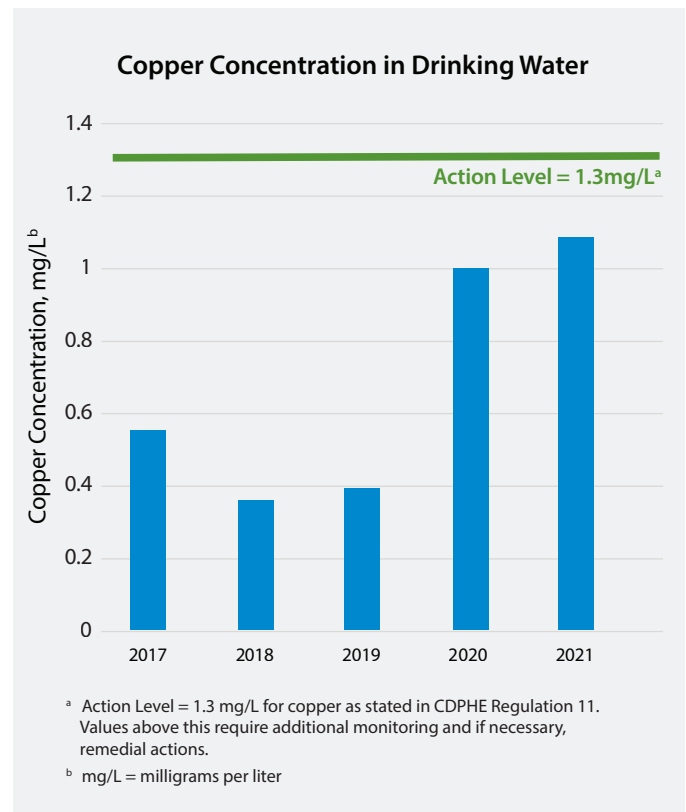


Figure 6. Results of Copper Monitoring in Drinking Water at the Flatirons Campus, 2017–2021

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 (7,571-L) day tank where chlorine is added to boost disinfectant levels before the water is distributed to campus buildings (Figure 4 and Figure 5).

The State of Colorado permits the Flatirons Campus drinking water system. Weekly monitoring and periodic required sampling and analysis are conducted in accordance with the State of Colorado's annual monitoring plan. In 2021, monitoring results for residual chlorine, disinfection byproducts, and copper were within allowable regulatory ranges (Figure 4, Figure 5, and Figure 6). 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 2021.

In 2021, design for a new Flatirons Campus waterline project commenced. The project would deliver raw water from a nearby reservoir via a new 3-mile (4.8-km) pipeline. Once on campus, the raw water would be used to fill two new fire suppression water storage tanks and to feed a new drinking water treatment plant that would deliver potable water to campus buildings. The system would eliminate vulnerabilities associated with current trucked-in water and would provide sufficient fire suppression water storage to protect all campus buildings.

2021 Accomplishments and Highlights

- Provided 354,168 gallons (1,340,672 L) of drinking water to the Flatirons Campus, a decrease of approximately 20,878 gallons (79,032 L) or nearly 6% less than 2020.
- Successfully passed a State of Colorado inspection of the Flatirons Campus public water supply system. The inspection found no violations or deficiencies, and no recommendations for improvement in the system or its operation.
- Completed a water balance study that quantified water use by individual building from data collected between 2014 and 2020 at the Flatirons Campus and the STM Campus. The study will guide water management and climate resilience planning activities.

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 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 either the STM Campus or 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 firefighting foam. Though many PFAS chemicals are no longer manufactured in the U.S., 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 EPCRA. 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 (1,893-L) 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 were 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.

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



A multiyear effort to stabilize the hillside west of the Field Test Laboratory Building was deemed successful in 2021. *Photo by Werner Slocum, NREL 68353*

Rock Creek at the Flatirons Campus. Sediment, debris, and chemicals transported to these water bodies via stormwater runoff could harm or kill fish and other wildlife either directly or by destroying aquatic and riparian habitat. High volumes of sediment could 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. Significant efforts were made in 2021 to address permit requirements.

2021 Accomplishments and Highlights

- Completed a multiyear effort to stabilize the hillside adjacent to the Field Test Laboratory Building. The building was first damaged by a water line break and was further impaired by the erosive effects of a September 2013 flood event. Efforts to stabilize the hillside were deemed successful.
- Continued to develop MS4 permit programs intended to reduce the discharge of pollutants in stormwater runoff from the STM Campus.

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 Metro Water Recovery’s central treatment plant. Wastewater from the ReFUEL also flows to this central treatment plant.

Primary nondomestic wastewater discharge is generated at the STM Campus’ Integrated Biorefinery Research 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 no discharges occurred in 2021 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.



Approximately one-third of the storm drain inlets on the STM campus were stenciled with the words “No Dumping: Drains to Waterway”. *Photo by Werner Slocum, NREL 64466*

Metro Water Recovery 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 or multiple tanks 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.

2021 Accomplishments and Highlights

- Submitted an application to Metro Water Recovery to discharge wastewater from a research project. The project involved using a specialized bacteria to generate methane that can ultimately be used to provide heating or electricity. The request was for a one-time discharge to the sanitary sewer of 250 gallons (946-L) from a large bioreactor at the Energy Systems Integration Facility on the STM Campus.
- Submitted a second application to Metro Water Recovery for small, regularly occurring discharges (approximately 1-gallon [3.8-L]) to the sanitary sewer over a period of one year. These discharges will be similar in character to the one-time 250-gallon (946-L) wastewater from the large bioreactor but will be generated as part of a research effort to develop a small-scale mobile laboratory in which methane can be successfully produced.
- Started a project to develop a wastewater treatment feasibility study for the Flatirons Campus. The study is intended to include innovative yet practical solutions to onsite wastewater treatment systems that also afford researchers the opportunity to assist in early-stage advance technologies for use in the public domain, federal lands, in Arctic communities, and on native tribal reservations.



7 HAZARDOUS MATERIALS AND HAZARDOUS WASTE MANAGEMENT

Outdoor storage of hydrogen, which is considered a hazardous material, is properly maintained to support research activities. *Photo by Werner Slocum, NREL 64478*

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 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
- Aboveground storage tank 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. Program Management](#).

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 EPCRA reporting requirements that were met in 2021. The reporting requirements for each EPCRA section are defined in [Section 4, Compliance Summary](#).

Table 5. 2021 EPCRA Reporting by EPCRA Section

EPCRA Section	Description of Reporting	Status
302	Planning notification	Not required ^a
304	Extremely hazardous substance release notification	Not required ^a
311	Safety data sheet notification	Not required ^a
312	Tier II reporting	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.

Hazardous Materials Incidents

In 2021, the following hazardous material incidents occurred:

- When waste was added to a waste container of corrosive liquids, a color change and an abnormal smell were observed indicating an unintended reaction had occurred. Emergency responders helped remove the container from the laboratory and an emergency treatment permit was obtained from CDPHE to render the chemical inactive.
- A large battery associated with energy storage developed a leak within its secondary containment of sulfuric acid and vanadium electrolyte solution. The affected area was treated to neutralize any remaining acid within the secondary containment. There were no impacts to groundwater or surface water.
- While a contractor was performing work at Flatirons Campus, a fuel tank was punctured releasing approximately 20 gallons of diesel fuel to the soil. Secondary containment was quickly secured. Remaining fuel was placed into a secondary container and affected soil was removed for proper disposal. There were no impacts to groundwater or surface water.

2021 Accomplishments and Highlights

- Continued implementing a new chemical inventory software that integrates safety data sheet management. Installation of the software and associated training is expected in 2022.
- Continued physical inventory of chemical containers at the STM Campus, which reviewed approximately 7,000 containers.
- Hired and trained two additional staff members on proper waste management to assist with chemical and waste management across NREL's Colorado sites.



An NREL employee inventories chemicals in a research laboratory.

Photo by Eric Schmitz, NREL 63779

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-containing articles and lamps, batteries, aerosol cans, used oil, computers, hard drives, monitors, and research instrumentation containing electronic circuitry.

Figure 7 summarizes the waste generated at NREL from 2017 to 2021. Universal waste electronics and other universal waste generated for 2021 is exceedingly higher than other years due to the recycling of an Energy Systems Integration Facility supercomputer and three large lithium-ion bus battery packs.

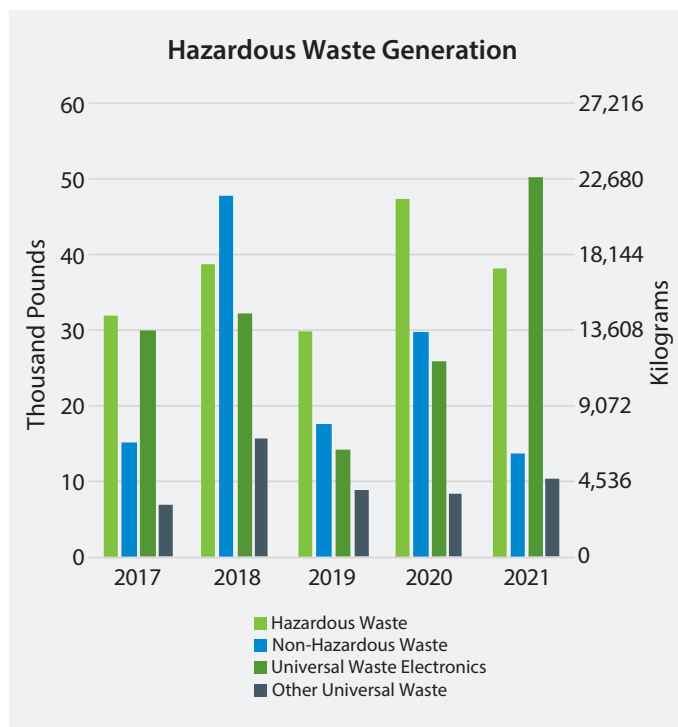


Figure 7. Comparison of Four Waste Categories Generated at NREL Facilities by Net Weight, 2017–2021



A nonhazardous waste accumulation area in use at the Structural Testing Lab at the Flatirons Campus. Photo by Werner Slocum NREL 56894

2021 Accomplishments and Highlights

- Worked with research groups to recycle large stainless-steel research equipment within the Science and Technology Facility and the Solar Energy Research Facility at the STM Campus.
- Initiated preliminary planning for the design and construction of a replacement waste storage and handling facility to accommodate expected growth of laboratory activities.

7.3 Aboveground Storage Tank Management

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

NREL only operates aboveground storage tanks (ASTs), which decreases risk of underground soil and water contamination. Unlike underground tanks, ASTs provide access for regular inspections, reducing repair and cleanup costs.

NREL operates several petroleum-based ASTs, including:

- Nineteen on the STM Campus with a total capacity of 13,920 gallons (52,693 L)
- Five on the Flatirons Campus with a total capacity of 1,289 gallons (4,879 L)
- One at Building 16 with a capacity of 500 gallons (1,893 L).



A 1,000-gallon (4,546-L) aboveground storage tank on the STM Campus containing gasoline is maintained to refuel site support vehicles. Photo by Dennis Schroeder, NREL 32151

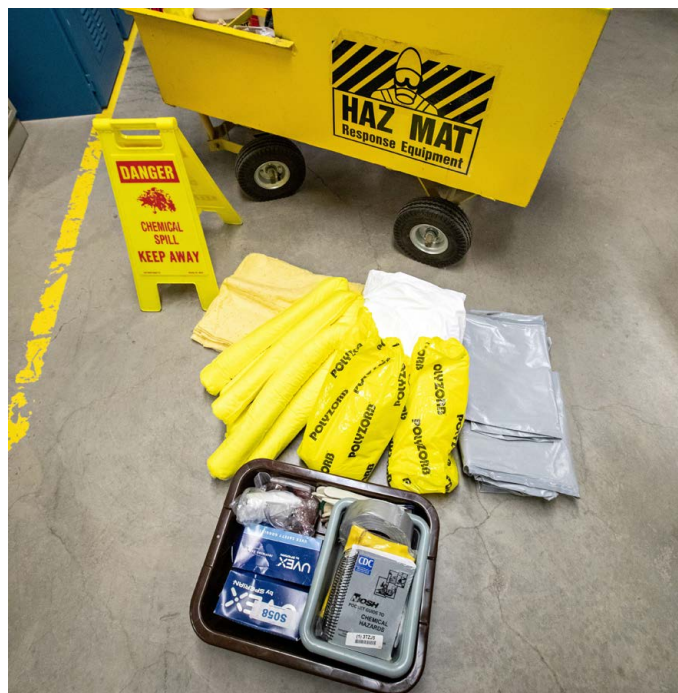
7.4 Petroleum Spill Prevention and Response

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 are intended to reduce spills and minimize 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. Because less than 1,320 gallons (4,997 L) of petroleum is stored at Building 16—and no petroleum is stored at the Golden Warehouse, the Washington D.C. Office, or the Research and Testing Facility—SPCC plans are not required at those locations.

2021 Accomplishments and Highlights

- Revised SPCC plans for the STM Campus, Flatirons Campus, and ReFUEL, which included updating oil-containing equipment information, spill history, and cleanup resources.
- Updated the SPCC annual training program to reflect the revised SPCC plans and emphasize spill prevention and immediate response requirements; training was delivered virtually due to the ongoing COVID-19 pandemic.



A wide variety of materials and equipment are placed in spill carts and are distributed throughout the laboratory's facilities to aid in spill response. *Photo by Werner Slocum, NREL 56077*

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. A summary of petroleum spills is listed in Table 6. In 2021, 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.

Table 6. Petroleum Spills

Location: Description	Quantity (gal, [L])
Flatirons Campus: Drilling contractor vehicle fuel spill	20.0 (75.7)
STM Campus: Contractor mower hydraulic leak	1.5 (5.7)
Flatirons Campus: Hydraulic test equipment leak	1.0 (3.8)
STM Campus: Contractor vehicle antifreeze spill	1.0 (3.8)
Flatirons Campus: Indoor test equipment hydraulic spill	0.5 (1.9)
STM Campus: Contractor service vehicle	0.5 (1.9)
STM Campus: Sweeping machine hydraulic leak	0.5 (1.9)
STM Campus: Boom lift hydraulic leak	0.3 (1.1)
STM Campus: Vehicle oil leak	0.1 (0.4)

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. 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

Activity	2017	2018	2019	2020	2021
Total activity (mCi) ^b	3.88	3.88	3.88	3.89	3.87
Effective dose equivalent (mrem/yr)	0.045	0.037	0.037	0.039	0.043

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 and 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 2021.

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 U.S. receives about 310 mrem each year from natural sources and an additional 310 mrem from medical procedures and consumer products.



8 NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE

An environmental review was completed before crews could install hydrogen storage tanks at the Flatirons Campus; the tanks are a part of a hydrogen energy storage infrastructure system. *Photo by Werner Slocum, NREL 66374*

The National Environmental Policy Act (NEPA) of 1969 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 committed 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. Program Management](#).

In 2021, the laboratory collaborated with DOE Golden Field Office to develop two new programmatic NEPA determinations. The first addresses offsite installation of research monitoring devices on existing structures and has resulted in more efficient reviews for certain offsite projects. The second addresses onsite flights of uncrewed aircraft systems and streamlines the review process for certain types of flights onsite. 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 the DOE Golden Field Office to have no significant environmental impacts and outlines the conditions under which each determination applies.



NREL researchers and crew deployed three moorings in Cook Inlet, Alaska, to collect data for a potential tidal energy site. A NEPA review was completed beforehand to evaluate potential environmental impacts of the project.. *Photo by Levi Kilcher, NREL 66087*

2021 Accomplishments and Highlights

Hosted consistent and frequent NEPA strategy meetings and collaboration reviews to address environmental aspects of upcoming projects.

- Coordinated and facilitated the development of consultation documents for the U.S. Fish and Wildlife Service and National Marine Fisheries Service. The consultation documents addressed potential impacts to marine species from offsite buoy deployment projects.
- Developed two new programmatic NEPA determinations to support efficient reviews for certain onsite and offsite projects.



Three young great horned owls (*Bubo virginianus*) sit in their nest near the STM Campus Parking Garage. Photo by Werner Slocum, NREL 64457

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.

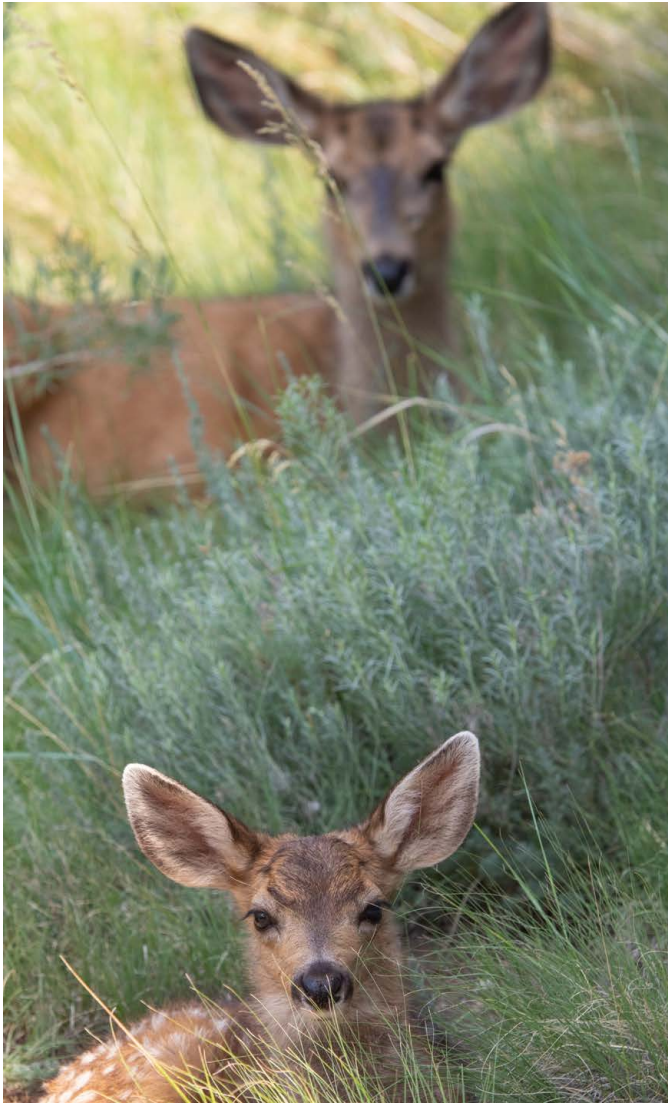
Additional information about program management for these five areas can be found in [Appendix A. Program Management](#).

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. The original wildlife survey of the STM Campus was completed in 1987. Additional surveys were completed at the STM Campus in 1999, 2005, 2011, and 2017.

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 been recorded at or flying above the STM Campus, especially during spring migration. Two raptor species are residents at the



A mule deer (*Odocoileus hemionus*) fawn stays close to its mother outside the Research Support Facility at the STM Campus. Photo by Werner Slocum, NREL 51812

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 Campus 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 (*Ursus americanus*)

and mountain lions (*Puma concolor*) 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 (*Cervus canadensis*), mule deer (*Odocoileus hemionus*), coyotes (*Canis latrans*), cottontails (*Sylvilagus* spp.), bobcats (*Lynx rufus*), several species of bats (*Chiroptera* spp.), 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 viridis*), bull snakes (*Pituophis catenifer*), yellow-bellied racers (*Coluber constrictor*), and several other reptiles are also known to occupy the Flatirons Campus. Amphibians, including boreal chorus frogs (*Pseudacris hapsus*), Woodhouse's toad (*Anaxyrus woodhousii*), and sand northern leopard frogs (*Lithobates pipiens*), occupy ephemeral wetlands at the Flatirons Campus.

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. Wildlife Species Observed at the STM Campus and the Flatirons Campus](#).

Rattlesnake Safety and Research

Western (prairie) rattlesnakes (*Crotalus viridis*) are important to the native ecology of South Table Mountain and are commonly found on the STM Campus. Rattlesnakes can be found on campus in locations where human safety is compromised such as doorways, equipment boxes, and other areas where staff may be at risk. Staff is made aware to call NREL security to have rattlesnakes and any other type of snakes removed. Security is trained to safely capture and relocate snakes to a safer location on the STM Campus.

NREL has been working with Adaptation Environmental Services, a local environmental firm specializing in rattlesnake safety and research. For the past three 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 Passive Integrated Transponder (PIT) tagging on relocated snakes to monitor snake movements and better understand their behavior. Some rattlesnakes that were captured and relocated on the STM Campus were given PIT tags. The capture location, date, and

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.



An employee on NREL's environment team holds a non-venomous bull snake (*Pituophis catenifer*) during a training exercise to learn about snake safety and proper handling. Photo by Eryn Lussier, NREL 68123

sex of the snake are recorded along with the PIT tag number. PIT tagging of relocated rattlesnakes started in April 2018 and has continued through 2021. During this time, 24 rattlesnakes, consisting of 10 females and 15 males, have been given a PIT tag and relocated.

Wildlife Incidents at the STM Campus and the Flatirons Campus

In January 2021, an officer of the Colorado Parks and Wildlife Division was called to the STM Campus to dispatch a buck mule deer (*Odocoileus hemionus*) that was immobile. The buck later tested positive for chronic wasting disease. Two more mule deer that were found deceased on the STM Campus were assumed to also have died from the disease, but testing did not occur. Chronic wasting disease is common in Jefferson County and many other locations in Colorado.

In November 2021, a rough-legged hawk (*Buteo lagopus*) was found dead along Row 4 at the Flatirons Campus. The cause of death was undetermined, but it was found in an area with high density of guy wires. Rough-legged hawks are winter migrants and may not be as familiar with these surroundings compared to year-round resident raptors.



NREL staff at the STM Campus assists a local environmental firm with research efforts to monitor western (prairie) rattlesnakes (*Crotalus viridis*). Photo by Tom Ryon, NREL 68124

2021 Accomplishments and Highlights

- Observed bobcats (*Lynx rufus*) at the western end of the STM Campus that were likely the same family of bobcats that denned within the Research Support Facility courtyard in 2020. To prevent the bobcats from denning in the courtyard again, natural animal deterrent was sprayed in 2021.
- Identified building features to discourage bird perching and nesting for a proposed new building. These features will be further evaluated during the design phase to minimize building damage and maintenance associated with bird use.
- Incorporated bird-friendly window glass into the design of a new STM Campus building. A fritted pattern within the window glass was selected to provide a durable solution and minimize the potential for bird strikes.
- Captured and tagged five rattlesnakes with PIT tags at South Table Mountain and inside the STM Campus boundary, bringing NREL's total number of PIT-tagged rattlesnakes over four years to 24.
- Provided training sessions to 12 interested staff on snake handling, ecology, and taxonomy to minimize injuries to snakes and enhance safety awareness of responders during snake relocation activities.
- Delayed repairing holes in the STM Campus Education Center façade made and occupied by Northern flickers (*Colaptes auratus*) until the nesting season was over and the flickers were gone.

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 with ESA 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*). In December 2020, the monarch butterfly (*Danaus plexippus*) was proposed for listing and is considered a candidate for listing. A candidate species has no official protection under the ESA, but agencies are encouraged to take advantage of any opportunities to conserve candidate species. 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.



A monarch butterfly (*Danaus plexippus*), an important pollinator species, feeds on some rabbitbrush (*Chrysothamnus nauseosus* subsp.) flowers on the STM Campus. Photo by Tom Ryon, NREL 66524

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 (*Lithobates pipiens*). 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 campuses but had to be stopping over or otherwise using habitat at the campus, such as by nesting or foraging.

The USFWS has designated critical habitat associated with the federally endangered Preble's meadow jumping mouse (*Zapus hudsonius preblei*) 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.

Four 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 two birds (the piping plover [*Charadrius melodus*] and the whooping crane [*Grus americana*]), a fish (the pallid sturgeon [*Scaphirhynchus albus*]), and a plant (the western prairie fringed orchid [*Platanthera praeclara*]). The U.S. Department of the Interior delisted the least tern (*Sternula antillarum*) on January 12, 2021. As part of the STM and Flatirons' 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.

2021 Accomplishments and Highlights

- Sowed seeds of two species of milkweed into the grounds around the STM Campus detention basin. Swampy milkweed (*Asclepias incarnata*) seeds were sown in hydric soils, and showy milkweed (*Asclepias speciosa*) seeds were sown in more mesic soils. These plants will encourage use by pollinators, including monarch butterflies (*Danaus plexippus*).
- Sowed native wildflower forb seed mixes at the STM Campus at three separate locations to create "forb islands" where the area from previous construction activities remained denuded. These seed islands are intended to provide additional pollinator food sources on campus.

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 native 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*), dalmatian 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 (*Cirsium arvense*) 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 the program 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 balancing the conservation and manipulation of 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 U.S. 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 2021; the permits were obtained for microorganisms imported to the STM Campus: one for microorganisms from within the U.S. and one for microorganisms from Japan.

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

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

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

2021 Accomplishments and Highlights

- Designed new seed mixes with a local agronomist to select native species shown to be successful in this region. The new mixes are campus-specific and landscape-specific so that restoration efforts can be tailored accordingly.
- 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 140 acres (57 hectares) at the Flatirons Campus with appropriate herbicides to control diffuse knapweed (*Centaurea diffusa*), Canada thistle (*Cirsium arvense*), and sulfur cinquefoil (*Potentilla recta*).
- Evaluated small areas of leafy spurge (*Euphorbia esula*) treated in 2020 at the Flatirons Campus to ensure regrowth of the noxious weed had not occurred. No leafy spurge was found, and these areas and surrounding areas will be evaluated again in 2022.
- Treated 18 acres (7 hectares) of noxious weeds, including Canada thistle (*Cirsium arvense*), houndstongue (*Cynoglossum officinale*), and myrtle spurge (*Euphorbia mysinites*) at the STM Campus. Jointed goatgrass (*Aegilops cylindrica*), another noxious weed recently discovered on the STM Campus, was also treated in areas surrounding the Solar Radiation Research

Laboratory, a photovoltaic solar array, and conservation trail easements. These areas will be evaluated again in 2022 to verify that treatment remains effective.

- Removed select rabbitbrush (*Chrysothamnus* spp.) bushes on the STM Campus to decrease the population and to address wildfire risk. In recent years, the quantity of rabbitbrush has increased exponentially for unknown reasons which has limited biodiversity. Select bushes are left to keep these important pollinator plants in balance with other native plants.
- Updated vegetation management maps for the STM Campus and the Flatirons Campus. These maps are important to coordinate mowing, herbicide spraying, and other approaches to reduce fire danger and manage noxious weeds at the campuses.
- Biologically controlled specific noxious weeds at the STM Campus. Bindweed mites (*Aceria malherbae*) were released in infested areas of the campus, and knapweed weevils (*Cyphocleonus Achates*) were released on diffuse knapweed (*Centaurea diffusa*) within pine tree (*Pinus* spp.) stands where use of herbicide is discouraged to avoid tree damage.
- Applied a broad-spectrum herbicide in 2018 and 2020 to reduce areas of smooth brome (*Bromus inermis*) at the Flatirons Campus. In 2021 it was confirmed that native grasses and plants had reestablished the areas.



Milkweed species (*Asclepias* spp.) are known to encourage pollinator use. Here, an NREL environment team member sows swampy milkweed (*Asclepias incarnata*) and showy milkweed (*Asclepias speciosa*) near the detention pond at the STM Campus. Photo by Tom Ryon, NREL 64459

Wetlands are lands that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that 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 floodplains. 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 conserve 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

2021 Accomplishments and Highlights

- Conducted a review of surface water resources including wetlands, waters of the U.S., and floodplains near the Flatirons Campus to determine whether any of those water resources could potentially be affected by a proposed water system project. No floodplains were identified within the study area. Several wetland systems and waters of the U.S. were identified within the proposed construction corridor. Should the project proceed, avoidance, minimization, and mitigation would be performed throughout construction of the project to reduce impacts to surface water resources. Construction is anticipated to commence in 2022.

contain 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 as 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 in 2019 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 (0.05)
Palustrine emergent wetland and palustrine scrub-shrub wetland	1.58 (0.64)

A field investigation conducted within the Flatirons Campus in 2020 identified approximately 7.53 acres (3.05 hectares) and 2,142 ft (653 m) 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 (ft [m])
Jurisdictional Areas (Waters of the U.S.)		
Palustrine emergent wetland	2.03 (0.82)	—
Non-Jurisdictional Areas		
Palustrine emergent wetland	5.50 (2.23)	—
Ephemeral stream channel	—	2,142 (653)

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.

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 historical and cultural resources have been performed on the STM Campus. 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, include:

- An open-air amphitheater
- A stone bridge spanning a natural drainage channel adjacent to the amphitheater
- A stone and concrete ammunition “igloo” south of the amphitheater.

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 1995⁹ did not identify any additional significant historical or archeological resources.

2021 Accomplishments and Highlights

- Conducted a cultural resource survey of the proposed location of a new building on the STM Campus. The survey did not find cultural resources and concluded that development of the building would have no adverse effects to existing cultural resources.
- Conducted a cultural resource survey of the proposed location of the Flatirons Campus water system project. The survey did not find cultural resources and concluded that development of the water system would have no adverse effects to existing cultural resources.



The ammunition “igloo” on the STM Campus is a protected historical resource. It was used by Camp George West, a military facility operated by the Colorado National Guard from 1903 through the early 1930s. *Photo by Werner Slocum, NREL 67260*

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



A view of the STM Campus conservation easement. *Photo by Kurt Schlomberg, NREL 50038*

10 CONSERVATION EASEMENT

In 1999, DOE granted Jefferson County a conservation easement of 177 acres (72 hectares) at the STM Campus (Figure 8).

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 historical 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.

2021 Accomplishments and Highlights

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



A western kingbird (*Tyrannus verticalis*) perches atop a yucca (*Yucca glauca*) within the STM Campus conservation easement. Photo by Werner Slocum, NREL 56730

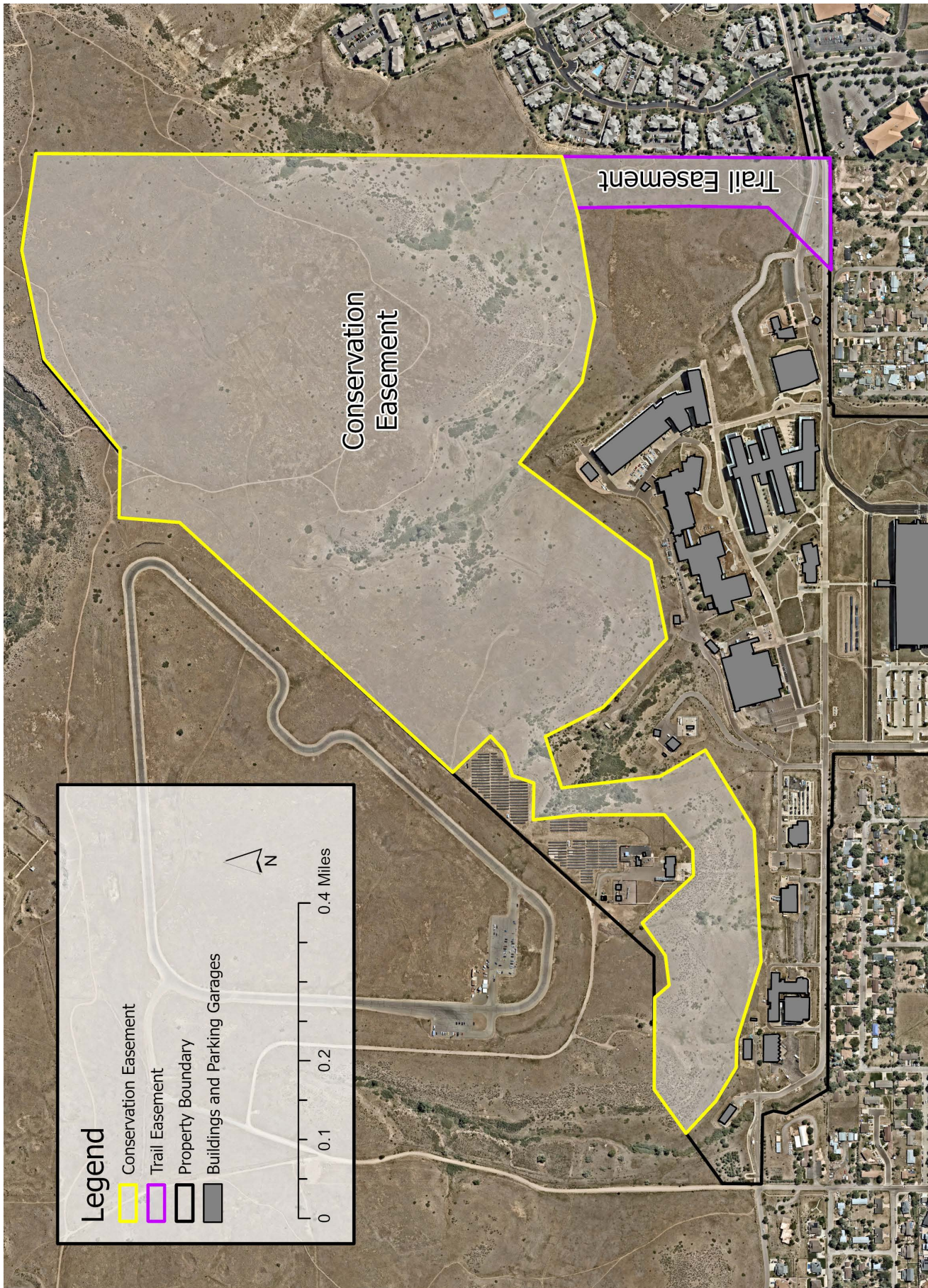


Figure 8. Conservation Easement at the STM Campus



A red-winged blackbird (*Agelaius phoeniceus*) flies from cattails (*Typha* spp.) surrounding the detention pond at the STM Campus. Photo by Werner Slocum, NREL 56771

APPENDIX A. PROGRAM MANAGEMENT

This appendix 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 information and current performance in this area, see [Section 2, 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 and current 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 can 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 general information and current 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 and current performance in this area, see [Section 3.2, Resilience Planning](#).

Air Quality

For general information and current performance in this area, see [Section 5, Air Quality Protection](#).

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, building comfort heating systems, and pollution control systems) that are subject to minimal permit and compliance requirements.

The laboratory has in place a fugitive particulate emissions permit for the STM Campus that was originally required for construction activity over the last several years. This permit has been maintained in case of need due to new construction activity. 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. NREL is required to submit an annual report to Colorado stating deicer is not used and confirming sand is not used.

For information and current 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 (CO₂e) 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 CO₂e emissions in the major source permit if CO₂e emissions exceed 75,000 U.S. tons (68,000 MT) per year. The STM Campus is a "minor" source for most criteria air pollutants and was classified as a "synthetic minor"

source for NO_x emissions. Because CO₂e emissions for the STM Campus and the Flatirons Campus are lower than both of the above-mentioned limits, GHG/CO₂e reporting is not required.

Certain GHGs are essential to safe operation of certain equipment. As an example, sulfur hexafluoride, 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 sulfur hexafluoride and reports to DOE sulfur hexafluoride released to the atmosphere as a result of leaks or equipment failures.

For information and current 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. The NREL refrigerant management program is intended to achieve that goal.

Management of refrigerants, including ozone depleting substances, is accomplished by maintaining a detailed inventory of refrigerants and appliances containing more than 1 lb (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 ozone depleting refrigerant they contain.

For information and current performance in this area, see [Section 5.2, Refrigerants](#).

Water Quality

For general information and current performance in this area, see [Section 6, Water Quality Protection](#).

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 or 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 and current 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 its monitoring program. Occasionally, groundwater wells may be installed and monitored to obtain water level data needed for construction or building maintenance purposes.

For information and current 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 a 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 evaluate site conditions during construction for 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 though 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 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 implemented in subsequent permit terms.

For information and current performance in this area, see [Section 6.3, Surface Water](#).

Wastewater

The wastewater management program is multifaceted and encompasses activities across all NREL sites and facilities, from using “green” cleaning supplies to minimizing the use of harmful chemicals in laboratory operations. The program addresses the requirements of the Metro Water Recovery, which receives and treats waste from the STM Campus. The program also addresses disposal of waste from South Table Mountain mesa top facilities and from the Flatirons Campus, which must comply with state and county health department requirements.

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 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 and current performance in this area, see [Section 6.4, Wastewater](#).

Hazardous Materials and Hazardous Waste Management

For general information and current performance in this area, see [Section 7, Hazardous Materials and Hazardous Waste Management](#).

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 a 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 the laboratory is involved in the emergency planning concepts of EPCRA.

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 and current 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 whereby 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; however, 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.

For information and current 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 gasoline 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 leaks, 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 absence of interstitial liquid.

For information and current performance in this area, see [Section 7.3, Aboveground Storage Tank Management](#).

Spill Prevention and Response

The laboratory prepares for spills 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. 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 petroleum-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 occur occasionally. NREL's policy for spills is that, regardless of spill size, they 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 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 and current 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 few 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's COMPLY model (Version 1.6) to determine the effective dose equivalent to the public. COMPLY uses radionuclide data that provides estimated dose values rather than measured emissions that provide actual dose values.

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 and current performance in this area, see [Section 7.5, Radiological Materials and Waste Management](#).

National Environmental Policy Act

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 onsite and offsite) must undergo a NEPA review to evaluate and understand the potential environmental impacts of a project. A NEPA determination is the outcome of such a review.

NREL and the 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.

Using the site-wide environmental assessment and programmatic NEPA determinations, NREL and DOE Golden Field Office 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 NREL and DOE Golden Field Office, and they 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:** 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 Golden Field Office 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 and current performance in this area, see [Section 8, National Environmental Policy Act Compliance](#).

Natural and Cultural Resources

For general information and current performance in this area, see [Section 9, Natural and Cultural Resources Protection](#).

Wildlife Management

NREL developed its wildlife management program to implement measures to meet or exceed regulatory requirements and to minimize or avoid impacts to wildlife species and their habitats. Regulatory requirements include those of the Migratory Bird Treaty Act, a Colorado Parks and Wildlife statute prohibiting the harassment of wildlife (including damaging or 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. The Migratory Bird Treaty Act provides for penalties for “take” of birds or bird parts whether it occurs with or without intent.

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 off and a buffer area is established until nestlings fledge. In this manner, projects avoid “take” and conserve nesting birds. 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 conservation is intertwined with wildlife protection, program activities often overlap with vegetation management ([Section 9.3, 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 and current 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 four 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 and current 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
- Maximize ground cover to reduce soil erosion
- Establish a variety of habitats to support diverse wildlife
- Reduce the need for and use of pesticides and fertilizers
- Reduce maintenance costs
- Create an aesthetically pleasing landscape.

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

NREL participated in a Sustainable Sites Initiative 2-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 U.S. 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 prefer certain weed species)
- Herbicides applied through spot-spraying.

The use of multiple strategies for control has been successful in significantly reducing populations of diffuse knapweed (*Centaurea diffusa*), Canada thistle (*Cirsium arvense*), and sulfur cinquefoil (*Potentilla recta*). 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 periodically assesses the effectiveness of control methods for noxious weeds. At the STM Campus and the Flatirons Campus, comprehensive weed surveys and mapping are performed approximately every five years and smaller areas are assessed annually.

For information and current performance in this area, see [Section 9.3, Vegetation Management](#).

Wildfire Risk Management

Because wildfires could affect DOE property and impact operational activities, NREL developed a fire protection program. To protect staff, 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 and current 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 U.S. 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 and current 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 avoiding or 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 to ensure regulated and unregulated wetlands are properly identified.

For information and current 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 historical resources. This includes 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 and current 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 (*Zapus hudsonius preblei*), and a rocky outcropping supporting ponderosa pine (*Pinus ponderosa*) and shrublands.

For general information and current performance in this area, see [Section 10, Conservation Easement](#).



COLORADO
Air Pollution Control Division
Department of Public Health & Environment

CONSTRUCTION PERMIT

Permit number: **13JE2276** Issuance: **1**

Date issued: May 24, 2018

Issued to: **U.S. Department of Energy**

Facility Name: National Renewable Energy Laboratory
Plant AIRS ID: 059/1944
Physical Location: 16173 Denver West Parkway, Golden
County: Jefferson
General Description: Electrical generator

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 2021

Location: Description	Category	Issuing Agency	ID	Permit or Registration Status
Air				
Laboratory-wide: servicing of chlorofluorocarbon-containing equipment	Notification	APCD	647	Active
STM Campus: fugitive dust from construction activities	Permit	APCD	08JE0889L	Active
STM Campus: ESIF: diesel-fired standby electrical generator	Permit	APCD	11JE3542	Active
STM Campus: ESIF: research electrical generator #1	APEN	APCD	12JE1734 XP	Terminated
STM Campus: ESIF: research electrical generator #2	APEN	APCD	12JE1735 XP	Terminated
STM Campus: ESIF: research electrical generator #3	Permit	APCD	13JE2829	Active
STM Campus: FTLB: waste gas combustor	Permit	APCD	99JE0400	Active
STM Campus: FTLB: diesel-fired standby electrical generator	Permit	APCD	10JE1630	Active
STM Campus: IBRF: ammonia scrubber and baghouse	Permit	APCD	20JE0749	Active
STM Campus: IBRF: standby electrical generator	Permit	APCD	20JE0748	Active
STM Campus: Parking Garage diesel-fired standby electrical generator	Permit	APCD	11JE1997	Active
STM Campus: RFHP: wood waste boiler	Permit	APCD	07JE0277	Active
STM Campus: RSF 1: diesel-fired standby electrical generator	Permit	APCD	10JE1400	Active
STM Campus: RSF 2: diesel-fired standby electrical generator	Permit	APCD	11JE1303	Active
STM Campus: SERF: two chlorofluorocarbon-containing stationary sources	Registration	APCD	647	Active

Location: Description	Category	Issuing Agency	ID	Permit or Registration Status
STM Campus: SERF: standby electrical generator	APEN	APCD	13JE2275 XP	Active
STM Campus: S&TF: standby electrical generator	APEN	APCD	13JE2274 XP	Active
STM Campus: 12 boilers and heaters at FTLB, SERF, and S&TF	Permit	APCD	20JE0747	Active
Flatirons Campus: Building 251: standby electrical generator	APEN	APCD	13JE2272 XP	Active
Flatirons Campus: CoMET: facility composite demonstration facility	APEN	APCD	16JE0934 XP	Terminated
Flatirons Campus: Site 4.0: diesel-fired standby electrical generator	Permit	APCD	10JE1712	Active
Flatirons Campus; Site 4.4: diesel-fired standby electrical generator	APEN	APCD	13JE2270 XP	Active
Flatirons Campus: STL: standby electrical generator	APEN	APCD	13JE2271 XP	Active
Alcohol				
Laboratory-wide: tax-free alcohol use	Permit	TTB	US-TF-20125	Active
Laboratory-wide: specially denatured spirits procurement	Permit	TTB	US- SDS-20087	Active
STM Campus: IBRF: alcohol fuel production	Permit	TTB	AFP-CO-00255	Active
Animals, Plants				
Laboratory-wide: Scientific Collection Permit for salvage	Permit	Colorado Parks and Wildlife	2329073684	Active
STM Campus: controlled import permit to import <i>Agrobacterium tumefaciens</i> from within the U.S.	Permit	APHIS	P526P-19-02851	Active
STM Campus: controlled import permit to import <i>Sphingobium</i> from Japan	Permit	APHIS	P526P-18-02318	Terminated
STM Campus: controlled import permit to import <i>Sphingobium</i> from Japan	Permit	APHIS	P526P-21-04851	Active
Drinking Water				
Flatirons Campus: drinking water system ID	Registration	WQCD	CO0230860	In effect; does not expire
Hazardous Materials				
Denver West Business Park: Building 16: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
ReFUEL: hazardous material storage and use permit	Permit	Denver Fire Department	2021DFD-HZ-007915	Completed
STM Campus: ESIF: 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: IBRF: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed

Location: Description	Category	Issuing Agency	ID	Permit or Registration Status
STM Campus: S&TF: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
STM Campus: SERF: 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
STM Campus: WHF: hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
Hazardous Waste				
Denver West Business Park: Building 16: RCRA hazardous waste generator status EPA ID	Notification	HMWMD	CO4890000017	Completed
Flatirons Campus: RCRA hazardous waste generator status EPA ID	Notification	HMWMD	COD983902448	Completed
Joyce Street Facility: RCRA hazardous waste generator status EPA ID	Notification	HMWMD	COD980805162	Terminated
ReFUEL: RCRA hazardous waste generator status EPA ID	Notification	HMWMD	COR000207563	Completed
STM Campus: RCRA hazardous waste generator status EPA ID	Notification	HMWMD	CO3890090076	Completed
Historic Resource				
STM Campus: ammunition "igloo"	Registration	National Park Service	93000379	In effect; does not expire
STM Campus: amphitheater and stone footbridge	Registration	National Park Service	93000378	In effect; does not expire
Stormwater				
STM Campus: MS4	Permit	EPA	COR042009	Active
STM Campus: RAIL	Permit	EPA	COR10F075	Active
STM Campus: S&TF and SERF: landscape/site improvements	Permit	EPA	COR10F00K	Active

Acronyms Used in the Table

APCD	Air Pollution Control Division (Colorado Department of Public Health and Environment)
APEN	Air Pollutant Emission Notice
APHIS	Animal and Plant Health Inspection Service (U.S. Department of Agriculture)
CDPHE	Colorado Department of Public Health and Environment
CoMET	Composites Manufacturing Education and Technology
EPA	U.S. Environmental Protection Agency
ESIF	Energy Systems Integration Facility
FTLB	Field Test Laboratory Building
HMWMD	Hazardous Materials and Waste Management Division (Colorado Department of Public Health and Environment)
IBRF	Integrated Biorefinery Research Facility
MS4	municipal separate storm sewer system
RAIL	Research and Innovation Laboratory
RCRA	Resource Conservation and Recovery Act
RFHP	Renewable Fuel Heat Plant
RSF	Research Support Facility
S&TF	Science and Technology Facility
SERF	Solar Energy Research Facility
STL	Structural Technology Laboratory
TTB	Alcohol and Tobacco Tax and Trade Bureau (U.S. Department of the Treasury)
WHF	Waste Handling Facility
WQCD	Water Quality Control Division (Colorado Department of Public Health and Environment)



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

A young cottontail (*Sylvilagus* spp.) sits in the snow outside the Energy Systems Integration Facility on the STM Campus. Cottontails, among many other species of wildlife, call the STM Campus and the Flatirons Campus their home. Photo by Werner Slocum, NREL 66794

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

STM Campus				
Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Birds				
American coot	<i>Fulica americana</i>			X
American crow	<i>Corvus brachyrhynchos</i>	X	X	X
American goldfinch	<i>Carduelis tristis</i>		X	X
American kestrel	<i>Falco sparverius</i>	X	X	X
American pipit	<i>Anthus rubescens</i>		X	X
American redstart	<i>Setophaga ruticilla</i>		X	X
American robin	<i>Turdus migratorius</i>	X	X	X
American tree sparrow	<i>Spizella arborea</i>	X	X	
American white pelican	<i>Pelecanus erythrorhynchos</i>		X	
Bald eagle	<i>Haliaeetus leucocephalus</i>			
Barn swallow	<i>Hirundo rustica</i>		X	X
Black-billed magpie	<i>Pica hudsonia</i>	X	X	X
Black-capped chickadee	<i>Poecile atricapilla</i>	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>.

STM Campus				
Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Black-crowned night heron	<i>Nycticorax nycticorax</i>	X		
Black-headed grosbeak	<i>Pheucticus melanocephalus</i>		X	
Blue-gray gnatcatcher	<i>Poliophtila caerulea</i>		X	
Blue jay	<i>Cyanocitta cristata</i>	X	X	
Blue-winged teal ^a	<i>Spatula discors</i>			
Brewer's blackbird	<i>Euphagus cyanocephalus</i>		X	
Brewer's sparrow	<i>Spizella breweri</i>		X	X
Broad-tailed hummingbird	<i>Selasphorus platycercus</i>		X	X
Broad-winged hawk	<i>Buteo platypterus</i>		X	
Brown-headed cowbird	<i>Molothrus ater</i>	X	X	X
Bullock's oriole	<i>Icterus bullockii</i>	X	X	X
Bushtit	<i>Psaltiriparus minimus</i>		X	
California gull	<i>Larus californicus</i>	X		
Canada goose	<i>Branta canadensis</i>	X	X	
Cedar waxwing	<i>Bombycilla cedrorum</i>		X	
Cassin's kingbird	<i>Tyrannus vociferans</i>		X	X
Chestnut-collared longspur	<i>Calcarius ornatus</i>		X	
Chipping sparrow	<i>Spizella passerina</i>		X	X
Clay-colored sparrow	<i>Spiella pallida</i>			X
Cliff swallow	<i>Petrochelidon pyrrhonota</i>		X	X
Common grackle	<i>Quiscalus quiscula</i>		X	X
Common nighthawk	<i>Chordeiles minor</i>	X	X	X
Common raven	<i>Corvus corax</i>	X	X	X
Common yellowthroat	<i>Geothlypis trichas</i>			X
Cooper's hawk	<i>Accipiter cooperii</i>	X	X	
Dark-eyed junco	<i>Junco hyemalis</i>	X	X	X
Double-crested cormorant	<i>Phalacrocorax auritus</i>		X	X
Eastern kingbird	<i>Tyrannus tyrannus</i>		X	
Eurasian collared-dove	<i>Streptopelia decaocto</i>			X
European starling	<i>Sturnus vulgaris</i>	X	X	X

STM Campus

Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Golden eagle	<i>Aquila chrysaetos</i>	X		
Grasshopper sparrow	<i>Ammodramus savannarum</i>		X	
Gray catbird	<i>Dumetella carolinensis</i>			X
Great blue heron	<i>Ardea herodias</i>	X	X	
Great horned owl	<i>Bubo virginianus</i>			X
Greater roadrunner ^a	<i>Geococcyx californianus</i>			
Green-tailed towhee	<i>Pipilo chlorurus</i>		X	
Hammond's flycatcher	<i>Empidonax hammondii</i>			X
Hepatic tanager	<i>Piranga flava</i>		X	
Hermit thrush	<i>Catharus guttatus</i>		X	
Horned lark	<i>Eremophila alpestris</i>		X	
House finch	<i>Carpodacus mexicanus</i>	X	X	X
House sparrow	<i>Passer domesticus</i>	X	X	X
House wren	<i>Troglodytes aedon</i>		X	X
Killdeer	<i>Charadrius vociferous</i>	X	X	
Lark bunting	<i>Calamospiza melanocorys</i>	X		
Lark sparrow	<i>Chondestes grammacus</i>		X	X
Lazuli bunting	<i>Passerina amoena</i>		X	
Lesser goldfinch	<i>Carduelis psaltria</i>		X	X
Lincoln's sparrow	<i>Melospiza lincolni</i>			X
Loggerhead shrike	<i>Lanius ludovicianus</i>	X		
MacGillivray's warbler	<i>Oporornis tolmiei</i>	X		
Mallard	<i>Anas platyrhynchos</i>	X		
Mountain bluebird	<i>Sialia currucoides</i>	X		X
Mountain chickadee	<i>Poecile gambeli</i>		X	
Mourning dove	<i>Zenaida macroura</i>	X		X
Northern flicker	<i>Colaptes auratus</i>	X		X
Northern goshawk	<i>Accipiter gentilis</i>		X	
Northern harrier	<i>Circus cyaneus</i>	X		X
Northern mockingbird	<i>Mimus polyglottos</i>			X

STM Campus				
Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Northern pygmy-owl	<i>Glaucidium californicum</i>			X
Northern rough-winged swallow	<i>Stelgidopteryx serripennis</i>			X
Northern saw-whet owl ^a	<i>Aegolius acadicus</i>			
Orange-crowned warbler ^a	<i>Oreothlypis celata</i>			
Osprey	<i>Pandion haliaetus</i>	X		X
Peregrine falcon	<i>Falco peregrinus</i>		X	
Pine siskin	<i>Carduelis pinus</i>		X	
Prairie falcon	<i>Falco mexicanus</i>	X		X
Red-breasted nuthatch	<i>Sitta canadensis</i>	X		X
Red-tailed hawk	<i>Buteo jamaicensis</i>	X		X
Red-winged blackbird	<i>Agelaius phoeniceus</i>			X
Rock dove	<i>Columba livia</i>	X		X
Rock wren	<i>Salpinctes obsoletus</i>	X		
Ruby-crowned kinglet	<i>Regulus calendula</i>		X	
Sage thrasher	<i>Oreoscoptes montanus</i>		X	X
Say's phoebe	<i>Sayornis saya</i>	X		X
Sharp-shinned hawk	<i>Accipiter striatus</i>		X	X
Spotted towhee	<i>Pipilo maculatus</i>	X		X
Swainson's hawk	<i>Buteo swainsoni</i>	X		
Tree swallow	<i>Tachycineta bicolor</i>	X	X	X
Turkey vulture	<i>Cathartes aura</i>	X		X
Vesper sparrow	<i>Pooecetes gramineus</i>	X		X
Virginia's warbler	<i>Oreothlypis virginiae</i>		X	
Violet-green swallow	<i>Tachycineta thalassina</i>		X	X
Western kingbird	<i>Tyrannus verticalis</i>	X		X
Western meadowlark	<i>Sturnella neglecta</i>	X		X
Woodhouse's (western) scrub-jay	<i>Aphelocoma californica</i>	X		X
White-crowned sparrow	<i>Zonotrichia leucophrys</i>	X		X
White-faced ibis	<i>Plegadis chihi</i>		X	
White-throated swift	<i>Aeronautes saxatalis</i>		X	

STM Campus				
Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Wilson's snipe	<i>Gallinago delicata</i>	X		
Yellow warbler	<i>Setophaga petechia</i>			X
Yellow-breasted chat	<i>Icteria virens</i>		X	X
Yellow-rumped warbler	<i>Dendroica coronata</i>		X	
Mammals				
Big brown bat ^a	<i>Eptesicus fuscus</i>			
Black bear ^a	<i>Ursus americanus</i>			
Black-tailed jackrabbit	<i>Lepus californicus</i>		X	
Bobcat ^a	<i>Lynx rufus</i>			
Bushy-tailed woodrat ^a	<i>Neotoma cinerea</i>			
Common muskrat ^a	<i>Ondatra zibethicus</i>			
Coyote	<i>Canis latrans</i>	X	X	
Deer mouse	<i>Peromyscus maniculatus</i>		X	
Elk ^a	<i>Cervus canadensis</i>			
Fox squirrel	<i>Sciurus niger</i>	X		
Hoary bat	<i>Lasiurus cinereus</i>			X
Long-tailed weasel	<i>Mustela frenata</i>	X		
Mexican woodrat	<i>Neotoma mexicana</i>	X	X	
Mountain cottontail	<i>Sylvilagus nuttalli</i>	X	X	X
Mule deer	<i>Odocoileus hemionus</i>	X	X	X
Prairie vole	<i>Microtus ochrogaster</i>	X		
Raccoon	<i>Procyon lotor</i>	X	X	
Red fox	<i>Vulpes</i>		X	
Striped skunk	<i>Mephitis</i>		X	
Western harvest mouse	<i>Reithrodontomys megalotis</i>	X	X	
Western spotted skunk	<i>Spilogale gracilis</i>		X	
White-tailed jackrabbit	<i>Lepus townsendii</i>	X		
Reptiles and Amphibians				
Boreal chorus frog	<i>Pseudacris maculata</i>		X	X
Bull snake	<i>Pituophis catenifer</i>		X	

STM Campus				
Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Plains garter snake	<i>Thamnophis radix</i>	X		
Prairie lizard	<i>Sceloporus consobrinus</i>		X	
Six-lined racerunner	<i>Cnemidophorus sexlineatus</i>	X		
Wandering garter snake ^a	<i>Thamnophis elegans</i>			
Tiger salamander	<i>Ambystoma tigrinum</i>	X	X	X
Western (prairie) rattlesnake	<i>Crotalus viridis</i>	X	X	
Woodhouse's toad	<i>Anaxyrus woodhousii</i>		X	
Yellow-bellied racer	<i>Coluber constrictor</i>		X	
Terrestrial Arthropods				
Aphrodite fritillary ^a	<i>Speyeria aphrodite</i>			
Monarch butterfly ^a	<i>Danaus plexippus</i>			
Tiger swallowtail ^a	<i>Papilio rutulus</i>			

^a Species observed at a time other than during a survey

Table C-2. Wildlife Species at the Flatirons Campus

Flatirons Campus				
Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Birds				
American crow	<i>Corvus brachyrhynchos</i>		X	
American goldfinch	<i>Spinus tristis</i>	X	X	
American kestrel	<i>Falco sparverius</i>	X	X	X
American pipit	<i>Anthus rubescens</i>		X	
American robin	<i>Turdus migratorius</i>	X	X	X
American tree sparrow	<i>Spizella arborea</i>		X	
Bald eagle	<i>Haliaeetus leucocephalus</i>		X	
Barn swallow	<i>Hirundo rustica</i>	X	X	X
Black-billed magpie	<i>Pica hudsonia</i>	X	X	X
Black-capped chickadee	<i>Poecile atricapillus</i>	X	X	
Blue-gray gnatcatcher	<i>Poliophtila caerulea</i>	X		X

Flatirons Campus

Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Blue jay	<i>Cyanocitta cristata</i>		X	
Brewer's blackbird	<i>Euphagus cyanocephalus</i>	X	X	X
Brewer's sparrow	<i>Spizella breweri</i>		X	
Broad-tailed hummingbird	<i>Selasphorus platycercus</i>	X	X	X
Broad-winged Hawk ^a	<i>Buteo platypterus</i>			
Brown-headed cowbird	<i>Molothrus ater</i>	X	X	
Bullock's oriole	<i>Icterus bullockii</i>		X	X
Canada goose	<i>Branta canadensis</i>		X	X
Cedar waxwing	<i>Bombycilla cedrorum</i>		X	
Chipping sparrow	<i>Spizella passerina</i>	X	X	
Cliff swallow	<i>Petrochelidon pyrrhonota</i>	X		
Common grackle	<i>Quiscalus quiscula</i>	X	X	
Common nighthawk	<i>Chordeiles minor</i>	X		X
Common raven	<i>Corvus corax</i>	X	X	X
Cooper's hawk ^a	<i>Accipiter cooperii</i>			
Dark-eyed junco	<i>Junco hyemalis</i>		X	
Double-crested cormorant	<i>Phalacrocorax auritus</i>	X		X
Downy woodpecker	<i>Picoides pubescens</i>		X	
Eurasian collared-dove	<i>Streptopelia decaocto</i>		X	
European starling	<i>Sturnus vulgaris</i>	X	X	X
Ferruginous hawk	<i>Buteo regalis</i>	X	X	
Franklin's gull	<i>Larus pipixcan</i>		X	
Golden eagle ^b	<i>Aquila chrysaetos</i>	X	X	
Grasshopper sparrow	<i>Ammodramus savannarum</i>	X	X	X
Gray catbird	<i>Dumetella carolinensis</i>		X	X
Great blue heron	<i>Ardea herodias</i>	X	X	X
Great horned owl	<i>Bubo virginianus</i>		X	X
Green-tailed towhee	<i>Pipilo chlorurus</i>	X		X
Hairy woodpecker	<i>Picoides villosus</i>		X	
Horned lark	<i>Eremophila alpestris</i>	X	X	
House finch	<i>Carpodacus mexicanus</i>	X	X	X

Flatirons Campus				
Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
House wren	<i>Troglodytes aedon</i>			X
Killdeer	<i>Charadrius vociferus</i>		X	X
Lark bunting	<i>Calamospiza melanocorys</i>		X	
Lark sparrow	<i>Chondestes grammacus</i>	X		X
Loggerhead shrike	<i>Lanius ludovicianus</i>		X	
Long-billed curlew	<i>Numenius americanus</i>		X	
Mallard	<i>Anas platyrhynchos</i>	X	X	
Mountain bluebird	<i>Sialia currucoides</i>	X	X	
Mountain chickadee	<i>Poecile gambeli</i>		X	
Mourning dove	<i>Zenaida macroura</i>	X	X	X
Northern flicker	<i>Colaptes auratus</i>	X	X	
Northern harrier	<i>Circus cyaneus</i>	X	X	
Peregrine falcon	<i>Falco peregrinus</i>	X	X	
Prairie falcon	<i>Falco mexicanus</i>	X		
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>		X	
Red-tailed hawk	<i>Buteo jamaicensis</i>	X	X	X
Red-winged blackbird	<i>Agelaius phoeniceus</i>	X	X	X
Rough-legged hawk	<i>Buteo lagopus</i>	X	X	
Ruby-crowned kinglet	<i>Regulus calendula</i>		X	
Sandhill crane	<i>Grus canadensis</i>		X	
Savannah sparrow	<i>Passerculus sandwichensis</i>		X	
Say's phoebe	<i>Sayornis saya</i>	X	X	X
Song sparrow	<i>Melospiza melodia</i>		X	X
Spotted towhee	<i>Pipilo maculatus</i>		X	X
Swainson's hawk	<i>Buteo swainsoni</i>		X	
Townsend's solitary	<i>Myadestes townsendi</i>		X	
Tree swallow	<i>Tachycineta bicolor</i>		X	
Turkey vulture	<i>Cathartes aura</i>	X	X	
Vesper sparrow	<i>Pooecetes gramineus</i>	X	X	X

Flatirons Campus

Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Western kingbird	<i>Tyrannus verticalis</i>	X	X	X
Western meadowlark	<i>Sturnella neglecta</i>	X	X	X
Western wood peewee	<i>Contopus sordidulus</i>			X
Wilson's snipe	<i>Gallinago delicata</i>		X	X
Wilson's warbler	<i>Wilsonia pusilla</i>	X		
Yellow-rumped warbler	<i>Dendroica coronata</i>	X		

Mammals

Big brown bat	<i>Eptesicus fuscus</i>		X	X
Black-tailed prairie dog ^a	<i>Cynomys ludovicianus</i>	X		
Bobcat	<i>Felis rufus</i>			X
Coyote	<i>Canis latrans</i>		X	X
Deer mouse	<i>Peromyscus maniculatus</i>		X	X
Desert cottontail	<i>Sylvilagus audubonii</i>		X	X
Eastern red bat	<i>Lasiurus borealis</i>		X	X
Elk	<i>Cervus canadensis</i>		X	X
Fringed myotis ^b	<i>Myotis thysanodes</i>		X	X
Hoary bat	<i>Lasiurus cinereus</i>		X	X
Little brown myotis ^b	<i>Myotis lucifuaus</i>		X	X
Masked shrew	<i>Sorex cinereus</i>		X	X
Meadow vole	<i>Microtus pennsylvanicus</i>		X	X
Mexican woodrat	<i>Neotoma mexicana</i>		X	X
Mountain lion	<i>Puma concolor</i>			X
Mule deer	<i>Odocoileus hemionus</i>		X	X
Myotis bat	<i>Myotis sp.</i>		X	X
Prairie vole	<i>Microtus ochrogaster</i>		X	X
Silver-haired bat	<i>Lasionycteris noctivagans</i>		X	X
Thirteen-lined ground squirrel	<i>Spermophilus tridecemlineatus</i>		X	

Flatirons Campus				
Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Western harvest mouse	<i>Reithrodontomys megalotis</i>		X	X
Western small-footed myotis	<i>Myotis ciliolabrum</i>		X	X
White-tailed deer	<i>Odocoileus virginiana</i>			X
Yellow-bellied marmot ^a	<i>Marmota flaviventris</i>			
Reptiles and Amphibians				
Boreal chorus frog	<i>Pseudacris maculata</i>		X	X
Bull snake	<i>Pituophis catenifer</i>		X	X
Northern leopard frog ^b	<i>Lithobates pipiens</i>			X
Painted turtle ^a	<i>Chrysemys picta</i>			
Tiger salamander	<i>Ambystoma tigrinum</i>			X
Western (Prairie) rattlesnake	<i>Crotalus viridis</i>	X	X	X
Woodhouse's toad	<i>Anaxyrus woodhousii</i>		X	X
Terrestrial Arthropods ^c				
Aphrodite fritillary	<i>Speyeria aphrodite</i>		X	
Cabbage white	<i>Pieris rapae</i>		X	
Checkered white	<i>Pontia protodice</i>		X	
Common wood nymph	<i>Cercyonis pegala</i>		X	
Dainty sulphur	<i>Nathalis iole</i>		X	
Gray hairstreak	<i>Strymon melinus</i>		X	
Orange sulphur	<i>Colias eurytheme</i>		X	
Western white	<i>Pontia occidentalis</i>		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 at the STM Campus and Flatirons Campus, but only observed during the survey at the Flatirons Campus.



A ladybird beetle (*Coccinellidae*) climbs a dalmatian toadflax (*Linaria genistifolia* subsp. *Dalmatica*) on the STM Campus. Photo by Werner Slocum, NREL 56722

APPENDIX D. PLANT COMMUNITIES AT THE STM CAMPUS AND THE FLATIRONS CAMPUS

Vegetation surveys are periodically completed for the STM Campus and the Flatirons Campus. The most recent surveys occurred 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 in this section.

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 in this section 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 (*Chondrosium gracile*), a native prairie species, and downy brome, cheatgrass (*Bromus 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. *vivipara*). Well-drained 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 (*Chondrosum gracile*) 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 downy brome (*Bromus tectorum*), an aggressive noxious weed. It 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 (*Chondrosum gracile*) and downy brome (*Bromus tectorum*) but are dominated by a mixed-grass species association of needle-and-thread grass (*Hesperostipa comata*) 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, many 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 (*Rhus aromatica* subsp. *Trilobata*), chokecherry (*Padus virginiana*), 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. Downy brome 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 (*Chrysothamnus nauseosus* subsp.). The other common location for short shrublands is on the outer slopes of the ravines. Skunkbrush (*Rhus aromatica* subsp. *Trilobata*) 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 (*Rhus aromatica* subsp. *Trilobata*), chokecherry (*Padus virginiana*), and wild plum (*Prunus americana*), which often grow in dense, impassible thickets. A few plains cottonwoods (*Populus deltoides*) 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 subsurface drainage have created a pocket of saturated soil. Species here include sedges (*Carex* spp.), rushes (*Juncus* spp.), bulrush (*Schoenoplectus* spp.), and peachleaf willow (*Salix amygdaloides*). The area at the mouth of the ravine may no

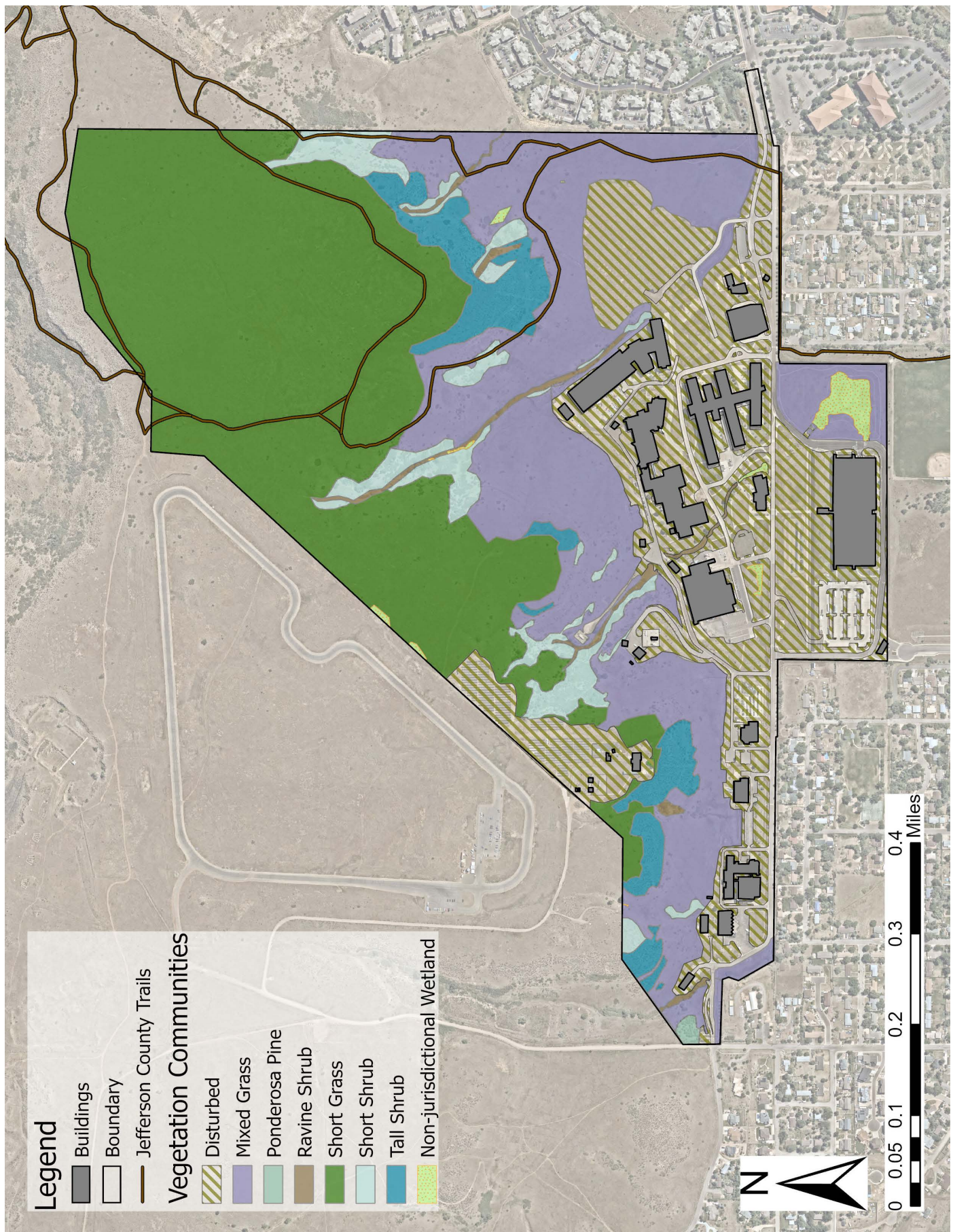


Figure D-1. STM Campus Land Cover Types

longer experience the hydrology that originally allowed these plants to establish there.

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*).

Disturbed and Reclaimed Land

This habitat type comprises all the areas at the STM Campus 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 (*Chondrosium 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 since the Flatirons Campus was first surveyed are discussed in this section, 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 (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), Canada bluegrass (*Poa compressa*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*) and purple three-awn (*Aristida purpurea*). Common forbs in this community include scurf-pea (*Psoralegium* spp.), 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 (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and Canada bluegrass (*Poa compressa*). Non-native species make up 65%–90% of the vegetative cover in this community. Commonly observed forb species include alysium (*Alyssum simplex*), Canada horseweed (*Conyza canadensis*), fringed sage (*Artemisia frigida*), prairie sage (*Artemisia ludoviciana*), scurfpea (*Psoralegium* spp.), and hairy golden aster (*Heterotheca villosa*). Native grasses within this community, particularly big bluestem (*Andropogon gerardii*) and switchgrass (*Panicum virgatum*), 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 within the Flatirons Campus. This community is dominated by purple three-awn (*Aristida purpurea*), big bluestem (*Andropogon gerardii*), and switchgrass (*Panicum virgatum*). Other commonly observed species in this community include non-native grasses such as smooth brome (*Bromus inermis*) 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, cheatgrass (*Bromus tectorum*), smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), 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 (*Bromus tectorum*) 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 (*Helianthus annuus*). 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 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 (*Bromus inermis*), 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 (*Pinus ponderosa*) 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 (*Ribes cereum*), skunkbrush sumac (*Rhus trilobata*), chokecherry (*Padus virginiana*), 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 (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), big bluestem (*Andropogon gerardii*), junegrass (*Koeleria macrantha*), and sideoats grama (*Bouteloua curtipendula*). Common forbs include scurfpesa (*Psoraleidum* spp.), prairie sage (*Artemisia ludoviciana*), golden banner (*Thermopsis rhombifolia*), hairy golden aster (*Heterotheca villosa*), 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.¹⁴ 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* spp.) species. Patches of smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), big bluestem (*Andropogon gerardii*), 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.

Another palustrine emergent wetland occurs in Row 3 of the Flatirons Campus. This wetland consists of a large stand of cattails (*Typha* spp.) and foxtail barley (*Hordeum jubatum*) 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

14 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.

Arctic rush (*Juncus arcticus*), foxtail barley (*Hordeum jubatum*), Nebraska sedge (*Carex nebrascensis*), and prairie cordgrass (*Spartina pectinata*). Significant patches of Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), and common teasel (*Dipsacus fullonum*), all List-B noxious weeds, occur within the northernmost drainage. Other observed species include short-beak sedge (*Carex brevior*), swordleaf rush (*Juncus ensifolius*), longstyle rush (*Juncus longistylis*), Torrey's rush (*Juncus torreyi*), common spikerush (*Eleocharis palustris*), and switchgrass (*Panicum virgatum*). Occasional plains cottonwood (*Populus deltoides*) trees and sandbar willow (*Salix exigua*) shrubs occur along these drainages.

Disturbed Areas and Non-Habitat

These cover types reflect surface disturbance that is due to human activities on the site, including 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 (*Bromus inermis*). (These areas are not specifically listed 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 (*Padus virginiana*) and rose (*Rosa* spp.) bushes. (These areas are not specifically listed in Figure D-2.)

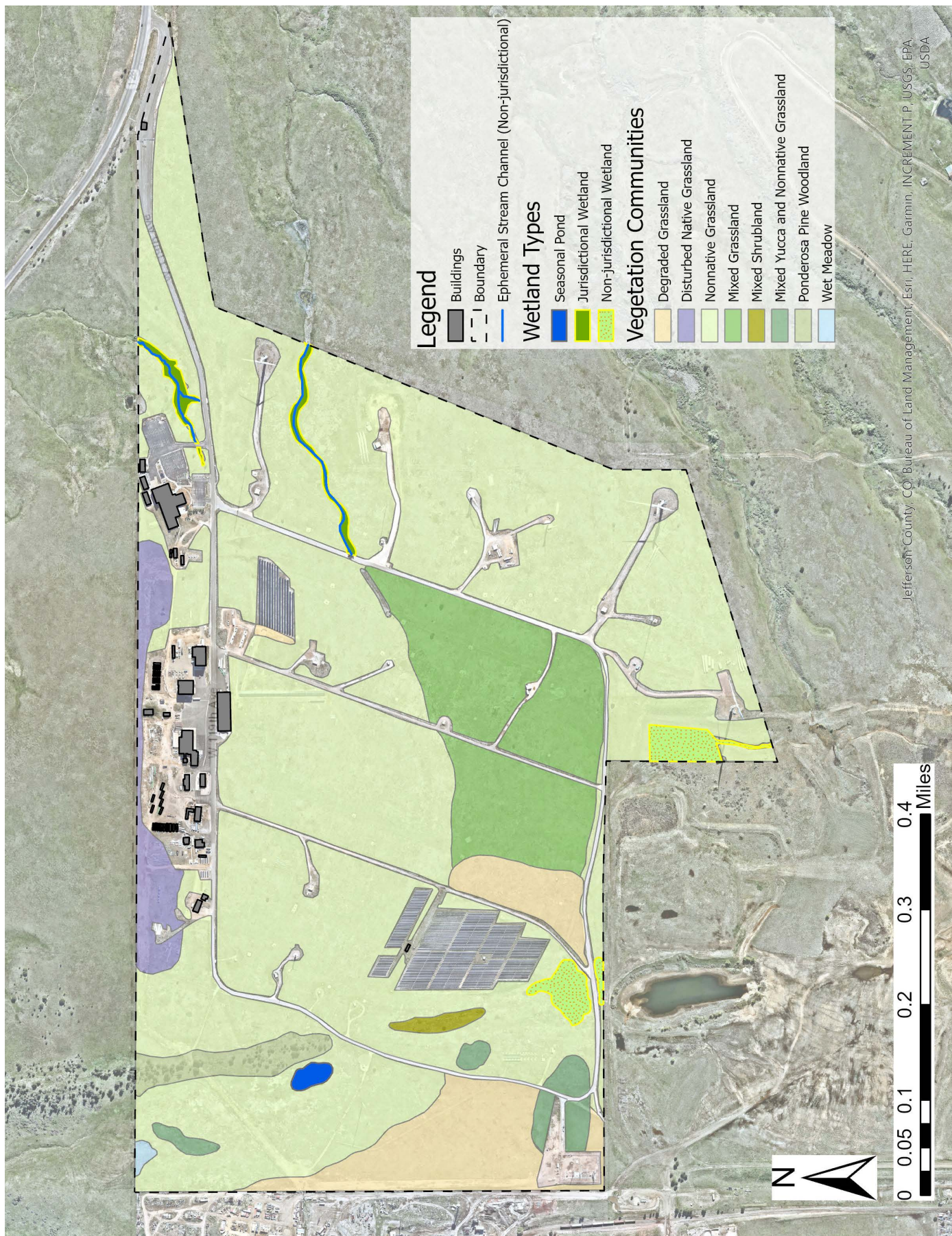


Figure D-2. Flatirons Campus Wetland Types and Vegetation Communities



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