NREL
Transforming ENERGY

ENVIRONMENTAL PERFORMANCE REPORT 2022

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

Cover Photo: A mother great horned owl (*Bubo virginianus*) and her owlet young sit inside their nest inside National Renewable Energy Laboratory's South Table Mountain Campus parking garage in Golden, Colorado. *Photo by Werner Slocum, NREL 80079.*

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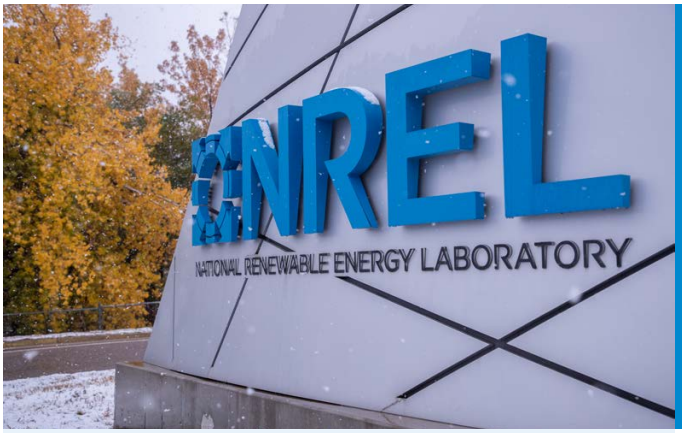
Photo by Werner Slocum, NREL 74876

NOMENCLATURE

APEN	air pollutant emission notice
APHIS	Animal and Plant Health Inspection Service
AST	aboveground storage tank
CCR	Colorado Code of Regulations
CDPHE	Colorado Department of Public Health and Environment
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
cm	centimeter
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COVID-19	coronavirus disease 2019
DOE	U.S. Department of Energy
EMS	Environmental Management System
ECHO	Enforcement & Compliance History Online (U.S. Environmental Protection Agency)
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act of 1986
EPEAT	Electronic Product Environmental Assessment Tool
ESA	Endangered Species Act
ESH&Q	Environment, Safety, Health, and Quality Office
ESIF	Energy Systems Integration Facility
ft	foot
FY	fiscal year (October through September)
GHG	greenhouse gas
HAA5	haloacetic acids
HAP	hazardous air pollutants
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
HFO	hydrofluoroolefin
in	inch
ISO	International Organization for Standardization
kBtu	kilo-British thermal unit
kg	kilogram
km	kilometer
L	liter
LEED	Leadership in Energy and Environmental Design
m	meter
mCi	millicurie
MCL	maximum contaminant level
mg/L	milligram per liter
mrem	millirem
MS4	municipal separate storm sewer system
MT	metric ton
N_2O	nitrous oxide

NEPA	National Environmental Policy Act
NO_x	nitrogen oxides
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



The East Entrance of the National Renewable Energy Laboratory's (NREL's) South Table Mountain (STM) Campus on the first snow of winter 2022. *Photo by Joe DelNero, NREL 72785*

EXECUTIVE SUMMARY

Purpose

The National Renewable Energy Laboratory's (NREL's) *Environmental Performance Report 2022* describes the laboratory's environmental management activities in 2022. 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.

Every 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 2022 to enhance sustainability and environmental performance and has made, and 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 2022:

- Conducted separate internal assessments for NREL's MS4 permit and drinking water programs. No major issues were identified and actions to address the minor nonconformities and opportunities for improvement have been completed or are in progress.
- Completed a climate change focused Vulnerability Assessment and Resilience Plan which included more than 70 staff members from across NREL's operational and research teams to implement a stakeholder-driven process. Lab-wide vulnerabilities were identified relating to climate change and were assigned a risk level. Climate concerns focused mostly on high-likelihood changes, including the increased chance of drought, wildfire, heat waves, and average temperatures, and degradation in air quality in the region.
- Completed comprehensive tank inspections for the two drinking water tanks at Flatirons Campus, a 15,000-gallon (56,781-L) tank and a 2,000-gallon (7,571-L) tank. No deficiencies were found.
- Prepared a Dry Weather Sampling Procedure and conducted the first round of sampling. These activities are associated with the illicit discharge detection and elimination minimum control measures of the MS4 permit.
- Inventoried PFAS-containing chemicals using NREL's new chemical management system's database. The database can run a report to display an inventory of U.S. Environmental Protection Agency-identified PFAS-containing chemicals to ease in tracking and quantity management.
- Continued developing a wastewater treatment feasibility study for the Flatirons Campus. The study includes innovative yet practical solutions to onsite wastewater treatment systems; it affords 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.
- Transitioned to a new chemical inventory software that integrates safety data sheet management, chemical inventory, and a chemical approval process. Implementation of this software has reduced paper documentation time and allowed for better management of incoming chemicals.
- Completed an environmental assessment for the Flatirons Campus water system project.
- Created an online environmental questionnaire for staff to submit NEPA-related information more easily and quickly for DOE review. The questionnaire is currently being used and updated based on user experiences, and NREL will continue to develop it to meet user needs.
- Developed and delivered nesting bird survey training to 28 staff members at Flatirons Campus and STM Campus. The training combines self-paced video instruction and field survey practice.
- Planted pollinator seeds in agrivoltaic study plots at the STM Campus as part of a vegetation study that assessed the ability of a variety of plants to thrive within a solar array.
- Treated 14 acres (5.7 hectares) of noxious weeds, including Canada thistle (*Cirsium arvense*), houndstongue (*Cynoglossum officinale*), and myrtle spurge (*Euphorbia*

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 2022. 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 two important recognitions in 2022 for its environmental and sustainability accomplishments:

- 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.

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.

- Utilized biologic control methods to address specific noxious weeds at the Flatirons Campus. 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.
- Conducted a wetland delineation within the Eastern Drainage of the STM Campus to determine if there were any jurisdictional features within the area that may impede future development, particularly for the future Energy Materials and Processing at Scale building. No floodplains or jurisdictional areas were identified within the study area. An Approved Jurisdictional Determination was issued by the U.S. Army Corps of Engineers confirming the absence of these features. Construction of the Energy Materials and Processing at Scale building is expected to commence in 2024.
- Initiated a historic resource survey of a 6.6-acre (2.7-hectare) portion of the Camp George West Historic District in preparation for DOE to take possession of the Colorado Correctional Facility parcel in 2023. The survey, conducted by a local environmental consulting firm, updated, in part, a multiple property survey conducted in 1992 for the entire Camp George West Historic District. This survey will be an important input to cultural resource management within this new DOE land holding.

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 2022. 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 some 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 2022, 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

Overall aerial view of the Flatirons Campus looking west. To the right is a 1.5-megawatt turbine. *Photo by Josh Bauer and Bryan Bechtold, NREL 73093*

- Hazardous materials and waste management, including pollution prevention; spill response; proper storage, use, and disposal of hazardous chemicals and materials; and planning, permitting, and reporting the use and emissions of materials
- National Environmental Policy Act (NEPA) reviews
- Protection of natural and cultural resources, including wildlife, vegetation, protected species, wetlands, and cultural resources management.

ABOUT NREL

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

An aerial view from the East Entrance of the STM Campus. *Photo by Josh Bauer and Bryan Bechtold, NREL 70812*

A research technician cuts crystalline silicon photovoltaic modules so they fit in a dumpster at the Flatirons Campus after reliability testing had been completed. The panels are then taken to a municipal solid waste landfill. A team of materials science researchers at the lab are focusing research on ways to reduce the recycling costs and environmental impacts of photovoltaic modules, compared to disposal, and to maximize material recovery.
Photo by Werner Slocum, NREL 72577

1 INTRODUCTION

This report summarizes the National Renewable Energy Laboratory's (NREL's) environmental management activities in 2022, including:

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

The report incorporates 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

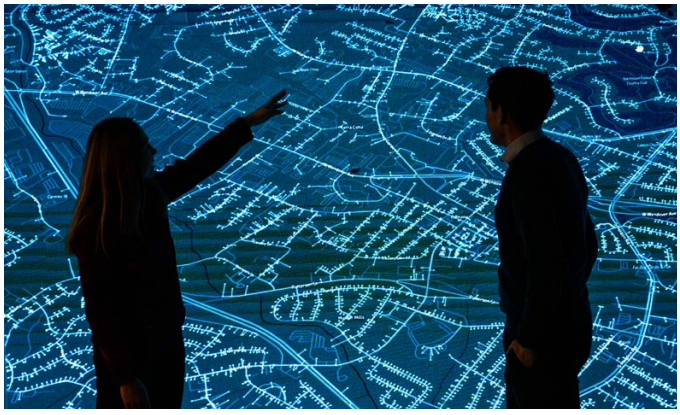
NREL's mission focuses on advancing the energy goals of DOE and the nation as captured in the laboratory's mission statement:

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 in:

- **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.

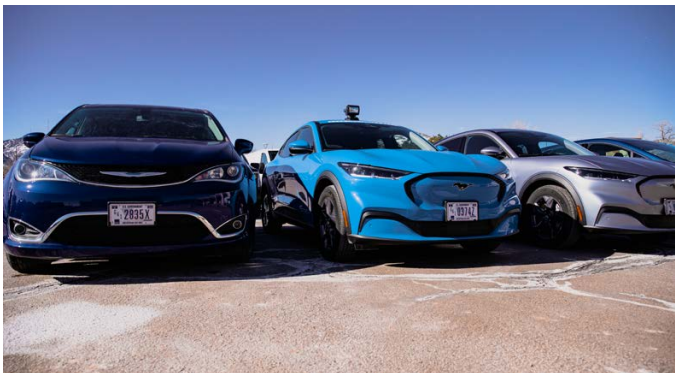
- **Buildings Research:** Buildings research at NREL is transforming energy through building science and integration. This research seeks to optimize energy use, generation, and storage in the built environment at multiple scales to enhance the resiliency, efficiency, and affordability of energy systems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



Cybersecurity researchers demonstrate the cyber range at the Energy Systems Integration Facility on the STM Campus. The cyber range provides the ability to virtualize, emulate, and visualize energy systems subjected to energy disruption scenarios. *Photo by Werner Slocum, NREL 74763*

Contractors work on a new home in Unalakleet, Alaska, a remote village on the coast of the Bering Sea. The home features a premade kitchen, bathroom and laundry area, which are built into a shipping container and placed on the foundation of the home. The foundation of the home is built in a way that the home could potentially be moved inland to higher ground, if needed, due to rising water levels. The home was designed by NREL's Research and Testing Facility in Fairbanks, Alaska. *Photo by Werner Slocum, NREL 72681*

A researcher performs a fuel analysis using an Advanced Fuel Ignition Delay Analyzer on the STM Campus. *Photo by Joe DelNero, NREL 70434*



NREL's STM Campus vehicle fleet is more than 30% electric. These electric vehicles assist the daily activities of Site Operations, including shipping and receiving, security, and environmental management. *Photo by Joe DelNero, NREL 74806*

- **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.
- **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 turbine-drivetrain components; designing, researching, and validating advanced wind power plant control systems; and manufacturing and testing turbine blades of various new composite materials.

A researcher examines the wave tank facilities on the Flatirons Campus. *Photo by Joe DelNero, NREL 70315*

1.2 Sites and Facilities

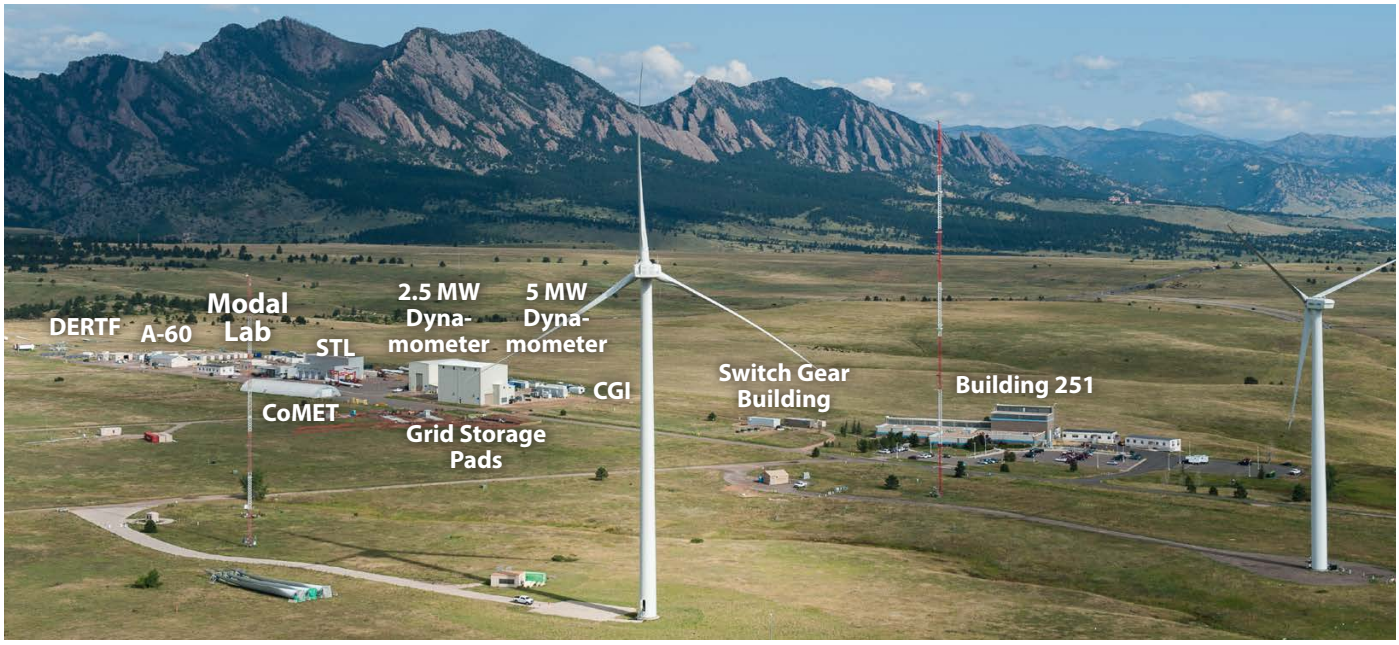
NREL's facilities occupy seven locations in Colorado, Alaska, and Washington, D.C., including:

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.



Aerial view of the northern portion of NREL's Flatirons Campus. *Photo by Dennis Schroeder, NREL 30766*

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 in the city of Arvada near the intersection of Colorado Highway 93 and Colorado Highway 128, between Boulder and Golden. It is approximately 15 miles (24.2 km) north of the STM Campus.

Land Use

The Flatirons Campus occupies 305 acres (124 hectares) that are surrounded by open space, grazing, and industrial land uses. The Rocky Flats National Wildlife Refuge borders the Flatirons Campus to the south and east. A restored, sand and gravel mine is located due south 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. Also, a propellant fracturing company has a small installation along the northern part of the campus' 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 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 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 high percentage of cobble and gravel in the soil volume, and by subsoil dominated by clay.

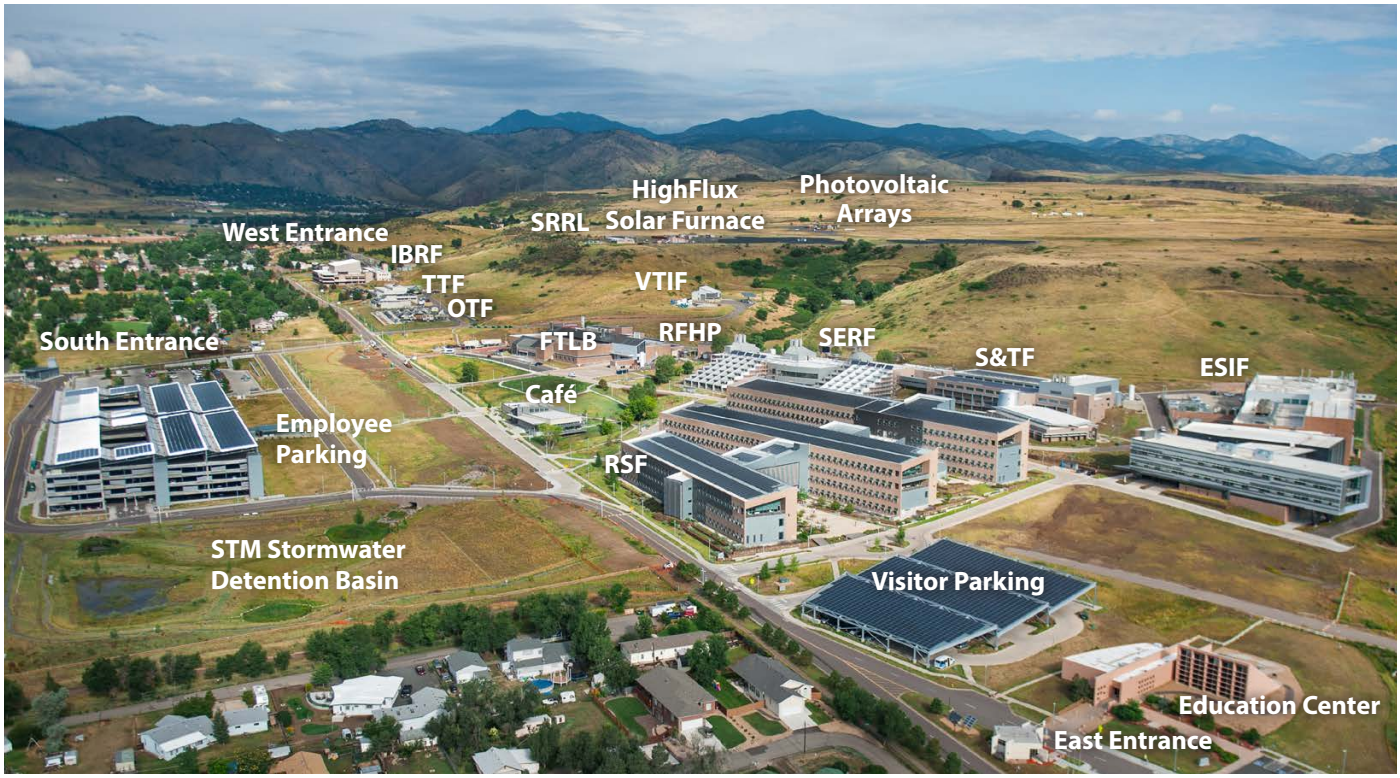
Surface Water

The area surrounding the Flatirons Campus is drained by five streams:

- Rock Creek 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.

1 EG&G Rocky Flats, Inc. 1992. *Rocky Flats Plant Site Environmental Report: January through December 1992*. Golden, Colorado.



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

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, shortgrass 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 laboratory staff have offices and laboratories there. The STM Campus is approximately two miles (3.2 kilometers [km]) east of Golden and 12 miles (19.3 km) west of downtown Denver.

Land Use

The STM Campus is a roughly triangular parcel of land occupying portions of the top and lower south-facing slopes of South Table Mountain, a mesa that stands approximately 500 feet (ft) (152 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

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.

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, but there are some existing utility easements for the land and some recreational trails are to be established there 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 consist 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 occurred. 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 on the site generally flows 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, and seasonal springs are 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 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 shortgrass and midgrass 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

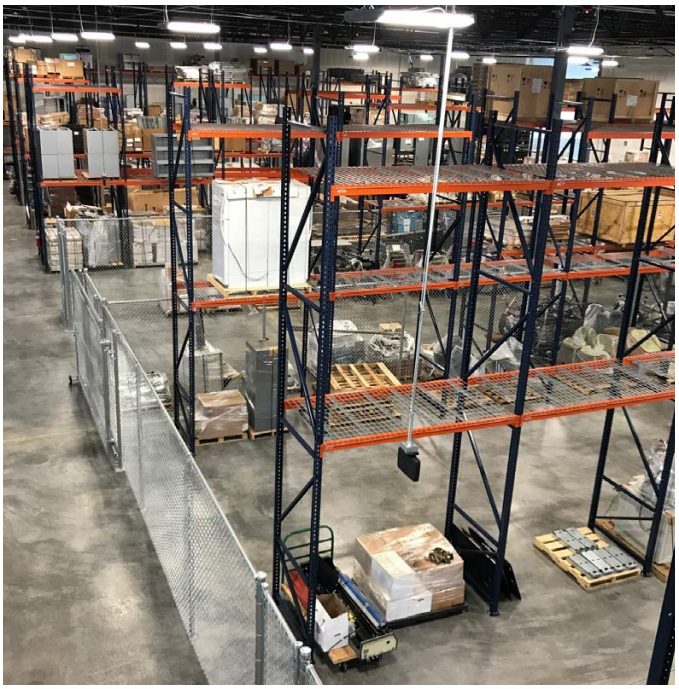
Building 16 is a leased office building within the Denver West Business Park, which is within the Lakewood, approximately two miles (3.2 km) east of Golden and 12 miles (19.3 km) west of downtown Denver. The Denver West Business Park is a fairly flat, landscaped office complex, consisting of several 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

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

Building 16 include fuel and battery characterization research, thermal analyses of vehicle cooling loops, vehicle electrical systems analysis, and photoelectrochemical hydrogen production research.

Golden Warehouse

NREL's leased Golden Warehouse is 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*

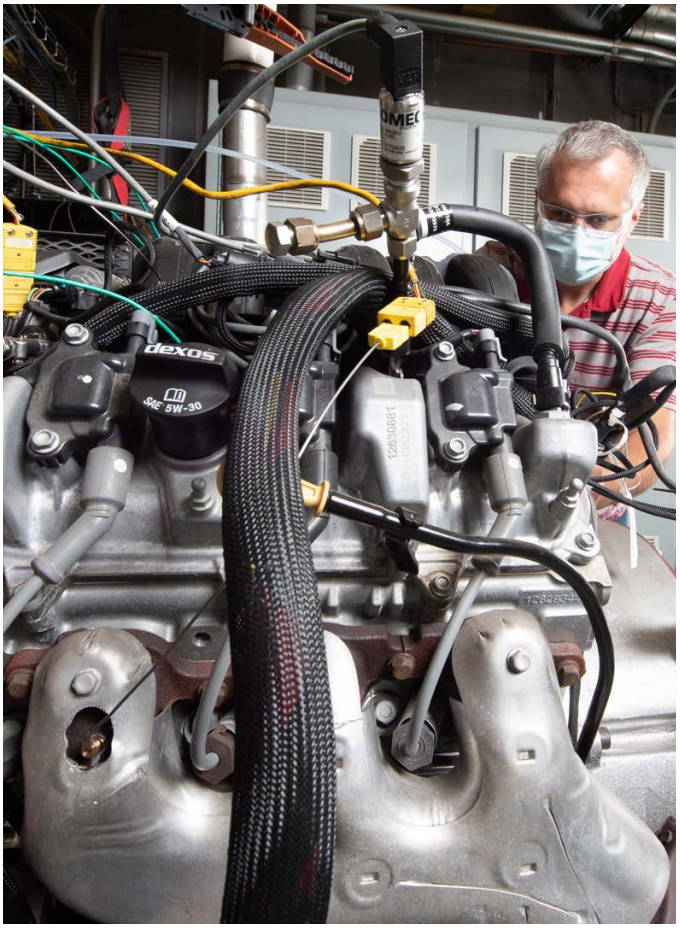
Renewable Fuels and Lubricants Research Laboratory

The 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.



A researcher works on a propane test engine at the ReFUEL. *Photo by Dennis Schroeder, NREL 62742*

The aurora borealis, or northern lights, glow in the skies above Fairbanks, Alaska, not far from the Research and Testing Facility, NREL's northernmost site. *Photo by Werner Slocum, NREL 72734*

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 Leadership in Energy and Environmental Design (LEED) Platinum facility is dedicated to the development, use, and testing of energy-efficient, durable, healthy, and cost-effective building technologies for people living in circumpolar regions around the globe. This 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 provide energy analysis and technical program support to DOE.

Climate of Washington, D.C. Facility

The Washington, D.C. Office is 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.

Two mule deer (*Odocoileus hemionus*) bucks travel through the South Table Mountain open space adjacent to the Research Support Facility on the STM Campus. NREL's Environmental Management System helps protect wildlife that call the campus home. *Photo by Werner Slocum, NREL 70466*

2 ENVIRONMENTAL MANAGEMENT SYSTEM

NREL's Environmental Management System (EMS) supports the laboratory's commitment to continually improve 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 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 level of 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 to manage environmental risks as part of its Integrated Safety Management System.
- **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

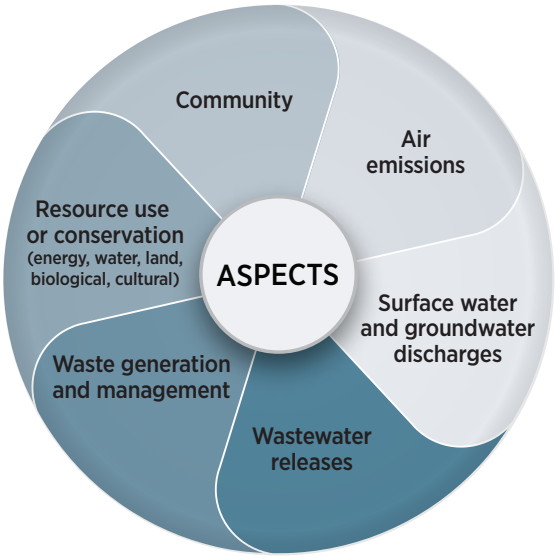


Figure 2. NREL's environmental aspects

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

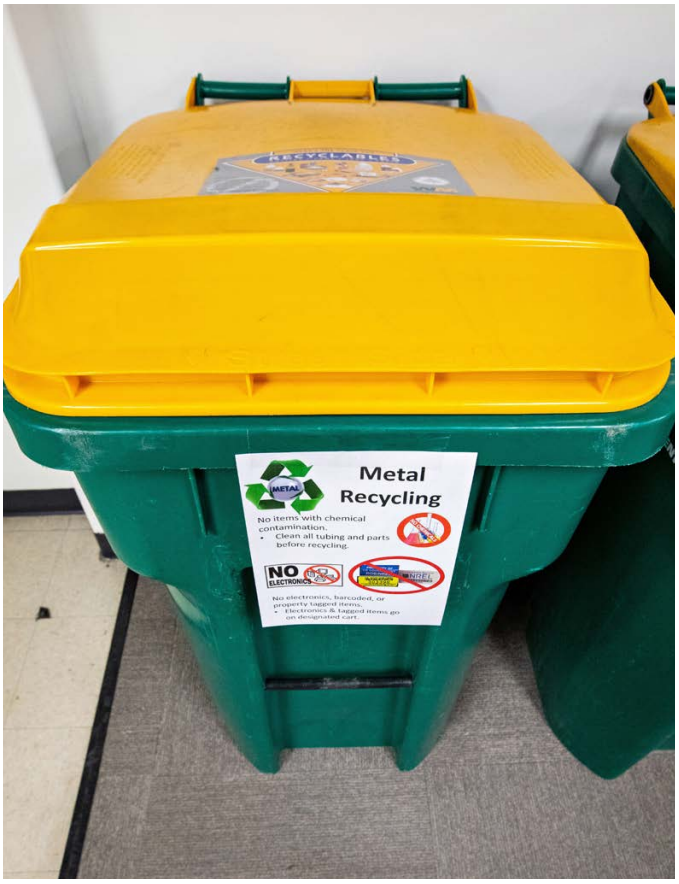
- **Monitoring, Measuring, and Evaluating Compliance:** NREL monitors key activities, tracks performance and progress toward environmental objectives, and conducts periodic assessments of compliance with legal requirements.
- **Assessments**: NREL periodically conducts assessments to verify that its 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 leadership team 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. 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. The laboratory also fulfills its commitment to pollution prevention by implementing controls for certain laboratory operations, properly using chemicals and fuels across the laboratory, and encouraging employee activities such as commuting.



A bin for metal recycling is available at the Field Test Laboratory Building on the STM Campus. *Photo by Werner Slocum, NREL 56087*

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

2.3 Performance Indicators and Progress

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

- The Performance Evaluation and Measurement Plan establishes key priorities and provides specific objectives, expected outcomes, and measures of performance for managing and operating the laboratory. Each fiscal year (October through September), NREL 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. The following are examples of achievements in 2022 that are related to the laboratory's environmental goal of providing a comprehensive, effective, and responsive environmental management program.

Demonstrated a shared commitment to efficiency, excellence, and compliance with requirements:

- Prepared for a land exchange which is expected to occur in 2023. The land exchange would trade Conservation Easement land on the STM Campus for a portion of state-owned land that resides within the Camp George West Historic district. In anticipation of the exchange, staff reviewed environmental reports to understand potential liabilities, concerns, and issues. Initial cultural resource guidance was developed in preparation for minor renovations. Staff also conducted a planning session with a cultural resource consultant to align NREL's actions with the State Historical Preservation Office's processes.
- Updated the Stormwater Pollution Prevention Plans to comply with the 2022 Environmental Protection Agency's Construction General Permit.
- Reevaluated the fire suppression system at the STM Campus, which contains per- and polyfluoroalkyl substances (PFAS), to assess the need for preventive actions and address DOE PFAS mitigation and reporting requirements.
- Used a geographic information tool to plot and delineate wetlands and drainage areas in the immediate vicinity of a proposed new building's location to aid in construction planning and determine whether wetlands would be impacted. After completing the map, NREL concluded no wetlands would be impacted by the buildings' development.
- Used a geographic information systems tool to depict water resources surrounding the proposed location of the Flatirons Campus water system project. After mapping these resources, the project location was modified to minimize water impacts.
- Conducted residual chlorine testing in advance of additional staff reoccupying the STM Campus after the relaxation of COVID-19 pandemic precautions.
- Updated spill prevention and countermeasures plans, inventoried and restocked all spill kits, and deployed additional spill kits.
- Identified and implemented revisions to the Acquisition Services Intake Questionnaire process to address NEPA reviews and process enhancements.
- Initiated a Clean Air Act Title V permit application due to the recent change in ozone non-attainment status for the Denver area.
- Deployed a new chemical inventory system to enhance chemical approval, tracking, and reporting.
- Completed internal assessments for the municipal separate storm sewer system and drinking water programs.

Shared successes, best management practices, expertise, and lessons learned to promote excellence and collaboration in environmental performance:

- Created a geographic information systems tool to produce cultural resource visibility maps for NEPA reviews for proposed offsite projects.
- Conducted a lessons learned session for the environmental assessment completed for the Flatirons Campus water system project.
- Participated in a newly formed resource group of DOE national laboratories to share practices and lessons learned associated with cultural resources and presented an overview of NREL resources and management practices.
- Continued to collaborate with a local environmental firm specializing in rattlesnake safety and research to consolidate rattlesnake capture data, create an associated map depicting the capture locations, and identify trends in movement on the STM Campus.
- Updated the Flatirons Campus vegetation management database and associated maps to include current features, infrastructure, and proposed development to support wildland fire management and weed control activities.
- Created snow management plans and associated maps for the STM Campus and the Flatirons Campus to help direct site operation crews and subcontractors on areas to push, avoid, or pile snow.
- Developed a video version of Nesting Bird Survey Training to improve and streamline the classroom training portion.

2.4 Assessment and Improvement

Assessments support the continual improvement of environmental management. Periodic assessment of the EMS and its components provide 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 are 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 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 2022 allowed NREL to enhance program effectiveness and make substantial environmental performance improvements:

- **Internal Assessments:** Separate internal assessments were completed for NREL's municipal separate storm sewer system (MS4) permit program and its drinking water program. No major issues were identified, and actions to address the opportunities for improvement have been completed or are in progress.
- **External Assessments:** NREL underwent a recertification 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.

2.5 Awards and Recognition

In 2022, NREL received a few awards and recognition of its environmental and sustainability achievements, including those described in this section.

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 2022, NREL received the Five-Star EPEAT Purchaser Award from the Green Electronics Council for 2021 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 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 Program[4] 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 fulfill its mission while addressing environmental, safety, health, and community considerations.

4 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.

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 Collaboration with Other Groups:** The laboratory actively collaborates with stakeholders on environmental issues, such as sustainability, renewable energy, and resource conservation and management.

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.

During the project planning and design phase NREL evaluates opportunities to incorporate features such as:

- Reclaimed materials
- Bird-friendly window glass
- Weed-free soil amendments
- Drought-tolerant and native vegetation
- Connectivity with existing infrastructure
- Wildlife and community-friendly efficient lighting
- Water reuse and conservation of natural drainages.

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, using a "plan of the day" to coordinate and control activities, performing nesting bird surveys and implementing stormwater controls before commencing earth-disturbing activities, controlling dust, tracking waste diversion, and properly storing hazardous materials. Minimizing impacts to wildlife is a consideration for all construction projects.

NREL crews and subcontracted crane operators work to install a 1-megawatt fuel cell at the Flatirons Campus. Before outdoor project activities took place, environmental impacts were assessed and communicated so proper environmental protection actions could be implemented. *Photo by Werner Slocum, NREL 72220*

2022 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 MS4 permit and drinking water programs. 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 the environment, safety, health, and quality management helps make NREL a safer, more environmentally responsible workplace.
- **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 goal 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.

A 480-kilowatt solar array on the Flatirons Campus create an environment to address the challenges of integrated energy systems at scale in the areas of energy storage, power electronics, hybrid energy systems, future energy infrastructure, and cybersecurity. *Photo by Josh Bauer and Bryan Bechtold, NREL 73087*

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 2022 is presented in Table 1, which summarizes 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 1. Sustainability Goals and Performance Summary

DOE Goal	Risk Level	Performance in Fiscal Year (FY) 2022
Multiple Categories		
Reduce Scope 1 and Scope 2 greenhouse gas (GHG) emissions[a]	Medium	Decreased Scope 1 and 2 GHG emissions 12% from FY 2021.
Reduce Scope 3 GHG emissions[b]	High	Increased Scope 3 emissions 62% from FY 2021.[c]
Energy Management		
Reduce energy use intensity (measured in 1,000 British thermal units per gross square foot) in goal-subject buildings	Medium	Energy use intensity decreased 3% from FY 2021.
Evaluate energy and water systems per Section 432 of the Energy Independence and Security Act[d] on a continuous 4-year cycle	Low	NREL conducted energy and water audits at all facilities through an investment grade audit completed for the energy service performance contract being investigated.
Meter individual buildings for electricity, natural gas, steam, and water use where cost-effective and appropriate	Medium	100% of relevant buildings have electricity meters, all of which are advanced meters.[e] 100% of relevant buildings have natural gas meters. 100% of relevant buildings have potable water meters and 93% of relevant buildings have advanced potable water meters.[e]
Water Management		
Reduce potable water use intensity (measured in gallons per gross square foot)	High	Potable water intensity increased by 6% from FY 2021.
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	62% diversion (composted or recycled) rate of nonhazardous solid waste.
Reduce construction and demolition materials and debris sent to treatment and disposal facilities	Low	91% diversion (composted or recycled) rate of construction and demolition waste.
Fleet Management		
Reduce petroleum consumption	Low	16% decrease from FY 2021 in total petroleum fuel consumption.
Increase alternative fuel consumption	Low	12% decrease from FY 2021 in alternative fuel consumption.
Acquire alternative fuel and electric vehicles	Low	Acquired three new zero-emission vehicles.

DOE Goal	Risk Level	Performance in Fiscal Year (FY) 2022
Clean and Renewable Energy		
Increase consumption of clean and renewable electric energy	Low	No change from FY 2021 in consumption of clean and renewable electric energy.
Increase consumption of clean and renewable nonelectric thermal energy	High	1% increase from FY 2021 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	50% of the eligible facilities met the guiding principles.
Acquisition and Procurement		
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring all sustainability clauses are addressed as appropriate	Low	100% of NREL's contracts contain appropriate sustainability provisions.
Efficiency and Conservation Measure Investments		
Implement life cycle cost-effective efficiency and conservation measures with appropriated funds and/or performance contracts	Medium	NREL continued work with 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) 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	98.5% of electronics purchases were EPEAT (Electronic Product Environmental Assessment Tool)-certified and 100% of electronics taken out of service were reused or recycled.
Increase energy and water efficiency in high-performance computing and data centers	Medium	The STM Campus' Research Support Facility data center achieved a power usage effectiveness[g] rating of 1.31. The STM Campus' Energy System Integration Facility High-performance computing data center achieved a power usage effectiveness of 1.03 and water usage effectiveness[h] of 0.92 liters per kilowatt hour.
Adaptation and Resilience		
Implement climate adaptation and resilience measures	Medium	NREL completed the Vulnerability Assessment and Resilience Plan.

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.

b. 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.

c. 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.

d. FY 2021's reduction occurred largely because of curtailment of commuting, business travel, and campus occupation associated with the COVID-19 pandemic. FY 2022 emissions were expected to increase and did increase when operations returned to normal.

e. Section 432 of the Energy Independence and Security Act of 2007 requires that 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.

f. An advanced meter, as defined by DOE, records energy or water consumption data hourly or more frequently and provides daily or more frequent transmittal of measurements to a central collection point.

g. To advance sustainable building principles and practices, the Council on Environmental Quality issued a guidance document[5] 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.

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 to the information technology equipment energy usage.

5 Council on Environmental Quality. 2020. *Guiding Principles for Sustainable Federal Buildings and Associated Instructions.* https://sftool.gov/learn/about/631/guiding-principles-sustainable-federal-buildings

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.

An NREL shuttle drives past a newly installed fire danger sign at the East Entrance of the STM Campus. Signs were also placed at the South Entrance and the West Entrance, and one at the Flatirons Campus. Wildfire awareness can improve NREL's environmental resilience. *Photo by Werner Slocum, NREL 73392*

2022 Accomplishments and Highlights

- Completed a climate change-focused Vulnerability Assessment and Resilience Plan. This effort involved more than 70 staff members from across NREL's operational and research teams. Climate change related vulnerabilities were identified across the lab and were assigned a risk level. Specifically, these focused mostly on high-likelihood changes, including the increased chance of drought, wildfire, heat waves, and average temperatures, and degradation in air quality in the region.
- Began discussions with external stakeholders, including utility providers and local municipalities, to ensure the laboratory's resilience approach and mitigation strategies are in alignment with those of the region. Initial meetings identified multiple areas of collaboration around microgrid technology, land and water management, emergency notification systems, and resilience strategy and planning. Integration of climate change resilience planning into the larger risk mitigation processes is an area of focus for future activities.
- Continued a project to install a permanent water pipeline to provide a more reliable water source for the Flatirons Campus. In a previous resilience risk assessment completed in 2015, the Flatirons Campus receiving trucked-in water was identified as a vulnerability.

A young cottontail rabbit (*Sylvilagus* spp.) sits in the snow outside the Energy Systems Integration Facility on the STM Campus. *Photo by Werner Slocum, NREL 66793*

4 COMPLIANCE SUMMARY

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

Table 2 includes a brief description of the statute or regulation and how compliance requirements were met in 2022. Detailed information for each area of compliance is found in the referenced sections of this report. For details, see Appendix B. Environmental Permits, Registrations, Notifications and EPA Compliance Data.

Table 2. Compliance Status for Federal, State, and Local Environmental Laws and Regulations

Regulatory Program	Compliance Status	Regulator Requirement: Regulation Title
Environmental Performance Report		
DOE Order 231.1B, Chg 1, Environment, Safety and Health Reporting, was implemented to ensure DOE receives timely, accurate information about events that have affected or could adversely affect the health and safety of the public or workers, the environment, or the operations of DOE facilities. The order requires DOE facilities to report specific site environmental information annually, including environmental management performance, environmental occurrences and response, compliance with environmental standards and requirements, significant programs and efforts, and property clearance activities for property contaminated with radiological materials.	NREL reports annually via this Environmental Performance Report.	DOE Order 231.1B, Chg. 1: Environment, Safety and Health Reporting
EMS and Sustainability		
Executive Order 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 orders established new federal level sustainability goals. They require federal agencies to meet statutory requirements in a manner that (1) increases the sustainability of federal supply chains to achieve net-zero emissions by 2050 and (2) makes federal agencies more adaptive and resilient to the impacts of climate change. DOE has subsequently established goals that accomplish those objectives. DOE Order 436.1, Departmental Sustainability, requires the laboratory to implement an EMS that conforms to the ISO 14001 structure. The EMS is implemented as part of a DOE-required Integrated Safety Management System, which systematically integrates safety and environmental protection into management and work practices at all levels to protect the public, the worker, and the environment.	Each year, NREL develops a site sustainability plan to report on past performance and set goals for the coming year. These performance goals are integrated with the laboratory's EMS. NREL's EMS is certified to the ISO 14001:2015 standard for environmental management systems since 2011. Annual assessments verify that NREL meets the ISO standard and is continually improving performance.	Executive Order 13990: Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis Executive Order 14057: Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability DOE Order 436.1: Departmental Sustainability
Resilience Planning		
Executive Order 14008, Tackling the Climate Crisis at Home and Abroad 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. DOE Order 436.1 requires facilities to annually develop a site sustainability plan that facilitates identifying and addressing opportunities for resiliency.	Efforts to connect the Flatirons Campus to a nearby permanent water supply continued in 2022. 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. NREL develops a site sustainability plan each year to report on past performance and set goals for the coming year. In FY 2022, NREL began discussions with external stakeholders, including utility providers and local municipalities, to ensure the laboratory's resilience approach and mitigation strategies are in alignment with those of the region. Initial meetings identified multiple areas of collaboration regarding microgrid technology, land and water management, emergency notification systems, and resilience strategy and planning. Integration of climate change resilience planning into the larger risk mitigation processes is an area of focus for future activities.	Executive Order 14008: Tackling the Climate Crisis at Home and Abroad DOE Order 436.1: Departmental Sustainability

Regulatory Program	Compliance Status	Regulator Requirement: Regulation Title
Air Quality		
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 limits, and operation of emission controls 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. On October 1, 2021, the U.S. Environmental Protection Agency (EPA) implemented hydrofluorocarbon phasedown requirements authorized by the American Innovation and Manufacturing Act of 2020 that are intended to reduce the use of hydrofluorocarbons in manufacturing to 15% of a 2011–2013 baseline by 2036. EPA's Protection of Stratospheric Ozone includes repair, servicing, recordkeeping, and other requirements for appliances containing more than 50 pounds (lb) (23 kilograms [kg]), of any regulated refrigerants, including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and hydrofluoroolefins (HFOs). Appliances containing 5 lb (2.3 kg) or more of these refrigerants are subject to end-of-life refrigerant recovery, recycling, and documentation requirements. EPA regulations require GHGs emitted by certain facilities to be tracked and reported if the emissions exceed 27,557 U.S. tons (25,000 metric tons [MT]) of carbon dioxide equivalent (CO_2e) per year. The purpose of this reporting is to better identify the actual emissions of such gases across the United States and provide the EPA with data on which to base future GHG regulations. Reporting and permitting of GHGs may be required under the EPA Prevention of Significant Deterioration regulation, Title V Tailoring Rule, and the EPA Greenhouse Gas Mandatory Reporting Rule, depending on the amount of GHGs emitted. Permits for major emissions sources (greater than 100 U.S. tons [90.7 MT] per year of a criteria pollutant) may be required to include GHGs in the permit if CO_2e emissions exceed 100,000 U.S. tons (90,718 MT) per year. The EPA has designated the Denver metropolitan area's ozone nonattainment status as "severe." Major source permitting thresholds for nitrogen oxides (NO_x) and volatile organic compounds (VOCs) are 25 U.S. tons (24.7 MT) per year. 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 EPA. Categories of regulated air pollutants include criteria air pollutants, hazardous air pollutants (HAP), ozone-depleting substances, and GHGs.	In 2022, program activities complied with all requirements. NREL did not exceed any air permit standard or other air regulatory requirement at any facility. 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. HAP emissions for each individual facility were below the EPA reporting and permitting thresholds of 10 U.S. tons (9.1 MT) per year for each individual HAP, and 25 U.S. tons (22.7 MT) per year for all HAPs combined. NREL completed an annual evaluation of compliance with federal and state facility-wide permitting and emission-control requirements. All facilities and individually permitted equipment items remain classified as minor or "synthetic minor" sources. Laboratory CO_2e and GHG emissions were below the federal reporting and permitting threshold of 27,500 U.S. tons (25,000 MT) per year. All equipment registrations, including annual registration renewals, for state-required ozone-depleting substances were completed for the STM Campus and Flatirons Campus. Refrigerant recovery equipment is no longer required to be registered with the EPA. No permit renewals were required during 2022. Emission tracking of all emitting equipment continued, whether the equipment was permitted or permit exempt. The STM Campus is within the Denver metropolitan area's "severe" ozone nonattainment status. The NREL STM Campus NO_x emissions exceed 25.0 U.S. tons per year, and a Title V facility-wide air permit application will be filed on or before the regulatory due date in 2023.	H.R. 133 Consolidated Appropriations Act, 2021 Section 103 in Division S: American Innovation and Manufacturing Act of 2020 EPA 40 CFR Part 40: Mandatory Greenhouse Gas Reporting EPA 40 CFR Part 50: National Primary and Secondary Ambient Air Quality Standards EPA 40 CFR Part 51: Requirements for Preparation, Adoption, and Submittal of Implementation Plans EPA 40 CFR Part 52: Approval and Promulgation of Implementation Plans EPA 40 CFR Part 60: Standards of Performance for New Stationary Sources EPA 40 CFR Part 63: National Emission Standards for Hazardous Air Pollutants for Source Categories EPA 40 CFR Part 70: State Operating Permit Programs EPA 40 CFR Part 71: Federal Operating Permit Programs EPA 40 CFR Part 82: Protection of Stratospheric Ozone EPA 40 CFR Part 98: Mandatory Greenhouse Gas Reporting CDPHE 5 Colorado Code of Regulations (CCR) 1001-3: Stationary Source Permitting and Air Pollutant Emission Notice Requirement CDPHE 5 CCR 1001-15: Control of Emissions of Ozone Depleting Compounds

Regulatory Program	Compliance Status	Regulator Requirement: Regulation Title
Air Quality *(continued)*		
Several state air regulations for sources of particulate pollution include large construction sites and cold weather street sanding operations. 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 and report street sanding in the winter and to minimize sand use as possible.	NREL maintains an STM Campus air permit allowing fugitive dust emissions from construction activities. NREL provided an annual street sanding report to the State of Colorado and Jefferson County in 2022, as required. The report confirmed that no sand was used at the STM Campus or the Flatirons Campus.	CDPHE 5 CCR 1001-16: Street Sanding Emissions
Drinking Water Quality		
The federal Safe Drinking Water Act establishes minimum drinking water standards and monitoring requirements for drinking water supplies. Under this act, the EPA has established allowable levels for contaminants in drinking water that are known as maximum contaminant levels. The Water Quality Control Division of CDPHE implements the federal Safe Drinking Water Act in Colorado under authority delegated by the EPA.	Program activities were in compliance with requirements. All monitored water quality parameters met requirements. A total of 443,106 gallons (1,677,339 L) of drinking water were provided to the Flatirons Campus.	EPA 40 CFR Part 141: National Primary Drinking Water Regulations EPA 40 CFR Part 142: National Primary Drinking Water Regulations Implementation EPA 40 CFR Part 143: National Secondary Drinking Water Regulations EPA 40 CFR Part 149: Sole Source Aquifers CDPHE 5 CCR 1002-11: Colorado Primary Drinking Water Regulations
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, geothermal technologies, and well installations.	Program activities were in compliance with requirements. In 2022, there were no spills or releases that impacted groundwater. There are currently no permitted groundwater monitoring wells at either the STM Campus or the Flatirons Campus. There are two permitted closed-loop geothermal systems at the STM Campus.	CDPHE 2 CCR 402-2: Rules and Regulations for Water Well Construction, Pump Installation, Cistern Installation, and Monitoring and Observation Hole/Well Construction CDPHE 2 CCR 402-10: Rules and regulations for Permitting the Development and the Appropriation of Geothermal Sources Through the Use of Wells CDPHE 5 CCR 1002-41: The Basic Standards for Ground Water

Regulatory Program	Compliance Status	Regulator Requirement: Regulation Title
Storm and Surface Water Quality		
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 and by retaining stormwater runoff and releasing it at predevelopment rates. Stormwater discharges resulting from construction activities at federal facilities that disturb one or more acres (0.4 or more hectares) of land are administered in Colorado by the EPA. To obtain coverage under an EPA Construction General Permit for stormwater discharges, a site-specific stormwater pollution prevention plan must be prepared and a notice of intent must be filed with the EPA. The Water Quality Control Division within CDPHE regulates stormwater discharges at nonfederal facilities within Colorado. For NREL construction projects that occur off federal property, a Colorado Discharge Permit System stormwater permit might be required. Owners and operators of a regulated municipal separate storm sewer system (MS4) are required to develop a management program to minimize the discharge of pollutants into local bodies of water. 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.	Program activities were in compliance with requirements. 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. 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. 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 terminated in 2022. NREL renewed coverage under the 2022 EPA Construction General Permit for the STM Campus' Research and Innovation Laboratory. NREL obtained coverage under the 2022 EPA Construction General Permit for the Flatirons Campus' Second Controllable Grid Interface project.	Public Law 110-140: Energy Independence and Security Act of 2007 EPA 40 CFR 122.26: Storm Water Discharges EPA 40 CFR 122.34: Permit Requirements for Regulated Small MS4 Permits CDPHE 5 CCR 1002-38: Classifications and Numeric Standards South Platte River Basin Laramie River Basin Republication River Basin Smoky Hill River Basin CDPHE 5 CCR 1002-61: Colorado Discharge System Permit Requirements CDPHE 5 CCR 1002-65: Regulation Controlling Discharges to Storm Sewers CDPHE 5 CCR 1002-93: Colorado's Section 303(D) List of Impaired Waters and Monitoring and Evaluation List

Regulatory Program	Compliance Status	Regulator Requirement: Regulation Title
Wastewater Quality		
Wastewater is regulated at the federal level under Clean Water Act, a U.S. federal law, and at the state level under the Colorado Water Quality Control Act by the Water Quality Control Division of CDPHE. 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. 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. Nondomestic wastewater discharges must comply with Metro Water Recovery rules and regulations, which incorporate requirements of the Clean Water Act.	Program activities were in compliance with requirements.	EPA 40 CFR 122: EPA Administered Permit Programs, The National Pollutant Discharge Elimination System EPA 40 CFR 123: State Program Requirements EPA 40 CFR 125: Criteria and Standards for the National Pollutant Discharge Elimination System EPA 40 CFR 127: National Pollutant Discharge Elimination System Reporting EPA 40 CFR 129: Toxic Pollutant Effluent Standards EPA 40 CFR 130: Water Quality Planning and Management EPA 40 CFR 131: Water Quality Standards EPA 40 CFR 133: Secondary Treatment Regulation EPA 40 CFR 136: Guidelines Establishing Test Procedures for the Analysis of Pollutants CDPHE 5 CCR 1002-62: Regulations for Effluent Limitations CDPHE 5 CCR 1002-63: Pretreatment Regulations

Regulatory Program	Compliance Status	Regulator Requirement: Regulation Title
Hazardous Materials Management		
Hazardous materials management is regulated at the federal level through Title III of the Superfund Amendments and Reauthorization Act, 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. EPCRA Section 302 requires a facility to notify state and local emergency response and planning agencies if any extremely hazardous substances in the facility's inventory are stored in quantities greater than regulatory thresholds. EPCRA Section 304 requires facilities to immediately notify state and local emergency response and planning agencies if there is an accidental spill or release of more than the predetermined reportable quantity. 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. EPCRA Section 312 requires an annual report of EPCRA Section 311 information. 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.	Program activities were in compliance with requirements. Section 302 notification was not required. There were no releases of hazardous materials that required reporting under Section 304. In accordance with DOE requirements, NREL screened selected chemicals to confirm quantities were below those requiring elevated operational protocols. An EPCRA Section 311 submission was not required. 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. An EPCRA Section 313 Toxic Release Inventory report was not required. Hazardous materials permits are required by the local fire jurisdiction for the STM Campus, Building 16 at the Denver West Office Park, and ReFUEL. Hazardous materials permits were acquired for facilities as appropriate. No reportable hazardous material spills occurred.	EPA 40 CFR 355: Emergency Planning and Notification EPA 40 CFR 370: Hazardous Chemical Reporting, Community Right-To-Know EPA 40 CFR 372: Toxic Chemical Release Reporting, Community Right-To-Know DOE Order 151.1D: Comprehensive Emergency Management System

Regulatory Program	Compliance Status	Regulator Requirement: Regulation Title
Hazardous Waste Management		
The Resource Conservation and Recovery Act (RCRA) established requirements for the management of regulated waste, including hazardous waste. In Colorado, the Hazardous Materials and Waste Management Division of CDPHE administers requirements under authority delegated by the EPA. In Alaska, the EPA administers the RCRA requirements with the Alaska Department of Environmental Conservation, which manages certain aspects of waste generated by a "very small quantity generator." Additional requirements for hazardous material transportation are regulated by the U.S. Department of Transportation. 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. EPA has three hazardous waste generator classifications: Very small quantity generator: Those who generate no more than 100 kg (220 lb) of hazardous waste and no more than 1 kg (2.2 lb) of acute hazardous waste per month Small quantity generator: Those who generate less than 1,000 kg (2204.6 lb) of hazardous waste and less than 1 kg (2.2 lb) of acutely toxic waste per month Large quantity generator: Those who generate 1,000 kg (2204.6 lb) or more of hazardous waste or more than 1 kg (2.2 lb) of acutely hazardous waste per month.	Program activities were in compliance with requirements. Applicable staff received annual hazardous and universal waste training in accordance with state and federal regulations. NREL maintains unique EPA identification numbers for four of its seven facilities: the STM Campus, Building 16, the Flatirons Campus, and ReFUEL. All regulatory notifications were completed and applicable waste generator fees were paid. The waste generator status for each NREL facility is: 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, Fairbanks Alaska: very small quantity generator Washington D.C. Office: no hazardous waste generated.	EPA 40 CFR 260-273: Hazardous Waste EPA 40 CFR 279: Standards for the Management of Used Oil CDPHE 6 CCR 1007-3: Hazardous Waste Regulations Alaska Department of Environmental Conservation 18 Alaska Admin Code 60.020: Hazardous Waste
Aboveground Storage Tank Management		
Aboveground storage tanks (ASTs) are regulated in Colorado by the Colorado Department of Labor and Employment's Division of Oil and Public Safety under Colorado AST regulations. They require that ASTs be constructed and installed according to specific standards, that they be regularly inspected with all inspections being documented, and that facilities meeting certain oil storage quantities employ a spill prevention control and countermeasures (SPCC) plan to manage oil sources of 55 gallons (208 L) or more.	Program activities were in compliance with requirements. All tanks were inspected to confirm continued adherence to State of Colorado regulations.	Colorado Department of Labor and Employment 7 CCR 1101-14: Storage Tank Regulations

Regulatory Program	Compliance Status	Regulator Requirement: Regulation Title
Petroleum Spill Prevention and Response		
Oil spill prevention and response is managed at the federal level under the Oil Pollution Prevention Act and the Clean Water Act, and at the state level under the Colorado Storage Tank Regulations as implemented by the Division of Oil and Public Safety. SPCC plans are required by the EPA and State of Colorado regulations for facilities that meet certain oil storage criteria. In general, facilities that store more than 1,320 gallons (5,000 L) of oil and have the potential for a spill to enter waters of the United States or Colorado waters must have an SPCC plan. SPCC regulations require that any equipment or containers with the capacity to store 55 gallons (208 L) or more of oil be included in the plan. The purpose of the SPCC plan is to prevent the discharge of oil and hazardous substances, provide site-specific petroleum storage information, list spill response resources, and minimize the impact of spills to adjacent waterways should a spill occur.	Program activities were in compliance with requirements. No reportable spills occurred. SPCC plans are maintained for the STM Campus, Flatirons Campus, and ReFUEL. Applicable staff received annual SPCC training in accordance with state and federal regulations.	EPA 40 CFR Part 112: Oil Pollution Prevention EPA Clean Water Act, Section 319: Nonpoint Source Management Program Colorado Department of Labor and Employment 7 CCR 1101-14: Storage Tank Regulations Colorado Water Quality Control Commission Colorado Revised Statutes 25-8-205: Control Regulations
Radiological Materials and Waste Management		
CFR Title 40, Protection of the Environment, Part 61, National Emission Standards for Hazardous Air Pollutant, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" require the measurement and reporting of radionuclides emitted from DOE facilities and the resulting offsite dose from those emissions. 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. DOE Order 458.1 establishes requirements that must be followed when the release of any radiologically contaminated equipment or real property to another DOE national laboratory, collaborating agency, or outside entity is proposed. These requirements detail the measurable radiological levels that must be verified and documented to comply with DOE-authorized limits. DOE Order 435.1, Radioactive Waste Management, establishes requirements to ensure radioactive waste is managed in a manner that protects the health and safety of workers and the public, and the environment. This is accomplished by evaluating and planning for proposed activities that would generate radioactive waste and documenting all requirements before those activities are authorized to commence.	Program activities were in compliance with requirements. Small quantities (less than 2.0 cubic yards [1.5 cubic meter]) of low-level radioactive waste are in storage awaiting offsite disposal. In 2018, two chemical fume hoods and laboratory cabinetry were removed during decommissioning of the laboratory's only low-level radioactive work area. Radiological sampling indicated the items were within limits for release and would not pose a hazard to workers, the public, or the environment. The items are being prepared for offsite disposal in accordance with DOE requirements. In accordance with 40 CFR 61, Subpart H, 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 2022, the effective dose equivalent of radiation to the public was 0.040 mrem, which is far below the 10 mrem per year limit. No property was either requested or authorized for clearance to be released for reuse or disposal.	Federal Regulation 40 CFR 61, Subpart H: Emissions of Radionuclides Other Than Radon from Department of Energy Facilities DOE Order 458.1: Radiation Protection of the Public and the Environment DOE Order 435.1: Radioactive Waste Management

Regulatory Program	Compliance Status	Regulator Requirement: Regulation Title
National Environmental Policy Act		
The National Environmental Policy Act (NEPA) requires federal agencies to analyze and disclose the potential environmental impacts of proposed federal actions and alternatives as part of its decision-making process. DOE regulations and orders establish how NEPA is implemented for DOE, and the Council on Environmental Quality reviews and approves federal agency NEPA procedures. Under NEPA, DOE considers the potential impacts to the environment, including natural, social, and economic factors, to determine the appropriate level of review for a proposed action. These include categorical exclusions, environmental assessments, and environmental impact statements.	Program activities were in compliance with requirements. NEPA reviews were completed for key projects being planned, including the Energy Materials and Processing at Scale building and the water system project at the Flatirons Campus.	40 CFR 1500-1508: Regulations for Implementing the Procedural Provisions of NEPA (Council on Environmental Quality) DOE 10 CFR 1021: NEPA Implementing Procedures
Wildlife Management		
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. The Migratory Bird Treaty Act and its amendments implement several treaties between the United States, 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. 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. 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.	Program activities were in compliance with requirements. Potential wildlife impacts are considered for proposed projects and routine maintenance activities. 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. To help reduce bird collisions with structures, various 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. NREL held one active Scientific Collection Permit for salvage in 2022. The permit is required for the collection of deceased bats to determine bat species.	USFWS 16 U.S.C. 703-712: The Migratory Bird Treaty Act Memorandum of Understanding between DOE and the USFWS Executive Order 13186: Responsibilities of Federal Agencies to Protect Migratory Birds Colorado Division of Parks and Wildlife Colorado Revised Statutes 33-6-128: Damage or Destruction of Dens or Nests, Harassment of Wildlife

Regulatory Program	Compliance Status	Regulator Requirement: Regulation Title
Endangered Species and Species of Concern		
Federal agencies are required to abide by the Endangered Species Act (ESA) to ensure their actions do not adversely affect species that are federally listed under the ESA as threatened, endangered, or candidate species. The 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. Additional federal and state laws and regulations, such as the Bald and Golden Eagle Protection Act, protect wildlife. DOE's formal consultation with the USFWS for the 2014 site-wide environmental assessments for the STM Campus and the Flatirons Campus resulted in an agreed-upon threshold for water usage to limit impacts to the Platte River system. The Colorado Division of Parks and Wildlife maintains a list of endangered, threatened, and wildlife species of concern for Colorado.	Program activities were in compliance with requirements. No activities were conducted in designated critical habitat for the federally threatened Preble's meadow jumping mouse (*Zapus hudsonius preblei*). No threatened or endangered plant species were identified at either the STM Campus or the Flatirons Campus. Water usage at the STM Campus and Flatirons Campus were below the thresholds identified through the DOE and USFWS formal consultation.	USFWS 50 CFR 17: Endangered and Threatened Wildlife and Plants Colorado Division of Parks and Wildlife 2 CCR 406-10, Article 2: Endangered Wildlife Colorado Division of Parks and Wildlife 2 CCR 406-10, Article 3: Threatened Wildlife
Vegetation Management		
The Federal Insecticide, Fungicide, and Rodenticide Act, as implemented by the EPA, regulates the use, storage, and disposal of herbicides and pesticides. For application of certain types of herbicides designated as "restricted use" by the EPA, a certified applicator must be used. 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. 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. Executive Order 13112, Invasive Species, requires the control of invasive species at federal facilities. Importation of regulated plants and animals/organisms from other states and countries requires permitting by the Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture. NREL's Biosafety Program manages the importation and use of these materials. 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 in addition to the ESA's that considers rare plants.	Program activities were in compliance with requirements. 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 (*Anthophila* spp.) and other pollinators. NREL acquired certified weed-free seed mixes to minimize the introduction of invasive weed species at its campuses. NREL held one active APHIS permit in 2022 for the import of *Sphingobium* microorganisms to the STM Campus from within the United States and from Japan. In 2021, NREL held an APHIS permit for *Agrobacterium tumefaciens*. This permit would have expired June 2022, but the U.S. Department of Agriculture delisted *Agrobacterium tumefaciens* as of March 10, 2022.	Executive Order 13112: Invasive Species Presidential Memorandum: Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators EPA 40 CFR 162: State Registration of Pesticide Products EPA 40 CFR 171: Certification of Pesticide Applicators Colorado Water Quality Control Commission 25-8-205: Noxious Weed Management, Municipal Authority U.S. Department of Agriculture 7 U.S. Code Ch. 61: Noxious Weeds U.S. Department of Agriculture Public Law 106-224: Agricultural Risk Protection Act of 2000 EPA 7 U.S. Code 136 et seq.: Federal Insecticide, Fungicide, and Rodenticide Act

Regulatory Program	Compliance Status	Regulator Requirement: Regulation Title
Wetlands and Floodplains		
Wetlands became regulated under the 1972 amendments to the Clean Water Act. Wetlands that meet certain soil, vegetation, and hydrologic criteria are protected under Section 404 of the Clean Water Act, which is administered by the U.S. Army Corps of Engineers and the EPA. 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. 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. 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. In Colorado, Jefferson County requires approval of development proposed in floodplains within its jurisdiction.	Program activities were in compliance with requirements. A wetland delineation was conducted within the Eastern Drainage area of the STM Campus to identify any potential impacts for future construction projects. The U.S. Army Corps of Engineers issued an Approved Jurisdictional Determination, which provided concurrence with the assessment of those areas identified in the study area as non-jurisdictional. A wetland delineation was conducted in 2021 for the Flatirons Campus water system project and delineation results were included in the project's 2022 environmental assessment.	U.S. Army Corps of Engineers Clean Water Act Section 404: Permit Program Executive Order 11988: Floodplain Management Executive Order 11990: Protection of Wetlands DOE 10 CFR 1022: Compliance with Floodplain and Wetland Environmental Review Requirements
Cultural Resources		
Cultural resources are protected under Sections 106 and 110 of the National Historic Preservation Act, which is administered in Colorado by the Colorado Office of Archaeology and Historic Preservation and the State Historic Preservation Office. Federal agencies must establish preservation programs—commensurate with their mission and the effects of their activities on historic properties—that provide for the careful consideration of historic properties. Significant cultural resources are either eligible for, or are listed in, the National Register of Historic Places. Cultural resources are defined as any prehistoric or historic district, site, building, structure, or object considered important to a culture, subculture, or community for scientific, traditional, religious, or other reason.	Program activities were in compliance with requirements. NREL initiated a historic resource survey of a 6.6-acre (2.7-hectare) portion of the Camp George West Historic District in preparation for DOE to take possession of the former Colorado Correctional Facility (parcel 8e) in 2023. The survey was conducted by a local environmental consulting firm and updated, in part, a multiple property survey conducted in 1992 for the entire Camp George West Historic District. The Colorado Correctional Facility is only a portion of the historic district; therefore, the report addresses only the historic structures in this parcel. This survey will be an important input to cultural resource management within this new DOE land holding.	National Park Service 36 CFR 60: National Register of Historic Places National Park Service 36 CFR 63: Determinations of Eligibility for Inclusion in the National Register of Historic Places National Park Service 36 CFR 79: Curation of Federally Owned and Administered Archaeological Collections National Park Service 36 CFR 800: Protection of Historic Properties 16 U.S.C. 470: National Historic Preservation Act State Historic Preservation Office 8 CCR 1504-7: Historical, Prehistorical, and Archaeological Resources

A diesel genset helps supply electricity to the Flatirons Campus. This engine-generator is the combination of an electrical generator and an engine mounted together to form a single piece of equipment. *Photo by Larry Durbin, NREL 24490*

5 AIR QUALITY PROTECTION

NREL strives to protect air quality and the environment by:

- Minimizing air emissions from research and operations activities and employee commuting
- Tracking and trending air emissions from the onsite sources
- Anticipating and 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. Laboratory 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 fuel use, chemical use, and facility operations. Specific 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.

Air permits issued to NREL that allow avoidance of a Title V STM Campus facility-wide air permit require monthly and annual tracking of operating hours and NO_X and CO emissions. NREL's tracking system was put in place immediately after the issuance of these permits. The system, which is updated monthly, demonstrates compliance with all permit requirements for two full years of operation. A summary of the estimated annual air pollutant emissions in 2022 is included in Table 3 and includes the emission emitted under these revised permits.

In late 2022, the EPA and the State of Colorado changed the ozone nonattainment status of northeastern Colorado from "serious" to "severe," which changed 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. The change requires NREL to obtain a Title V air permit for the STM Campus facility. The application for this Title V air permit must be filed by late 2023, and preparations for doing so began in late 2022.

Table 3. Estimated Annual Air Pollutant Emissions, in U.S. tons (and metric tons) per year, 2018–2022[a]

Year	Criteria Pollutants					GHGs			HAPs
	CO	NO_x	VOC	PM_{10}	SO_2	CO_2	CH_4	N_2O	All HAPs
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)
2022	7.73 (7.01)	15.71 (14.25)	0.71 (0.64)	3.34 (3.03)	0.47 (0.43)	11,038 (10,014)	0.54 (0.49)	0.38 (0.34)	0.56 (0.51)

a CO: carbon monoxide; NO_x: nitrogen oxides; VOC: volatile organic compound; PM_{10}: respirable particulate matter less than 10 micrometers in diameter; SO_2: sulfur dioxide; CO_2: carbon dioxide; CH_4: methane; N_2O: nitrous oxide; HAPs: hazardous air pollutants

5.2 Refrigerants

Refrigerants, such as chlorofluorocarbons (CFC) and hydrochlorofluorocarbons (HCFC) are considered ozone-depleting substances, have largely been banned from import into or manufacture in the United States, and are largely only available as recycled refrigerants. Non-ozone-depleting compounds such as hydrofluorocarbons (HFCs) and hydrofluoroolefins (HFOs) are used to replace ozone-depleting refrigerants. Many of these HFC 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 State of Colorado and EPA regulations and strives to minimize the release of refrigerants.

There is an increased interest by the EPA and state regulatory agencies to reduce the use of HFCs refrigerants because of their high level of use, increased releases to the atmosphere due to leaks, and their global warming potential (which is generally much greater than that of CO_2). In November 2021, the U.S. Congress enacted legislation that limits the use of HFCs in manufacturing. This legislation, now enacted as a rule by the EPA, mandates a reduction in HFC use starting in 2022 and progressively reducing its use to 15% of a 2011 baseline amount by 2036. This reduction in use does not require the retirement of existing appliances using HFC refrigerants; however, the availability of these refrigerants is expected to decrease, and costs are expected to increase over the phasedown period. The rule is expected to lead to a future decrease in the laboratory's use of HFC refrigerants as older equipment is replaced.

The refrigerant inventory for the laboratory changed in 2022 due to the removal of two old standby chillers and the installation of two new chillers. The refrigerant inventory includes 133 appliances, 20 of which contain 50 or more lb (23 kg) of refrigerant and are subject to strict "leak and repair" requirements. At the end of 2022, the total inventory of all refrigerants was 9347 lb (4,249 kg); of this amount, 320 lb (145 kg) were ozone depleting substances and the remaining 9,028 lb (4,104 kg) were non-ozone depleting HFC refrigerants that are GHGs.

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

2022 Accomplishments and Highlights

- Performed a detailed review of 20 existing fuel-burning sources to verify permit and estimated emissions data. Although no permit renewals were required during 2022, this database helps assure continued compliance.
- Received an air inspection by the Jefferson County Health Department on behalf of the Air Pollution Control Division of the Colorado Department of Public Health and Environment for the STM Campus and Flatirons Campus. No compliance advisory or notice of violation was issued as a result of the inspection.

A blue-winged teal (*Spatula discors*) swims in the detention pond near the parking garage at the STM Campus. *Photo by Werner Slocum, NREL 51355*

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 area 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.

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 watershed and, to a lesser degree, some watersheds on the western slope of Colorado. Water is trucked-in approximately three to four times per week and is then 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 issues a permit for 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 2022, monitoring results for residual chlorine and disinfection byproducts were within allowable regulatory ranges (Figure 4

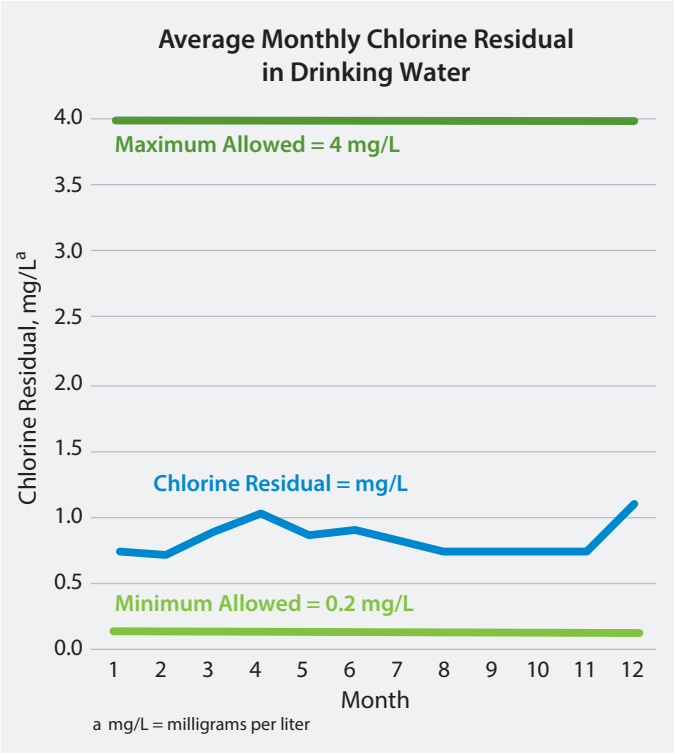


Figure 3. Results of average monthly residual chlorine monitoring in drinking water at the Flatirons Campus, 2022

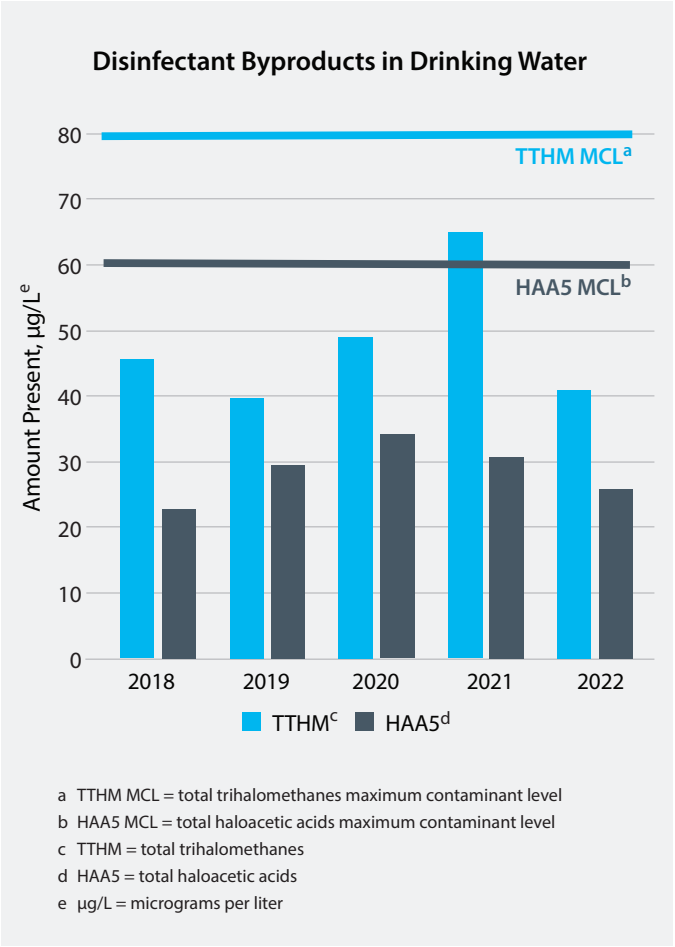


Figure 4. Results of disinfection byproduct concentrations in drinking water at the Flatirons Campus, 2018-2022

and Figure 5). In prior years, copper sampling was performed yearly, but the State of Colorado changed the frequency of sampling required for copper and lead to once every 3 years starting January 1, 2022; as such, NREL will be reporting on copper concentration in 2024. 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 2022.

In 2022, design for the Flatirons Campus water system project continued. The project will 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.

2022 Accomplishments and Highlights

- Provided 443,106 gallons (1,677,339 L) of drinking water to the Flatirons Campus, an increase of 88,938 gallons (336,667 L) or approximately 25% more than 2021, likely due to the increase in staff returning to the campus after working remotely during the Covid-19 pandemic.
- Completed comprehensive tank inspections for the two drinking water tanks at Flatirons Campus, a 15,000-gallon (56,781 L) tank and a 2,000-gallon (7,571 L) tank. No deficiencies were found.

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.

A contractor tests the water behind the Field Test Laboratory Building at the STM Campus. The wells were tested regularly to check the groundwater level, pH levels, and the total dissolved solids in the water. *Photo by Werner Slocum, NREL 56795*

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 focuses 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 United States, they persist in the environment and have been detected in soil, groundwater, and drinking water supplies, prompting the federal government to begin developing PFAS standards and regulation, including the addition of several PFAS compounds to the Toxics Release Inventory under Section 313 of 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 at the STM Campus as containing a 3% PFAS solution. The 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.

2022 Accomplishments and Highlights

- Inventoried PFAS-containing chemicals using NREL's new chemical management system's database. The database can run a report to display an inventory of U.S. Environmental Protection Agency-identified PFAS-containing chemicals to ease in tracking and quantity management.

6.3 Surface Water

Through its surface water program, NREL seeks to protect the quality of nearby waters into which the STM Campus and the Flatirons Campus drain. These receiving waters include Lena Gulch at the STM Campus, and Coal Creek and Rock Creek at the Flatirons Campus. Sediment, debris, and chemicals transported to these water bodies via stormwater runoff 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 an 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 completed by the end of the first 5-year permit term, which ends in 2023. The programs will be implemented in subsequent permit terms. Significant efforts were made in 2022 to address permit requirements.

2022 Accomplishments and Highlights

- Continued to develop MS4 permit programs intended to reduce the discharge of pollutants in stormwater runoff from the STM Campus.
- Prepared a Dry Weather Sampling Procedure and conducted the first round of sampling. These activities are associated with the illicit discharge detection and elimination minimum control measures of the MS4 permit.

The Central Arroyo Detention Basin near the parking garage on the STM Campus was created to direct stormwater away from campus. The detention basin also provides habitat for various species. *Photo by Werner Slocum, NREL 64473*

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 to convert 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 6–10 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. Boiler blowdown water from several buildings constitutes a third category of nondomestic wastewater discharge from the STM Campus. Pleasant View's 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 at the STM Campus mesa-top Solar Radiation Research Laboratory and two on the Flatirons Campus. A preventive maintenance and inspection program is in place to confirm proper system function.

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 64465*

2022 Accomplishments and Highlights

- Continued developing a wastewater treatment feasibility study for the Flatirons Campus. The study includes 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.

A hazardous waste collection area in use at the Composites Manufacturing Education and Technology facility at the Flatirons Campus. *Photo by Werner Slocum, NREL 56885*

7 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

Responsible acquisition, use, and disposal of materials and waste are critical to meeting regulatory compliance, preventing pollution, and caring for the environment. NREL seeks to purchase materials that contain recycled content and have low toxicity to reduce the environmental impact of the laboratory's 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 4 summarizes EPCRA reporting requirements that were met in 2022. The reporting requirements for each EPCRA section are defined in Section 4, Compliance Summary.

Table 4. EPCRA Reporting by EPCRA Section in 2022

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.

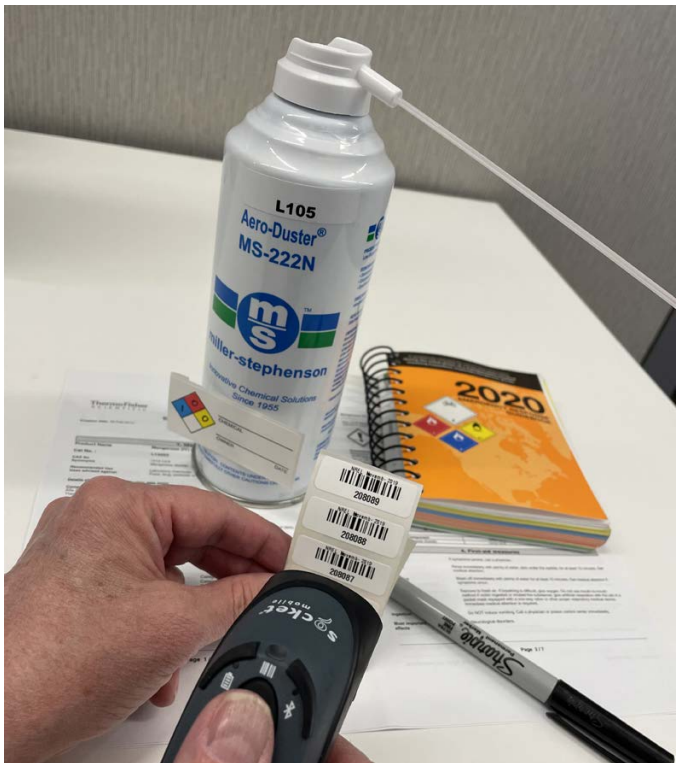
Hazardous Materials Incidents

In 2022, the following hazardous material incidents occurred:

- Four instances of inadvertent mixing of incompatible acids and bases during routine bench-scale research activities occurred. These were characterized as minor events involving quantities of 0.24 ounces (7 milliliters), 0.65 ounces (16 milliliters), 3.38 (100 milliliters) and 67.63 ounces (2,000 milliliters) of hazardous material. Although the number of instances was low, the laboratory identified opportunities to improve performance through training, communication, and more prominent container markings to reduce the number of similar instances. There were no injuries or environmental impacts from these events.
- During laboratory glovebox maintenance, a copper catalyst-containing media was to be replaced by first removing the copper media and placing it into a plastic receiving container. Upon removal and exposure to air, the copper media converted to copper oxide and liberated heat. The heat melted the plastic container but did not ignite. There were no injuries or environmental impacts due to this event. To inform others how this type of event could occur during glovebox catalyst replacements and to prevent recurrence, procedures were revised, a lessons learned document was developed and distributed throughout the laboratory, and plastic receiving containers were replaced with non-combustible metal containers.

2022 Accomplishments and Highlights

- Transitioned to a new chemical inventory software that integrates safety data sheet management, chemical inventory, and a chemical approval process. Implementation of this software has reduced paper documentation time and allowed for better management of incoming chemicals.
- Commenced design and environmental review for a new waste handling facility at the STM Campus. The new facility would be larger to accommodate staff and laboratory growth on campus.



NREL's new chemical inventory software allows for more efficient chemical management. Some features include improved inventory tracking and reporting, and planning for emergency preparedness. *Photo by John Eickhoff, NREL 77611*

7.2 Hazardous Waste Management

Research and development activities and site-wide facility operations generate 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 including laboratory debris contaminated with

chemicals (not including 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 5 summarizes the waste generated at NREL from 2018 to 2022. Universal waste electronics and other universal waste generated for 2022 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.

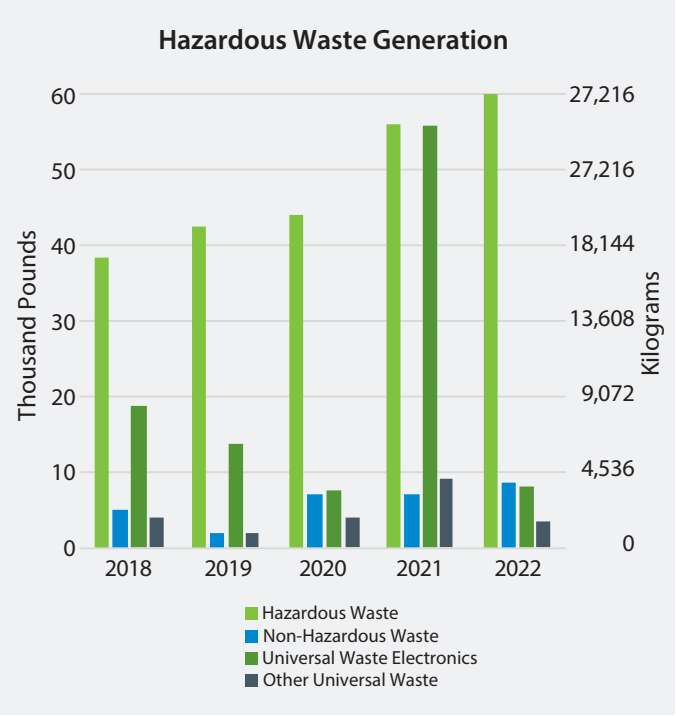


Figure 5. Comparison of four waste categories generated at NREL facilities by net weight, 2018–2022

2022 Accomplishments and Highlights

- Facilitated multiple laboratory cleanouts containing excess chemicals and hazardous waste.
- 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.
- Retrained 604 employees on waste management and minimization. This training is an annual refresher for all staff who have the potential to manage hazardous waste.

An acid scrubber system in the Science and Technology Facility on the STM Campus helps remove contaminants from exhaust streams. *Photo by Werner Slocum, NREL 55971*

7.3 Aboveground Storage Tank Management

Appropriate tank management prevents or minimizes spills and leaks of petroleum that can contaminate soil, surface water, groundwater, and drinking water. Monthly, annual, and interstitial inspections, including inspections for proper ullage of fuel, supports the laboratory's commitments to environmental stewardship and pollution prevention.

NREL operates only aboveground storage tanks (ASTs)—and no underground storage tanks—which decreases the risk of underground soil and water contamination. Unlike underground tanks, ASTs provide access for regular inspections, reducing repair and cleanup costs.

A 540-gallon (2,006-L) diesel AST containing diesel was installed at the newly constructed Research and Innovation Laboratory on the STM Campus to support laboratory growth. *Photo by Werner Slocum, NREL 80091*

NREL operates several petroleum-based ASTs, including:

- Twenty on the STM Campus with a total capacity of 14,460 gallons (54,737 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).

2022 Accomplishments and Highlights

- Installed a 540-gallon (2,044-L) diesel AST at the newly constructed Research and Innovation Laboratory to support power to the building during intended or unintended outages.
- Initiated planning activities for the replacement of one of NREL's oldest ASTs at the Field Test Laboratory Building. The AST replacement is expected to occur in 2023.
- Completed annual AST training for 80 employees.

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.

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. Table 5 summarizes the petroleum spills that occurred in 2022. A total of 19 spills were recorded for a total of 16.4 gallons (62 L). No spills were reportable to either the 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 5. Petroleum Spills in 2022

Location: Description	Quantity[a] (gal, [L])
STM Campus: Snow removal equipment hydraulic spill	1.0 (3.8)
STM Campus: Forklift diesel fuel spill	0.5 (1.9)
Flatirons Campus: Forklift hydraulic spill	1.5 (5.7)
Flatirons Campus: Turbine nacelle hydraulic oil spill	2.0 (7.6)
STM Campus: Combined quantity of vehicle oil spills in parking spaces at the STM parking garage	0.3 (1.1)
Oil spots near Research and Innovation Laboratory building. Spill cause and source unknown	0.2 (0.8)
STM Campus: Spill of hydraulic oil. Spill cause and source unknown	3.0 (11.4)
Flatirons Campus: Forklift hydraulic spill	0.5 (1.9)
Flatirons Campus: Power transformer dielectric oil spill	2.0 (7.6)
Flatirons Campus: Small engine diesel spill from fitting failure	0.5 (1.9)
STM Campus: Vehicle engine oil spill	0.3 (1.1)
STM Campus: Power generator gasoline spill during refilling; some gas ran off concrete and onto soil.	0.3 (1.1)
STM Campus: Forklift hydraulic leak from hose failure	0.5 (1.9)
STM Campus: Forklift diesel spill from maintenance	0.5 (1.9)
Flatirons Campus: Transformer pinhole oil leak	1.0 (3.8)
STM Campus: Hydraulic leak	0.5 (1.9)
STM Campus: Thermal phase change research liquid spill	1.0 (3.8)
STM Campus: Vehicle lube oil spill	0.5 (1.9)
STM Campus: Pump truck hydraulic oil spill	0.5 (1.9)

a Spill quantities are estimated.

A wide variety of oil sorbent materials are placed in oil spill kits and are distributed throughout the laboratory's facilities to aid in spill response. *Photo by Werner Slocum, NREL 56076*

2022 Accomplishments and Highlights

- Revised SPCC plans for the STM Campus and Flatirons Campus, which included updating oil-containing equipment information, spill history, and cleanup resources.
- Added two additional spill kits to the Flatirons Campus to accommodate new oil-filled transformers.

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 non-radiological 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 6 lists the total activity onsite and the estimated effective dose equivalent to a member of the public for the past 5 years.

Table 6. Total Activity and Effective Dose Equivalent, 2018-2022[a]

Activity	2018	2019	2020	2021	2022
Total activity (mCi)[b]	3.88	3.88	3.89	3.87	3.87
Effective dose equivalent (mrem/yr)	0.037	0.037	0.039	0.043	0.040

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 NREL 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 2022.

What is "Effective Dose Equivalent"?

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

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

An average person in the United States receives about 620 mrem each year, half of this dose (310 mrem) from natural sources and another half (310 mrem) from man-made sources of radiation, including medical procedures, consumer products, and industrial sources. [6]

6 Learn more about radiation doses at the U.S. Nuclear Regulatory Commission's website "Protecting People and the Environment", https://www.nrc.gov/about-nrc/radiation/around-us/doses-daily-lives.html.

An extensive NEPA review was conducted before installing the 1-megawatt battery energy storage system at the Flatirons Campus. The system is used to validate large-scale storage solutions for high-renewable power systems. The battery is integrated with other grid assets to simulate real system dynamics and demonstrate advanced solutions for the power grid. *Photo by Werner Slocum, NREL 65136*

8 NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE

The National Environmental Policy Act (NEPA) of 1969 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, staff, 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 work with Golden Field Office federal staff to 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.

2022 Accomplishments and Highlights

- Hosted consistent and frequent NEPA strategy meetings and collaboration reviews to plan for environmental aspects of upcoming projects.
- Completed an environmental assessment for the Flatirons Campus water system project. A "Finding of No Significant Impact" was completed and signed by the DOE Golden Field Office.[7]
- Created an online environmental questionnaire for staff to submit NEPA-related information more easily and quickly for DOE review. The questionnaire is currently being used and updated based on user experiences, and NREL will continue to develop it to meet user needs.

7 Department of Energy. 2022. *Environmental Assessment for the Flatirons Campus Water System Project, Jefferson County, Colorado.* https://www.energy.gov/sites/default/files/2022-06/fonsi-2171-fc-water-system-2022-06_061422.pdf

NREL staff help spread straw to mulch and protect the agrivoltaic garden beds at an offsite research project. The work was done as part of a project that seeks to demonstrate how solar array land can be dual purposed to grow food. This project and other offsite NREL-supported projects all require NEPA reviews to better understand environmental impacts. *Photo by Joe DelNero, NREL 73250*

A tree swallow (*Tachycineta bicolor*) launches from a tree on the STM Campus. *Photo by Werner Slocum, NREL 56066*

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*), cottontail rabbits (*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 protective force officer who assists with wildlife calls observed this Say's phoebe (*Sayornis saya*) nest on the STM Campus. Ground-nesting birds like the Say's phoebe are common around both campuses and before any new development, ground-nesting surveys are conducted to protect these birds and their nests. *Photo by Steve Gurich, NREL 76040*

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.[8]

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.[9] A 2016 survey included mammals, reptiles, and amphibians; results of that survey duplicated the 2011 survey that showed that various mammals, including elk (*Cervus canadensis*), mule deer (*Odocoileus hemionus*), coyotes (*Canis latrans*), cottontail rabbits (*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 they are seldom seen, western (prairie) rattlesnakes (*Crotalus viridus*), 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 viridus*) 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 can be compromised by their presence, including for example, doorways and equipment boxes. Staff are 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. Since April 2018, this firm has been training NREL staff on snake ecology and taxonomy to minimize injuries to snakes and to increase safety awareness of responders during relocation activities. Additionally, the firm has been tagging relocated snakes with passive integrated transponder (PIT) tags to monitor snake movements and better understand their behavior. The capture location, date, and sex of the snake are recorded along with the PIT tag number. Since 2018, 27 rattlesnakes have been given a PIT tag and relocated to safer locations on the STM Campus.

Wildlife Incidents at the STM Campus and the Flatirons Campus

Two mule deer (*Odocoileus hemionus*) died from Chronic Wasting Disease on the STM Campus. Chronic Wasting

8 Two Dot Consulting, LLC. 2017. *2017 Vegetation and Wildlife Surveys at the National Renewable Energy Laboratory, South Table Mountain*. Jefferson County, Colorado

9 Tetra Tech EC, Inc. 2011. *Avian Monitoring and Mortality Report: National Wind Technology Center*. Jefferson County, Colorado.

Disease is prevalent in Colorado and frequently affects deer populations throughout the region.

A cottontail rabbit (*Sylvilagus* spp.) nest with young was found in an area that was going to be paved on the STM Campus. An NREL wildlife biologist removed the nest and took the young to a wildlife rehabilitation center in Castle Rock, Colorado.

A house finch (*Carpodacus mexicanus*) was trapped in a conference room at the Research Support Facility at the STM Campus. An NREL wildlife biologist captured the bird and released it outdoors.

A local environmental firm that specializes in the research and conservation of western (prairie) rattlesnakes (*Crotalus viridus*) speaks to NREL staff on rattlesnake safety by demonstrating with a non-venomous bull snake (*Pituophis catenifer*). The bull snake in this photo demonstrates its constricting power by picking up and holding the educator's badge. *Photo by Eryn Lussier, NREL 76041*

Additional western (prairie) rattlesnake (*Crotalus viridus*) caution signage was placed on the STM Campus in 2022 to protect both staff and rattlesnakes. *Photo by Werner Slocum, NREL 68144*

2022 Accomplishments and Highlights

- Developed and delivered nesting bird survey training to 28 staff members at Flatirons Campus and STM Campus. The training combines self-paced video instruction and field survey practice.
- Captured and tagged three rattlesnakes with PIT tags at South Table Mountain and inside the STM Campus boundary, bringing NREL's total number of PIT-tagged rattlesnakes over 4 years to 27.
- Provided training sessions to interested staff about snake handling, ecology, and taxonomy to minimize injuries to snakes and enhance safety awareness of responders during snake relocation activities.
- Installed a nest box for Northern flickers (*Colaptes auratus*) east of the STM Campus Education Center. This nest box is intended to reduce flicker damage to the building exterior.

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 the ESA ensures the laboratory's actions do not adversely affect threatened, endangered, or candidate species[10] 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. 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 Need could also exist in Jefferson County or Boulder County.

In 2017, a survey of the STM Campus did not detect any threatened species, endangered species, or species of concern. The 2016, the Flatirons Campus survey revealed three State of Colorado Species of Greatest Conservation Need 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 cannot simply be flying over the campuses but has 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*]). As part of the STM Campus' and Flatirons Campus' NEPA environmental assessments conducted in 2014, DOE consulted with the USFWS for future activities that have the potential to deplete water in the Platte River system.

A big brown bat (*Eptesicus fuscus*) rests on a tree at the STM Campus. Several species of bats are being considered for federal protection.
Photo by Ryan McKnight, NREL76039

2022 Accomplishments and Highlights

- Continued to monitor milkweed plantings around the STM Campus detention basin. Biologists monitoring milkweed progress observed many new milkweed plants of both species, swampy milkweed (*Asclepias incarnata*) and showy milkweed (*Asclepias speciosa)*. These plants will encourage use by pollinators, specifically monarch butterflies (*Danaus plexippus*) which have a symbiotic relationship with the milkweed.
- Planted pollinator seeds in agrivoltaic study plots as part of a STM Campus solar array vegetation study that assessed the ability of a variety of plants to thrive within a solar array.

10 A candidate species has no official protection under the ESA, but agencies are encouraged to take advantage of any opportunities to conserve candidate species.

Swampy milkweed (*Asclepias incarnata*) maturing within the Central Arroyo Detention Basin at the STM Campus. Two species of milkweed, swampy and showy (*Asclepias speciosa*), were sowed in 2021 to encourage pollinator use. NREL biologists continue monitoring both species' growth and observed many new milkweed plants of both species in 2022. *Photo by Rachael Boothe, NREL 76092*

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 disease specific to their locale. Non-native plants 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*), dalmation toadflax (*Linaria genistifolia* subsp. *Dalmatica*,), and myrtle spurge (*Euphorbia myrsinites*) are examples of non-native plants that can have destructive effects on natural habitats.

Vegetation management at NREL encompass four main areas:

- **Native Landscaping:** Landscaped areas near NREL buildings and common areas are designed to incorporate features such as native plantings, xeriscape principles, and infiltration of stormwater to provide water and nutrients to landscape plants and recharge groundwater in the area. Adhering to designs with such features 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 7.
- **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 fire management activities can be done in conjunction with other vegetation management activities, such as weed control. Annual assessments of defensible space are conducted for the STM Campus and the Flatirons Campus.
- **Imported Plant and Organism Permits:** An additional component of NREL's vegetation management program relates to the periodic use of certain animal and plant materials in research at the laboratory. Certain organisms and plants that are obtained from other states or from outside the United States are controlled by the Animal and Plant Health Inspection Service (APHIS). These might include the use of certain pathogenic organisms used in biomaterials research or plants such as sugarcane bagasse and other scrap agricultural products that are tested for their value in biofuels and biomaterial production. NREL held one active APHIS permit in 2022 for the import of *Sphingobium* microorganisms to the STM Campus from within the United States and Japan. The *Agrobacterium tumefaciens* permit NREL held last year (which would have expired June 2022) was delisted by U.S. Department of Agriculture as of March 10, 2022.

Table 7. 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 (*Euphorbia mysinites*)	None identified
Class B[c]	Canada thistle (*Cirsium arvense*) Common teasel (*Dipsacus fullonum*) Dalmation toadflax – broad-leaved (*Linaria genistifolia* subsp. *Dalmatica*) Diffuse knapweed (*Centaurea diffusa*) Hoary cress (*Cardaria draba*) Houndstongue (*Cynoglossum officinale*) Jointed goatgrass (*Aegilops cylindrica*) Leafy spurge (*Euphorbia esula*) Musk thistle (*Carduus nutans*) Russian olive (*Elaeagnus angustifolia*) Scotch thistle (*Onopordum acanthium*)	Bull thistle (*Cirsium vulgare*) Canada thistle (*Cirsium arvense*) Common teasel (*Dipsacus fullonum*) Dalmation toadflax – broad-leaved (*Linaria genistifolia* subsp. *Dalmatica*) Diffuse knapweed (*Centaurea diffusa*) Hoary cress (*Cardaria draba*) Leafy spurge (*Euphorbia esula*) Moth mullein (*Verbascum blattaria*) Musk thistle (*Carduus nutans*) Sulfur cinquefoil (*Potentilla recta*)
Class C[d]	Downy brome (cheatgrass) (*Bromus tectorum*) Field bindweed (*Convolvulus arvensis*) Common mullein (*Verbascum thapsus*)	Downy brome (cheatgrass) (*Bromus tectorum*) Field bindweed (*Convolvulus arvensis*) Chicory (*Cichorium intybus*) Common mullein (*Verbascum thapsus*) Common St. John's wort (*Hypericum perforatum*)

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

b Identified by the State of Colorado for eradication

c Identified by the State of Colorado to stop the spread

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

2022 Accomplishments and Highlights

- Updated a noxious weed management plan and conducted coordination meetings as needed to facilitate effective herbicide application and revegetation efforts.
- Evaluated small areas of previously disturbed land on the Flatirons Campus for leafy spurge (*Euphorbia esula*). Two patches of leafy spurge were found and treated. These areas and surrounding areas within the utility corridor will be evaluated again in 2023.
- Reviewed specimens of sulphur cinquefoil (*Potentilla recta*) at the University of Colorado Herbarium. Cinquefoils are a diverse group of plants in Colorado and sulphur cinquefoil is the only cinquefoil species that is classified as a noxious weed. Proper management of this noxious weed includes proper plant identification.
- Used a combination of spot and broadcast spraying methods to treat 141 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*).
- Treated 14 acres (5.7 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.
- Removed select rabbitbrush (*Chrysothamnus* spp.) on the STM Campus to decrease the population and to address wildfire risk near buildings. Select bushes are left to keep these important pollinator plants in balance with other native plants.
- Utilized biologic control methods to address specific noxious weeds at the Flatirons Campus. 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.

A seasonal pond emerges in June at the northwest portion of the Flatirons Campus. The pond helps support amphibians, insects, and waterfowl following substantial spring rains. Most years the pond is dry except for a few weeks after snow runoff season. *Photo by Don Young, NREL 35300*

9.4 Wetlands and Floodplains

Wetlands are lands that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support 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 contain a 100-year flood event or greater; in general, stream channels at NREL sites are better characterized by the former description.

2022 Accomplishments and Highlights

- Conducted a wetland delineation within the Eastern Drainage of the STM Campus to determine if there were any jurisdictional features within the area that may impede future development, particularly for the Energy Materials and Processing at Scale building. No floodplains or jurisdictional areas were identified within the study area. An Approved Jurisdictional Determination was issued by the U.S. Army Corps of Engineers confirming the absence of these features. Construction of the Energy Materials and Processing at Scale building is expected to commence in 2024.

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 (Figure 6) 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 8.

Table 8. 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 9.

Table 9. Flatirons Campus Wetlands Summary

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

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. Several formal surveys of historical and cultural resources have been performed on the STM Campus. Although formal cultural resource surveys did not identify any significant archeological sites,[11] significant historical resources were identified and recommended for further research and documentation. Three

11 Nelson, S.M., 1980. *Historic and Prehistoric Resources, South Table Mountain, Golden, Colorado*. University of Denver Department of Anthropology. A Literature Search, Survey, and Evaluation conducted for the Heritage Conservation and Recreation Services, U.S. Department of the Interior under an Inter-Agency Service, Denver Office.

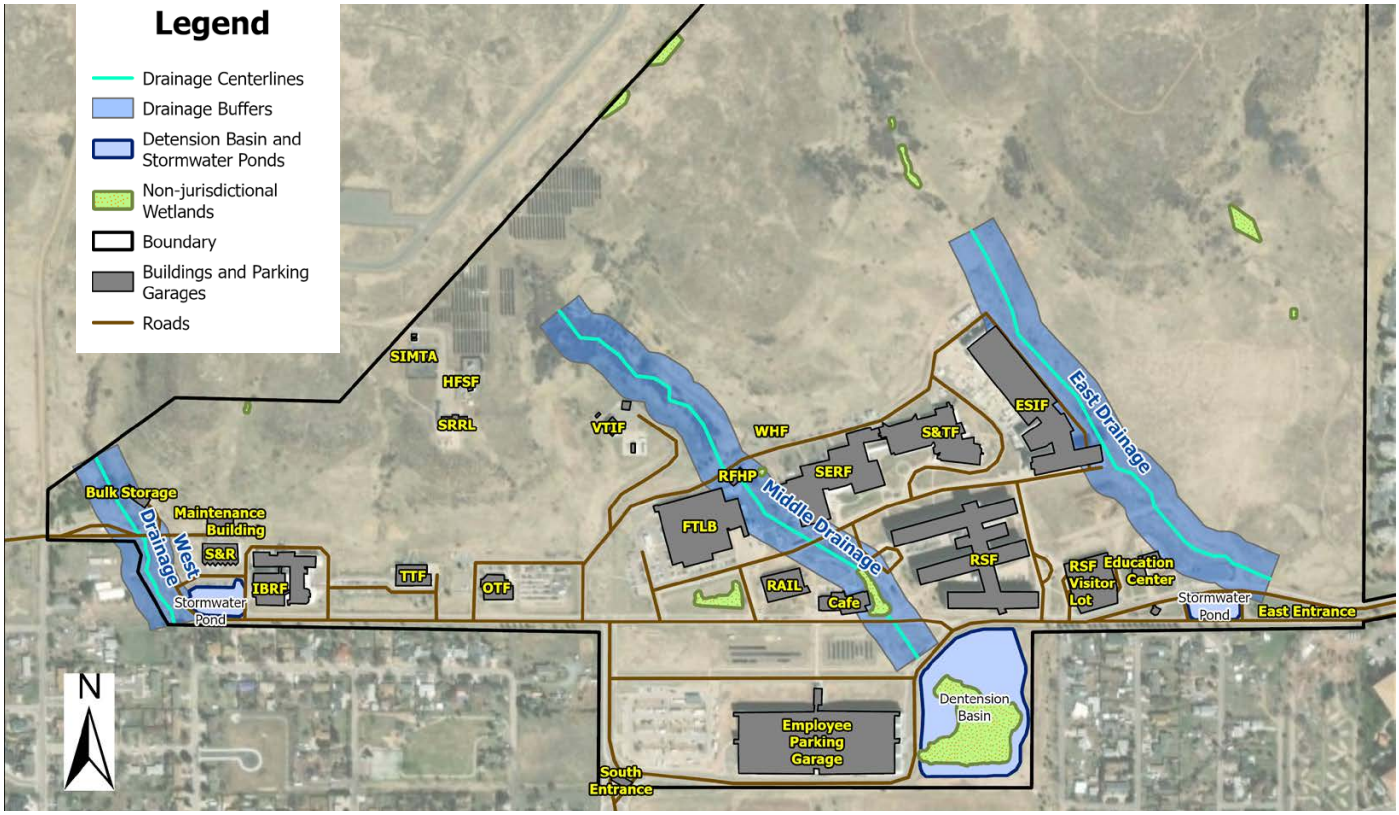


Figure 6. STM Campus main drainages.

historical resources have been identified as significant cultural resources[12] 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 1995[13] did not identify any additional significant historical or archeological 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 67264*

2022 Accomplishments and Highlights

- Initiated a historic resource survey of a 6.6-acre (2.7-hectare) portion of the Camp George West Historic District to prepare for DOE's ownership of the parcel in 2023. The parcel was the site of the former Colorado Correctional Facility which lies within the greater Camp George West Historic District. The survey, conducted by a local environmental consulting firm, updated, in part, a multiple property survey conducted in 1992 for the entire Camp George West Historic District. This survey will be an important input to cultural resource management within this new DOE land holding.

12 Butler, W.B., 1992. *Archeological Survey of Camp George West and the Works Progress Administration South Table Mountain Basalt Quarries, Jefferson County, Colorado*. Camp George West (Phase I) Department of Defense Legacy Resource Management Program, DOD Project 60.

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

Native grassland in the conservation easement on South Table Mountain. *Photo by Kurt Schlomberg, NREL 33062*

10 CONSERVATION EASEMENT

In 1999, DOE granted Jefferson County a conservation easement of 177 acres (72 hectares) at the STM Campus (Figure 7).

A baseline inventory of the property was prepared in 1999 to document the condition of the easement property and to assess its conservation value.[14] 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.

14 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.

2022 Accomplishments and Highlights

- Inspected the conservation easement in the summer and fall. Jointed goatgrass (*Aegilops cylindrica*), a noxious weed, was again found along one of the hiking trails and these areas were mowed, cut, and subsequently treated. Continued management may be required to eliminate goatgrass from this area.

Evening primrose (*Oenothera*) in bloom on the conservation easement at South Table Mountain. *Photo by Thomas Ryon, NREL 32777*

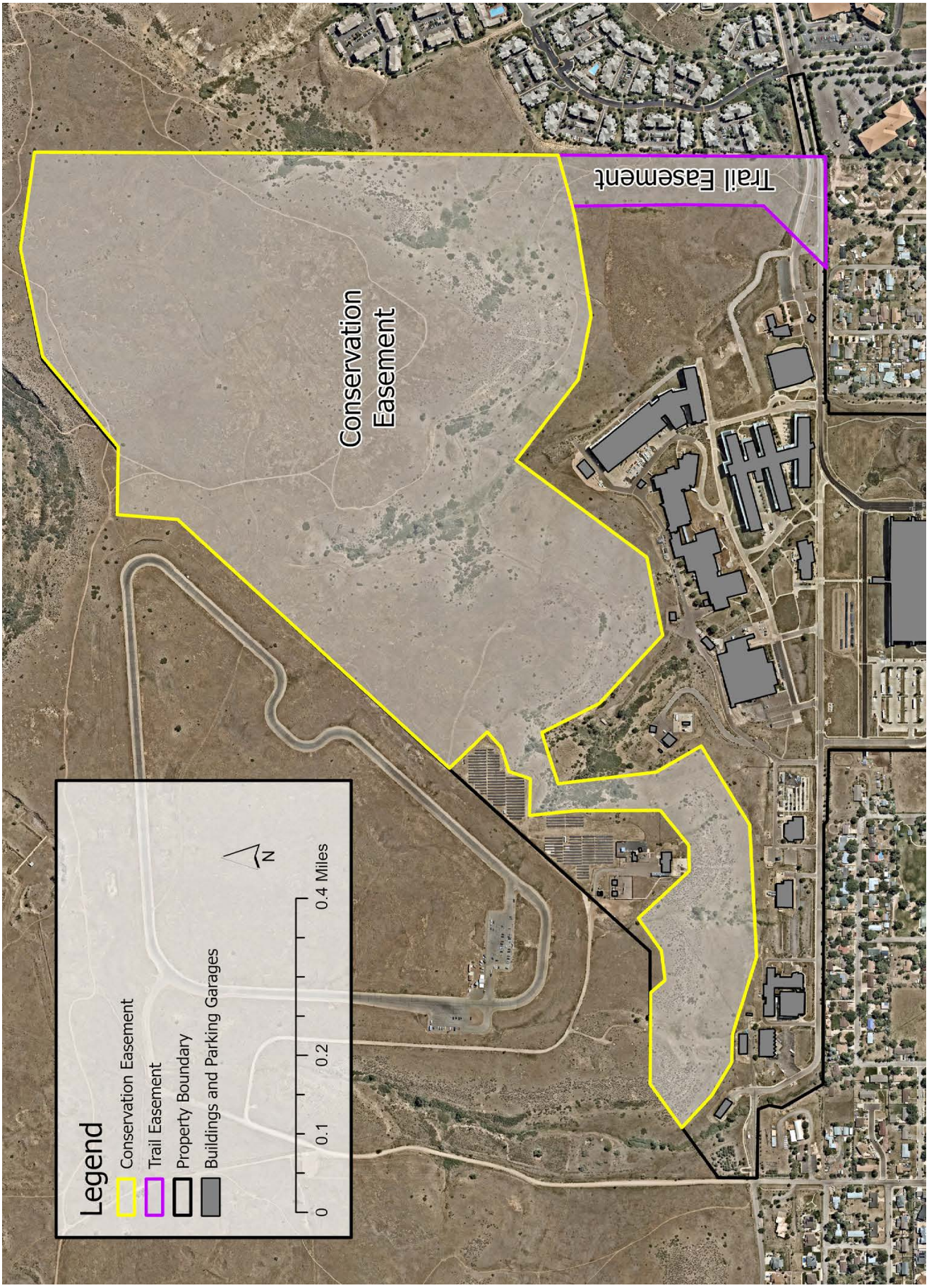


Figure 7. Conservation easement at the STM Campus

A group of staff members who support STM Campus construction projects stand outside the newly constructed Research and Innovation Laboratory on a snowy day in March. Environmental programs help NREL manage environmental resources throughout the entire construction process. *Photo by Joe DelNero, NREL 75434*

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 performing regular planning to achieve them
- Verifying worker competence with regard to environmental requirements through various training programs
- Communicating within the laboratory to unify staff 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 efforts at NREL address 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.

NREL addresses sustainability using an integrated and holistic approach. For example, NREL is committed to the design, operation, and maintenance of high-performance sustainable buildings and achieving net-zero emissions in these 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 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 can leverage a variety of expertise and experience to integrate sustainable operations throughout the laboratory to improve performance and resilience.

In addition, NREL's Intelligent Campus 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 efforts are designed to (1) anticipate, prepare for, and adapt to changing climate 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 (e.g., 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 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 used and confirming sand is not used on roadways.

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. The EPA requires that carbon dioxide equivalent greenhouse gas emissions (CO_2e) from any source that is greater than 27,500 U.S. tons (25,000 MT) per year be reported to the EPA annually. The EPA also requires that a major source of criteria pollutants include CO_2e emissions in the major source permit if CO_2e emissions exceed 75,000 U.S. tons (68,000 MT) per year. The STM Campus is a "minor" source for most criteria air pollutants and is classified as a "synthetic minor" source for NO_X emissions. Because CO_2e emissions for the STM Campus and the Flatirons Campus are lower than both of the above-mentioned limits, GHG/CO_2e reporting is not required.

Certain GHGs are essential to safe operation of certain equipment. As an example, sulfur hexafluoride, 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]) is completed annually; lead and copper testing is completed every 3 years.

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 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 the 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 at NREL 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 STM Campus 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 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
- Access to chemical safety data sheets
- 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, the 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 for a spill or release of a hazardous material are also in place; 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 landfilling.

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 visually 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 cleanup activities are used to improve management and spill response planning.

Spill response kits are strategically placed at every 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 its extremely low use of radioactive materials. In lieu of monitoring, NREL demonstrates compliance with radiological air emission standards by using the EPA's COMPLY model (Version 1.6) to determine the effective dose equivalent to the public. COMPLY uses radionuclide data that provide 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 (RCRA) 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 the 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 the 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 they 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 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 that pose the least-harmful effects to nontarget wildlife are selected.

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,[15] as well as species listed by the State of Colorado as rare plants, species of special concern, or Species of Greatest Conservation Need 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 might deplete water supplies to the Platte River system. For any NREL activities that might deplete water in the Platte River system, the USFWS must be consulted to determine potential impacts.

For information and current performance in this area, see Section 9.2, Endangered Species and Species of Concern.

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

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 broadleaf herb 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 (June 2010 – June 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. For the program, 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 5 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., pathogens) and plant species brought to the laboratory for research purposes, primarily for biofuels and biomaterials investigations. Some of the plants and pathogens obtained from other states or from outside the United States are controlled by the U.S. Department of Agriculture's 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 from site development to the maximum extent practicable.

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.

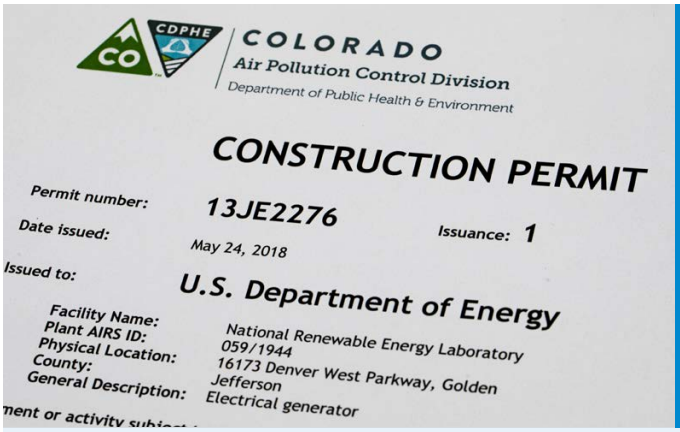
For information and current performance in this area, see Section 9.5, Cultural Resources.

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.



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

APPENDIX B.
ENVIRONMENTAL PERMITS, REGISTRATIONS, NOTIFICATIONS AND EPA COMPLIANCE DATA

Table B-1 is a list of NREL's environmental permits including each permit's issuing agency, identification, and status.

Table B-1. Environmental Permits, Registrations, and Notifications in 2022

Campus (Building): 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 diesel-fired electrical generator #3	Permit	APCD	13JE2829	Active
STM Campus (ESIF): research diesel-fired electrical generator #4	Permit	APCD	21JE0886	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 diesel-fired 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

Campus (Building): Description	Category	Issuing Agency	ID	Permit or Registration Status
Air *(continued)*				
STM Campus (SERF): two chlorofluorocarbon-containing stationary sources	Registration	APCD	647	Active
STM Campus (SERF): standby diesel-fired electrical generator	APEN	APCD	13JE2275 XP	Active
STM Campus (S&TF): standby diesel-fired electrical generator	APEN	APCD	13JE2274 XP	Active
STM Campus: 12 boilers and heaters at FTLB, SERF, and S&TF under one permit	Permit	APCD	20JE0747	Active
Flatirons Campus (Building 251): standby diesel-fired electrical generator	APEN	APCD	13JE2272 XP	Active
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 diesel-fired 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 and Plants				
Laboratory-wide: Scientific Collection Permit for salvage	Permit	Colorado Parks and Wildlife	2329073684	Active
STM Campus: controlled import permit to import *Agrobacterium tumefaciens* from within the United States	Permit	APHIS	P526P-19-02851	Delisted, as of March 10, 2022
STM Campus: controlled import permit to import *Sphingobium* 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	2022DFD-HZ-007284	Completed
STM Campus (ESIF): hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed

Campus (Building): Description	Category	Issuing Agency	ID	Permit or Registration Status
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
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
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
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				
Flatirons Campus: Second Controllable Grid Interface	Permit	EPA	COR10F07J	Active
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	Terminated

Acronyms and Abbreviations 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)

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

ReFUEL Renewable Fuels and Lubricants Laboratory

RFHP Renewable Fuel Heat Plant

RSF Research Support Facility

TTB Alcohol and Tobacco Tax and Trade Bureau (U.S. Department of the Treasury)

S&TF Science and Technology Facility

SERF Solar Energy Research Facility

STL Structural Testing Laboratory

WHF Waste Handling Facility

WQCD Water Quality Control Division (Colorado Department of Public Health and Environment)

The EPA's Enforcement & Compliance History Online (ECHO) database allows users to search for facilities and assess their compliance with environmental regulations. NREL-associated facilities listed within the ECHO database can be found by searching the keyword "NREL" by "Facility Name/ID".[16] According to the ECHO database, no violations or enforcement actions are associated with NREL facilities.

Table B-2 displays the ECHO search results for NREL facilities including each facility's address and registry service identification number.

Table B-2. ECHO Database "NREL"-Facility Search Results

Facility Name	Address (Street, City, State)	Facility Registry Service ID
National Renewable Energy Labs (NREL)/ South Table Mountain	W. 20th Ave. & Quaker St., Golden, CO	110020957026
National Renewable Energy Labs (NREL)/ South Table Mountain	20th & Quaker Streets, Golden, CO	110020882062
National Wind Technology Center	18200 State Highway 128, Golden, CO	110070058739
NREL NWTC Site Improvements, Power Gen. Upgrade, And Secondary Feeder Project	18200, Golden, CO	110070133199
NREL NWTC Site Improvements, Power Gen. Upgrade, And Secondary Feeder Project	18200 State Highway 128, Golden, CO	110070112544
NREL Renewable Fuels & L[a]b Research Lab / MRI	1980 31st St, Denver, CO	110016738949
NREL Research and Innovation Laboratory	15503 Denver West Parkway, Golden, CO	110071092264
NREL Substation	Hwy 93 And Hwy 72, Golden, CO	110070529159
U.S. Dept Of Energy - NREL	15003 Denver West Park Wy, Golden, CO	110022511628
U.S. Dept Of Energy - NREL Bio-Refinery	16173 Denver West Pkwy, Golden Area, CO	110054883060
U.S. DOE - NREL Solartac Facility	2950c N Hudson Rd, Aurora, CO	110064535007
US Dept of Energy - NREL - NWTC Site	18200 State Hwy 128, Broomfield, CO	110043176425
US DOE NREL Flatirons Campus-Treatment and Pumping Facility	15013 Denver West Pkwy, Golden, CO	110049738824
US DOE NREL Joyce St. Facility	6800 Joyce St, Golden, CO	110022511673

16 "Enforcement and Compliance History Online," U.S. Environmental Protection Agency, https://echo.epa.gov/

Coyotes (*Canis latrans*) frolicking around the Flatirons Campus as springtime wildlife begins to emerge. *Photo by Michael Goddard, NREL 75703*

APPENDIX C.

WILDLIFE SPECIES OBSERVED AT THE STM CAMPUS AND THE FLATIRONS CAMPUS

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 2005, 2011, and 2017.[17] Species listed for the Flatirons Campus (Table C-2) were identified in surveys completed in 2003, 2011, and 2016.[18]

Table C-1. Wildlife Species Observed at the STM Campus

STM Campus				
Common Name	**Scientific Name**	**2005 Survey**	**2011 Survey**	**2017 Survey**
Birds				
American coot	*Fulica americana*			X
American crow	*Corvus brachyrhynchos*	X	X	X
American goldfinch	*Carduelis tristis*		X	X
American kestrel	*Falco sparverius*	X	X	X
American pipit	*Anthus rubescens*		X	X
American redstart	*Setophaga ruticilla*		X	X
American robin	*Turdus migratorius*	X	X	X
American tree sparrow	*Spizella arborea*	X	X	
American white pelican	*Pelecanus erythrorhynchos*		X	
Bald eagle	*Haliaeetus leucocephalus*			
Barn swallow	*Hirundo rustica*		X	X

17 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.

18 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**
Birds				
Black-billed magpie	*Pica hudsonia*	X	X	X
Black-capped chickadee	*Poecile atricapilla*	X		X
Black-crowned night heron	*Nycticorax nycticorax*	X		
Black-headed grosbeak	*Pheucticus melanocephalus*		X	
Blue-gray gnatcatcher	*Polioptila caerulea*		X	
Blue jay	*Cyanocitta cristata*	X	X	
Blue-winged teal[a]	*Spatula discors*			
Brewer's blackbird	*Euphagus cyanocephalus*		X	
Brewer's sparrow	*Spizella breweri*		X	X
Broad-tailed hummingbird	*Selasphorus platycercus*		X	X
Broad-winged hawk	*Buteo platypterus*		X	
Brown-headed cowbird	*Molothrus ater*	X	X	X
Bullock's oriole	*Icterus bullockii*	X	X	X
Bushtit	*Psaltriparus minimus*		X	
California gull	*Larus californicus*	X		
Canada goose	*Branta canadensis*	X	X	
Cassin's kingbird	*Tyrannus vociferans*		X	X
Cedar waxwing	*Bombycilla cedrorum*		X	
Chestnut-collared longspur	*Calcarius ornatus*		X	
Chipping sparrow	*Spizella passerina*		X	X
Clay-colored sparrow	*Spiella pallida*			X
Cliff swallow	*Petrochelidon pyrrhonota*		X	X
Common grackle	*Quiscalus quiscula*		X	X
Common nighthawk	*Chordeiles minor*	X	X	X

STM Campus				
Common Name	**Scientific Name**	**2005 Survey**	**2011 Survey**	**2017 Survey**
Birds				
Common raven	*Corvus corax*	X	X	X
Common yellowthroat	*Geothlypis trichas*			X
Cooper's hawk	*Accipiter cooperii*	X	X	
Dark-eyed junco	*Junco hyemalis*	X	X	X
Double-crested cormorant	*Phalacrocorax auritus*		X	X
Eastern kingbird	*Tyrannus tyrannus*		X	
Eurasian collared-dove	*Streptopelia decaocto*			X
European starling	*Sturnus vulgaris*	X	X	X
Golden eagle	*Aquila chrysaetos*	X		
Grasshopper sparrow	*Ammodramus savannarum*		X	
Gray catbird	*Dumetella carolinensis*			X
Great blue heron	*Ardea herodias*	X	X	
Great horned owl	*Bubo virginianus*			X
Greater roadrunner[a]	*Geococcyx californianus*			
Green-tailed towhee	*Pipilo chlorurus*		X	
Hammond's flycatcher	*Empidonax hammondii*			X
Hepatic tanager	*Piranga flava*		X	
Hermit thrush	*Catharus guttatus*		X	
Horned lark	*Eremophila alpestris*		X	
House finch	*Carpodacus mexicanus*	X	X	X
House sparrow	*Passer domesticus*	X	X	X
House wren	*Troglodytes aedon*		X	X
Killdeer	*Charadrius vociferous*	X	X	
Lark bunting	*Calamospiza melanocorys*	X		

STM Campus				
Common Name	**Scientific Name**	**2005 Survey**	**2011 Survey**	**2017 Survey**
Birds				
Lark sparrow	*Chondestes grammacus*		X	X
Lazuli bunting	*Passerina amoena*		X	
Lesser goldfinch	*Carduelis psaltria*		X	X
Lincoln's sparrow	*Melospiza lincolnii*			X
Loggerhead shrike	*Lanius ludovicianus*	X		
MacGillivray's warbler	*Oporornis tolmiei*	X		
Mallard	*Anas platyrhynchos*	X		
Mountain bluebird	*Sialia currucoides*	X		X
Mountain chickadee	*Poecile gambeli*		X	
Mourning dove	*Zenaida macroura*	X		X
Northern flicker	*Colaptes auratus*	X		X
Northern goshawk	*Accipiter gentilis*		X	
Northern harrier	*Circus cyaneus*	X		X
Northern mockingbird	*Mimus polyglottos*			X
Northern pygmy-owl	*Glaucidium californicum*			X
Northern rough-winged swallow	*Stelgidopteryx serripennis*			X
Northern saw-whet owl[a]	*Aegolius acadicus*			
Orange-crowned warbler[a]	*Oreothlypis celata*			
Osprey	*Pandion haliaetus*	X		X
Peregrine falcon	*Falco peregrinus*		X	
Pine siskin	*Carduelis pinus*		X	
Prairie falcon	*Falco mexicanus*	X		X
Red-breasted nuthatch	*Sitta canadensis*	X		X

STM Campus				
Common Name	**Scientific Name**	**2005 Survey**	**2011 Survey**	**2017 Survey**
Birds				
Red-tailed hawk	*Buteo jamaicensis*	X		X
Red-winged blackbird	*Agelaius phoeniceus*			X
Rock dove	*Columba livia*	X		X
Rock wren	*Salpinctes obsoletus*	X		
Ruby-crowned kinglet	*Regulus calendula*		X	
Sage thrasher	*Oreoscoptes montanus*		X	X
Say's phoebe	*Sayornis saya*	X		X
Sharp-shinned hawk	*Accipiter striatus*		X	X
Spotted towhee	*Pipilo maculates*	X		X
Swainson's hawk	*Buteo swainsoni*	X		
Tree swallow	*Tachycineta bicolor*	X	X	X
Turkey vulture	*Cathartes aura*	X		X
Vesper sparrow	*Pooecetes gramineus*	X		X
Violet-green swallow	*Tachycineta thalassina*		X	X
Virginia's warbler	*Oreothlypis virginiae*		X	
Western kingbird	*Tyrannus verticalis*	X		X
Western meadowlark	*Sturnella neglecta*	X		X
White-crowned sparrow	*Zonotrichia leucophrys*	X		X
White-faced ibis	*Plegadis chihi*		X	
White-throated swift	*Aeronautes saxatalis*		X	
Woodhouse's (western) scrub-jay	*Aphelocoma californica*	X		X
Wilson's snipe	*Gallinago delicata*	X		
Yellow warbler	*Setophaga petechia*			X

STM Campus				
Common Name	**Scientific Name**	**2005 Survey**	**2011 Survey**	**2017 Survey**
Yellow-breasted chat	*Icteria virens*		X	X
Yellow-rumped warbler	*Dendroica coronata*		X	
Mammals				
Big brown bat[a]	*Eptesicus fuscus*			
Black bear[a]	*Ursus americanus*			
Black-tailed jackrabbit	*Lepus californicus*		X	
Bobcat[a]	*Lynx rufus*			
Bushy-tailed woodrat[a]	*Neotoma cinerea*			
Common muskrat[a]	*Ondatra zibethicus*			
Coyote	*Canis latrans*	X	X	
Deer mouse	*Peromyscus maniculatus*		X	
Elk[a]	*Cervus canadensis*			
Fox squirrel	*Sciurus niger*	X		
Hoary bat	*Lasiurus cinereus*			X
Long-tailed weasel	*Mustela frenata*	X		
Mexican woodrat	*Neotoma mexicana*	X	X	
Mountain cottontail rabbit	*Sylvilagus nuttalli*	X	X	X
Mule deer	*Odocoileus hemionus*	X	X	X
Prairie vole	*Microtus ochrogaster*	X		
Raccoon	*Procyon lotor*	X	X	
Red fox	*Vulpes vulpes*		X	
Striped skunk	*Mephitis mephitis*		X	
Western harvest mouse	*Reithrodontomys megalotis*	X	X	
Western spotted skunk	*Spilogale gracilis*		X	
White-tailed jackrabbit	*Lepus townsendii*	X		

STM Campus				
Common Name	**Scientific Name**	**2005 Survey**	**2011 Survey**	**2017 Survey**
Reptiles and Amphibians				
Boreal chorus frog	*Pseudacris maculata*		X	X
Bull snake	*Pituophis catenifer*		X	
Plains garter snake	*Thamnophis radix*	X		
Prairie lizard	*Sceloporus consobrinus*		X	
Six-lined racerunner	*Cnemidophorus sexlineatus*	X		
Tiger salamander	*Ambystoma tigrinum*	X	X	X
Wandering garter snake[a]	*Thamnophis elegans*			
Western (prairie) rattlesnake	*Crotalus viridus*	X	X	
Woodhouse's toad	*Anazyrus woodhousii*		X	
Yellow-bellied racer	*Coluber constrictor*		X	
Terrestrial Arthropods				
Aphrodite fritillary[a]	*Speyeria aphrodite*			
Monarch butterfly[a]	*Danaus plexippus*			
Tiger swallowtail[a]	*Papilio rutulus*			

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

Table C-2. Wildlife Species Observed at the Flatirons Campus

Flatirons Campus				
Common Name	**Scientific Name**	**2003 Survey**	**2011 Survey**	**2016 Survey**
Birds				
American crow	*Corvus brachyrhynchos*		X	
American goldfinch	*Spinus tristis*	X	X	
American kestrel	*Falco sparverius*	X	X	X
American pipit	*Anthus rubescens*		X	

Flatirons Campus				
Common Name	**Scientific Name**	**2003 Survey**	**2011 Survey**	**2016 Survey**
American robin	*Turdus migratorius*	X	X	X
American tree sparrow	*Spizella arborea*		X	
Bald eagle	*Haliaeetus leucocephalus*		X	
Barn swallow	*Hirundo rustica*	X	X	X
Black-billed magpie	*Pica hudsonia*	X	X	X
Black-capped chickadee	*Poecile atricapillus*	X	X	
Blue-gray gnatcatcher	*Polioptila caerulea*	X		X
Blue jay	*Cyanocitta cristata*		X	
Brewer's blackbird	*Euphagus cyanocephalus*	X	X	X
Brewer's sparrow	*Spizella breweri*		X	
Broad-tailed hummingbird	*Selasphorus platycercus*	X	X	X
Broad-winged Hawk[a]	*Buteo platypterus*			
Brown-headed cowbird	*Molothrus ater*	X	X	
Bullock's oriole	*Icterus bullockii*		X	X
Canada goose	*Branta canadensis*		X	X
Cedar waxwing	*Bombycilla cedrorum*		X	
Chipping sparrow	*Spizella passerina*	X	X	
Cliff swallow	*Petrochelidon pyrrhonota*	X		
Common grackle	*Quiscalus quiscula*	X	X	
Common nighthawk	*Chordeiles minor*	X		X
Common raven	*Corvus corax*	X	X	X
Cooper's hawk[a]	*Accipiter cooperii*			
Dark-eyed junco	*Junco hyemalis*		X	
Double-crested cormorant	*Phalacrocorax auritus*	X		X
Downy woodpecker	*Picoides pubescens*		X	
Eurasian collared-dove	*Streptopelia decaocto*		X	

Flatirons Campus				
Common Name	**Scientific Name**	**2003 Survey**	**2011 Survey**	**2016 Survey**
European starling	*Sturnus vulgaris*	X	X	X
Ferruginous hawk	*Buteo regalis*	X	X	
Franklin's gull	*Larus pipixcan*		X	
Golden eagle[b]	*Aquila chrysaetos*	X	X	
Grasshopper sparrow	*Ammodramus savannarum*	X	X	X
Gray catbird	*Dumetella carolinensis*		X	X
Great blue heron	*Ardea herodias*	X	X	X
Great horned owl	*Bubo virginianus*		X	X
Green-tailed towhee	*Pipilo chlorurus*	X		X
Hairy woodpecker	*Picoides villosus*		X	
Horned lark	*Eremophila alpestris*	X	X	
House finch	*Carpodacus mexicanus*	X	X	X
House wren	*Troglodytes aedon*			X
Killdeer	*Charadrius vociferus*		X	X
Lark bunting	*Calamospiza melanocorys*		X	
Lark sparrow	*Chondestes grammacus*	X		X
Loggerhead shrike	*Lanius ludovicianus*		X	
Long-billed curlew	*Numenius americanus*		X	
Mallard	*Anas platyrhynchos*	X	X	
Mountain bluebird	*Sialia currucoides*	X	X	
Mountain chickadee	*Poecile gambeli*		X	
Mourning dove	*Zenaida macroura*	X	X	X
Northern flicker	*Colaptes auratus*	X	X	
Northern harrier	*Circus cyaneus*	X	X	
Peregrine falcon	*Falco peregrinus*	X	X	
Prairie falcon	*Falco mexicanus*	X		

Flatirons Campus				
Common Name	**Scientific Name**	**2003 Survey**	**2011 Survey**	**2016 Survey**
Red-headed woodpecker	*Melanerpes erythrocephalus*		X	
Red-tailed hawk	*Buteo jamaicensis*	X	X	X
Red-winged blackbird	*Agelaius phoeniceus*	X	X	X
Rough-legged hawk	*Buteo lagopus*	X	X	
Ruby-crowned kinglet	*Regulus calendula*		X	
Sandhill crane	*Grus canadensis*		X	
Savannah sparrow	*Passerculus sandwichensis*		X	
Say's phoebe	*Sayornis saya*	X	X	X
Song sparrow	*Melospiza melodia*		X	X
Spotted towhee	*Pipilo maculatus*		X	X
Swainson's hawk	*Buteo swainsoni*		X	
Townsend's solitare	*Myadestes townsendi*		X	
Tree swallow	*Tachycineta bicolor*		X	
Turkey vulture	*Cathartes aura*	X	X	
Vesper sparrow	*Pooecetes gramineus*	X	X	X
Western kingbird	*Tyrannus verticalis*	X	X	X
Western meadowlark	*Sturnella neglecta*	X	X	X
Western wood-pewee	*Contopus sordidulus*			X
Wilson's snipe	*Gallinago delicata*		X	X
Wilson's warbler	*Wilsonia pusilla*	X		
Yellow-rumped warbler	*Dendroica coronata*	X		

Flatirons Campus				
Common Name	**Scientific Name**	**2003 Survey**	**2011 Survey**	**2016 Survey**
Mammals				
Big brown bat	*Eptesicus fuscus*		X	X
Black-tailed prairie dog[a]	*Cynomys ludovicianus*	X		
Bobcat	*Felis rufus*			X
Coyote	*Canis latrans*		X	X
Deer mouse	*Peromyscus maniculatus*		X	X
Desert cottontail rabbit	*Sylvilagus audubonii*		X	X
Eastern red bat	*Lasiurus borealis*		X	X
Elk	*Cervus canadensis*		X	X
Fringed myotis[b]	*Myotis thysanodes*		X	X
Hoary bat	*Lasiurus cinereus*		X	X
Little brown myotis[b]	*Myotis lucifuaus*		X	X
Masked shrew	*Sorex cinereus*		X	X
Meadow vole	*Microtus pennsylvanicus*		X	X
Mexican woodrat	*Neotoma mexicana*		X	X
Mountain lion	*Puma concolor*			X
Mule deer	*Odocoileus hemionus*		X	X
Myotis bat	*Myotis* sp.		X	X
Prairie vole	*Microtus ochrogaster*		X	X
Silver-haired bat	*Lasionycteris noctivagans*		X	X
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*		X	
Western harvest mouse	*Reithrodontomys megalotis*		X	X
Western small-footed myotis	*Myotis ciliolabrum*		X	X
White-tailed deer	*Odocoileus virginiana*			X
Yellow-bellied marmot[a]	*Marmota flaviventris*			

Flatirons Campus				
Common Name	**Scientific Name**	**2003 Survey**	**2011 Survey**	**2016 Survey**
Reptiles and Amphibians				
Boreal chorus frog	*Pseudacris maculata*		X	X
Bull snake	*Pituophis catenifer*		X	X
Northern leopard frog[b]	*Lithobates pipiens*			X
Painted turtle[a]	*Chrysemys picta*			
Tiger salamander	*Ambystoma tigrinum*			X
Western (Prairie) rattlesnake	*Crotalus viridus*	X	X	X
Woodhouse's toad	*Anazyrus woodhousii*		X	X
Terrestrial Arthropods[c]				
Aphrodite fritillary	*Speyeria aphrodite*		X	
Cabbage white	*Pieris rapae*		X	
Checkered white	*Pontia protodice*		X	
Common wood nymph	*Cercyonis pegala*		X	
Dainty sulphur	*Nathalis iole*		X	
Gray hairstreak	*Strymon melinus*		X	
Orange sulphur	*Colias eurytheme*		X	
Western white	*Pontia occidentalis*		X	

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

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

c Terrestrial arthropods were surveyed in 2011 at the STM Campus and Flatirons Campus, but only observed during the survey at the Flatirons Campus.

Bee balm (*Monarda fistulosa*), which blooms in the summertime around the Flatirons Campus, is known to attract a variety of pollinators with its bright bloom colors and fragrant foliage. *Photo by Brenda Beatty, NREL 24476*

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 appendix.

STM Campus Plant Communities

Most vegetation at the STM Campus belongs to the grassland community type. Within that association 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 (*Chondrosum gracile*), a native prairie species, and downy brome (cheatgrass) (*Bromus tectorum*), a List-C Noxious Weed in Colorado. 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* spp.), 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 do hen and chicks (*Echinocereus viridiflorus*) and pincushion cacti (*Coryphantha missouriensis* and *C. vivipara* var. *vivpara*). 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 shortgrass 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 (cheatgrass) (*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 (cheatgrass) (*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 ft [>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 Shrubland

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 the habitat is 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 (cheatgrass) (*Bromus tectorum*) is the most common herbaceous species in these areas, and it is intermixed with needle-and-thread grass (*Hesperostipa comata*), yucca (*Yucca glauca*), and many cacti (*Cactaceae* spp.).

Short Shrubland

The short shrublands occur on elevated flat areas amid 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 Shrubland

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 acres (0.2 hectares) 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 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. This area, which is perhaps situated where equipment was once staged, 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 (*Carex* spp.), rushes (*Juncus* spp.), 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.

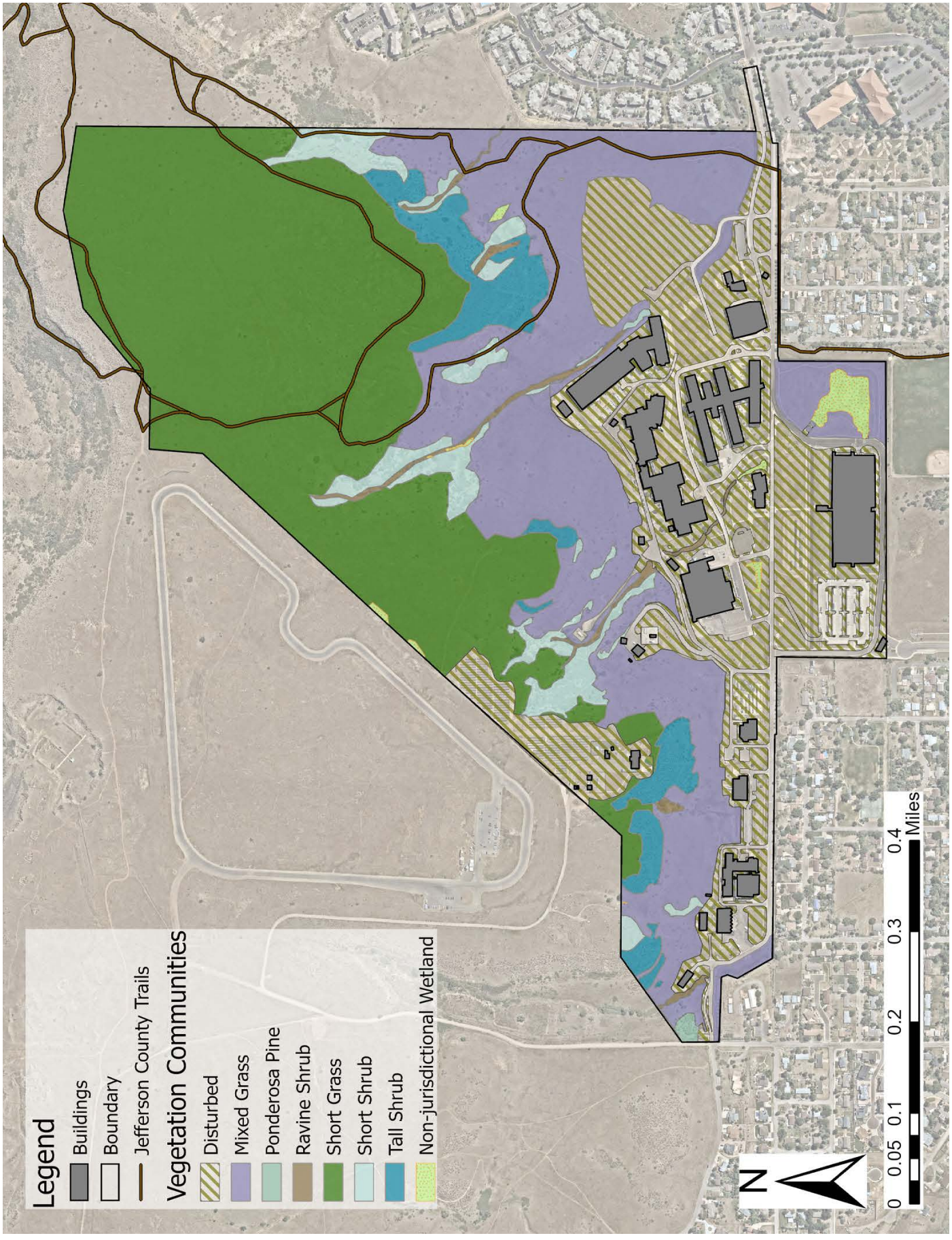


Figure D-1. Land cover types at the STM Campus

Flatirons Campus Plant Communities

Most 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*), alongside species more typical of the shortgrass prairie such as blue grama (*Chondrosum gracile*) and buffalo grass (*Buchloë dactyloides*). Intermediate grasses (mid-grasses), such as the needle grasses (*Hesperostipa* and *Nassella* spp.), wheat grasses (*Pascopyron, Agropyron, Elytrigia, Elymus,* and *Thinopyrum* spp.), and blue grasses (*Poa* spp.), are also important constituents of mixed-grass prairie.

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

Several changes in vegetation patterns 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 (*Psoralidium* 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 alyssum (*Alyssum* spp.), Canada horseweed (*Conyza canadensis*), fringed sage (*Artemisia frigida*), prairie sage (*Artemisia ludoviciana*), scurfpea (*Psoralidium* 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 (cheatgrass) (*Bromus tectorum*) and intermediate wheatgrass. 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 (cheatgrass), 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 might 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 scurfpea (*Psoralidium* spp.), prairie sage (*Artemisia ludoviciana*), golden banner (*Thermopsis rhombifolia*), hairy golden aster (*Heterotheca villosa*), and sulphur flower (*Eriogonum umbellatum*). An isolated group of hawthorn shrubs (*Crataegus erthyropoda*) 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.[19] 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 species (*Epilobium* spp.). 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 in the southwestern portion of the campus. 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 northeastern portion 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, or Riparian Emergent, Wetlands

Headwater, or riparian emergent, wetland communities occur within the two prominent drainages in the eastern half of the Flatirons Campus (Figure D-2), both of which show evidence of an ephemeral channel; both drainages are tributaries to Rock Creek. Dominant species within these wetlands include Arctic rush (*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.

19 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.*

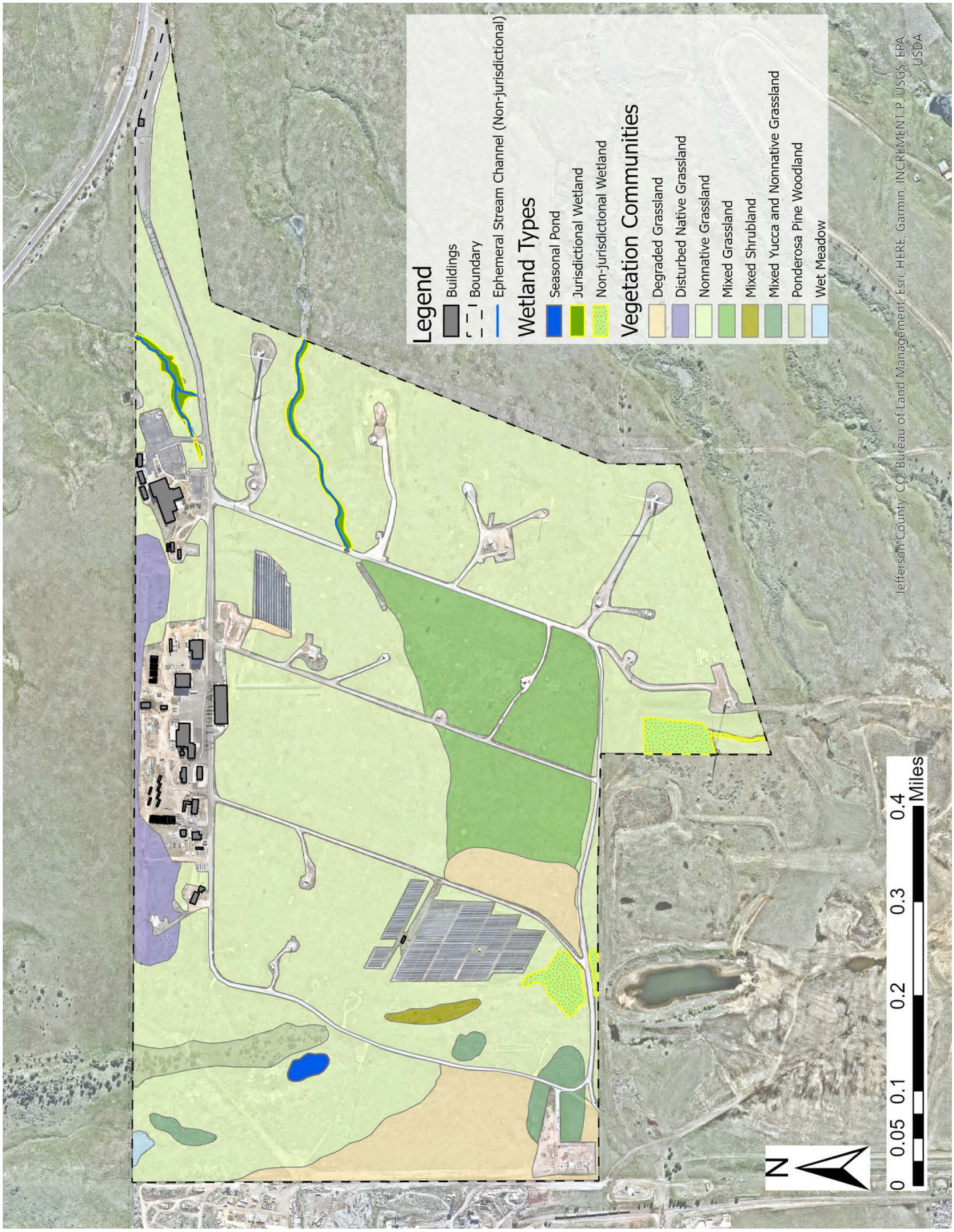


Figure D-2. Wetland types and vegetation communities at the Flatirons Campus

Disturbed Areas and Non-Habitat

These cover types reflect surface disturbance that is due to human activities, 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.)

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