NREL
Transforming ENERGY

ENVIRONMENTAL PERFORMANCE REPORT 2023

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

Vern Slocum looks through eclipse glasses at the Solar Radiation Research Laboratory. *Photo by Dennis Schroeder, NREL 46826*

Werner (Vern) Slocum was a passionate photographer and beloved NREL employee. He took many beautiful photographs featured in this report and in so many of the Annual Site Environmental Reports of years past. Vern passed away in December 2023, but his love for wildlife photography, kind-hearted nature, and friendship with so many of us working at the lab will never be forgotten. This year's report and cover photo are dedicated to him and his memory.

Cover Photo: A young cottontail rabbit (*Sylvilagus* spp.) sits in the grass on the South Table Mountain Campus. *Photo by Werner Slocum, NREL 88233*

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TABLE OF CONTENTS

Acknowledgements 1

Nomenclature 4

Executive Summary 5
- Purpose 5
- Environmental and Sustainability Performance 5
- Environmental Compliance and Monitoring 7

1 Introduction 9
- 1.1 Mission 9
- 1.2 Sites and Facilities 11

2 Environmental Management System 17
- 2.1 Structure of NREL's EMS 18
- 2.2 Pollution Prevention 19
- 2.3 Performance Indicators and Progress 19
- 2.4 Assessment and Improvement 20
- 2.5 Awards and Recognition 21
- 2.6 Integrated Environmental Stewardship in Construction Management 21

3 Sustainability 24
- 3.1 Sustainability Goals 24
- 3.2 Resilience Planning 27
- 3.3 Environmental Justice 27

4 Compliance Summary 28

5 Air Quality Protection 40
- 5.1 Criteria Pollutants and Hazardous Air Pollutants 40
- 5.2 Refrigerants 41

6 Water Quality Protection 43
- 6.1 Drinking Water 43
- 6.2 Groundwater 44
- 6.3 Surface Water 45
- 6.4 Wastewater 46

7 Hazardous Materials and Waste Management 47
- 7.1 Hazardous Materials Management 47
- 7.2 Hazardous Waste Management 48
- 7.3 Aboveground Storage Tank Management 49
- 7.4 Petroleum Spill Prevention and Response 50
- 7.5 Radiological Materials and Waste Management 50

8 National Environmental Policy Act Compliance 52
- Environmental Justice Within NEPA 52

9 Natural and Cultural Resources Protection 54
- 9.1 Wildlife Management 54
- 9.2 Endangered Species and Species of Concern 57
- 9.3 Vegetation Management 58
- 9.4 Wetlands and Floodplains 61
- 9.5 Cultural Resources 61

10 Conservation Easement 63

Appendix A. Program Management 65

Appendix B. Environmental Permits, Registrations, Notifications, and EPA Compliance Data 74

Appendix C. Wildlife Species Observed at the STM Campus and the Flatirons Campus 77

Appendix D. Plant Communities at the STM Campus and the Flatirons Campus 86

List of Figures

Figure 1. NREL's continual improvement cycle 18

Figure 2. NREL's environmental aspects 18

Figure 3. Results of average monthly residual chlorine monitoring in drinking water at the Flatirons Campus 44

Figure 4. Results of disinfection byproduct concentrations in drinking water at the Flatirons Campus 44

Figure 5. Comparison of four waste categories generated at NREL facilities 49

Figure 6. STM Campus New Boundary and Conservation Easement 64

Figure D-1. Land cover types at the STM Campus 88

Figure D-2. Wetland types and vegetation communities at the Flatirons Campus 89

List of Tables

Table 1. Sustainability Goals and Performance Summary 25

Table 2. Compliance Status for Federal, State, and Local Environmental Laws and Regulations 29

Table 3. Estimated Annual Air Pollutant Emissions 41

Table 4. EPCRA Reporting by EPCRA Section 48

Table 5. Petroleum Spills 50

Table 6. Total Activity and Effective Dose Equivalent 50

Table 7. Noxious Weed Species Identified at the STM Campus and the Flatirons Campus 59

Table 8. STM Campus Middle Drainage Wetlands Summary 61

Table 9. Flatirons Campus Wetlands Summary 61

Table B-1. Environmental Permits, Registrations, and Notifications 74

Table B-2. ECHO Database "NREL" Facility Search Results 76

Table C-1. Wildlife Species Observed at the STM Campus 77

Table C-2. Wildlife Species Observed at the Flatirons Campus 82

Photo by Agata Bogucka, NREL 88522

NOMENCLATURE

APCD	Air Pollution Control Division
APEN	Air Pollutant Emission Notice
APHIS	Animal and Plant Health Inspection Service
AST	aboveground storage tank
CFC	chlorofluorocarbons
CDPHE	Colorado Department of Public Health and Environment
CO^2	carbon dioxide
CO^2e	carbon dioxide equivalent
DOE	U.S. Department of Energy
ECHO	Enforcement and Compliance History Online
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPEAT	Electronic Product Environmental Assessment Tool
ESA	Endangered Species Act
ESIF	Energy Systems Integration Facility
FTLB	Field Test Laboratory Building
FY	fiscal year
GHG	greenhouse gas
HAP	hazardous air pollutant
HCFC	hydrochlorofluorocarbons
HFC	hydrofluorocarbon
HFO	hydrofluoroolefins
HMWMD	Hazardous Materials and Waste Management Division
IBRF	Integrated Biorefinery Research Facility
ISO	International Organization for Standardization
mrem	millirem
MS4	municipal separate storm sewer system
MT	metric ton
NEPA	National Environmental Policy Act
NO_x	nitrogen oxides
NREL	National Renewable Energy Laboratory
PIT	passive integrated transponder
RAIL	Research and Innovation Laboratory
RCRA	Resource Conservation and Recovery Act
ReFUEL	Renewable Fuels and Lubricants Laboratory
RSF	Research Support Facility
S&TF	Science and Technology Facility
SERF	Solar Energy Research Facility
SPCC	spill prevention, control, and countermeasures
STEP	South Table Mountain Energy Park
STM	South Table Mountain
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
WQCD	Water Quality Control Division

The sign marking the entrance to the National Renewable Energy Laboratory's South Table Mountain (STM) Campus is lit up in the early morning. *Photo by Werner Slocum, NREL 63032*

EXECUTIVE SUMMARY

Purpose

The National Renewable Energy Laboratory's (NREL's) *Environmental Performance Report 2023* describes the laboratory's environmental management activities in 2023. 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 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 2023 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 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 their adoption and effectiveness through participation by staff.

The following are some of the laboratory's key accomplishments in 2023:

- 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 two separate internal assessments for NREL's Spill Prevention, Control, and Countermeasures (SPCC) and Historic Resources programs. No major issues were identified, and actions to address the minor nonconformities and opportunities for improvement have been completed or are in progress.
- Purchased 100% clean energy for the total grid electricity at the Flatirons Campus through Xcel Energy's Renewable Connect Flex green tariff program.
- Connected the new Control Center Facility building at the Flatirons Campus to the existing drinking water distribution system.
- Developed an operations and maintenance manual for the South Table Mountain (STM) and Flatirons' stormwater structural control features, such as inlets, culverts, detention basins, swales, and channels.
- Completed the construction of an on-site wastewater treatment system at the Flatirons Campus associated with the Control Center Facility. The on-site wastewater treatment system is anticipated to be operational in 2024.
- Completed the physical chemical inventory audit efforts, which included accounting for nearly 6,000 chemical containers, for a wall-to-wall inventory that began in February 2020. The audit utilized new software that allows for chemical container barcode scanning and mobile device application.
- Implemented prescreening on all emergency planning and response and per- and polyfluoroalkyl substances (PFAS) materials to minimize the quantity of new materials arriving to any NREL site.
- Continued use of a new hazardous material screening process has led to more advanced information of hazardous materials intended to be brought on-site. This advanced notification has better prepared NREL to implement appropriate controls for the incoming materials. This process identified several more hazardous chemicals requested to be brought on-site. For each of these chemicals, safety staff and researchers worked together to discontinue the purchase, substitute the chemicals for less hazardous ones, or apply safety controls.
- Collaborated with various research groups to facilitate the disposal of multiple fume hoods and ducting within the Science and Technology Facility (S&TF), the Solar Energy Research Facility (SERF), and Field Test Laboratory Building (FTLB) at the STM Campus.
- Completed preliminary planning for the design and construction of a replacement waste storage and handling facility. Construction is necessary to accommodate the anticipated growth of laboratory activities.
- Installed a 540-gallon (2,006-L) standby diesel-fired electrical generator with an integrated AST at the RAIL to guarantee

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 2023. 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 2023 for its environmental and sustainability accomplishments:

- "5 Product Categories" Electronic Product Environmental Assessment Tool (EPEAT) Purchaser Award from the Global Electronics Council in recognition of NREL's excellence in the procurement of sustainable electronics.
- Colorado Green Business Network 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 (CDPHE) since 2004.

uninterrupted power supply to the facility during both planned and unplanned outages.

- Successfully completed an internal SPCC assessment. Findings from the assessment included one opportunity for improvement and several ideas for improvement. Progress to correct and improve the processes behind these findings are currently underway.
- Updated the entire National Environmental Policy Act (NEPA) online training course provided to employees to make the information more clear, concise, and engaging to users.
- Completed the field portion of a sitewide wildlife survey at the Flatirons Campus.
- Conducted threatened and endangered species surveys on the Flatirons Campus. These included small mammal trappings, bird surveys, rare plant searches, and general observations. No federally threatened or endangered species were observed. The results of these studies will help NREL plan for future development by understanding what species reside on the campus.
- Deployed bat ultrasonic recorders, which detected two bat species that are Colorado Species of Greatest Conservation Need: the fringed myotis (*Myotis thysanodes*) and little brown myotis (*Myotis lucifugus*).
- Released seed-head-feeding weevils (*Cyphocleonus achates*) and lesser knapweed flower weevils (*Larinus minutus*) along the western boundary at the Flatirons Campus to combat diffuse knapweed (*Centaurea diffusa)* within pine tree (*Pinus* spp.) stands where use of herbicide is discouraged to avoid tree damage
- Acquired a portion of the Camp George West Historic District, a 6.6-acre (2.7-hectare) parcel that includes mess halls, a pedestrian underpass, orderly rooms, and three tent pad structures that are listed in the National Register of Historic Places. The (South Table Mountain Energy Park) STEP Campus is within the Camp George West Historic District, which is also listed in the National Register of Historic Places. Prior to commencing projects planned at the STEP Campus, activities must receive a NEPA review and determination, including a review for potential impacts to cultural resources.

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 2023. 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.

A researcher measures the length and weight of vegetables planted under a photovoltaic array testing site on the STM Campus. The researcher checks for differences between plants grown in full sunlight and those grown between the solar panels. The solar garden is part of an agrivoltaics project, which studies the effects that solar panels and crops have on each other. *Photo by Werner Slocum, NREL 82361*

The laboratory continued to improve its environmental management and performance in 2023, as demonstrated by its record of excellent compliance with regulatory requirements and established leadership in environmental and sustainability management. Major environmental programs at NREL include:

- Air quality protection, including air permitting, ozone-depleting substance management, and greenhouse gas emissions monitoring.
- Water quality protection, including construction stormwater management, drinking water monitoring, and prevention of unallowable sanitary sewer system discharges.
- Hazardous materials and waste management, including pollution prevention; spill response; proper storage, use, and disposal of hazardous chemicals and materials; 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 DOE's Office of Science and 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. The 160-acre (65-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 R&D achievements have helped shape clean energy alternatives for powering homes and businesses, as well as 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*

Employees of DOE's Office of the Under Secretary of Infrastructure and NREL tour the Flatirons Campus site.
Photo by Josh Bauer, NREL 87704

1 INTRODUCTION

This report summarizes the National Renewable Energy Laboratory's (NREL's) environmental management activities in 2023, including:

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

The report incorporates the U.S. Department of Energy's (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.

An NREL researcher works to quantify and reduce plastic waste in rivers. *Photo by Josh Bauer, NREL 88062*

- **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.

The Infrastructure Perception and Control laboratory applies advanced sensing and computation controls to the coordinated movement of both vehicles on the road and people in large facilities. The IPC lab builds upon the evolving role advanced sensing and computation controls play in connected and automated movement. The benefits of this approach range from increased safety and equity to reduced travel time and energy use for mobility across various realms. *Photo by Joe DelNero, NREL 87670*

- **Grid Modernization:** Grid modernization work at NREL advances critical science and technology through innovative R&D to improve the nation's electric grid infrastructure, making it more flexible, reliable, resilient, secure, and sustainable.
- **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.

The combined accelerated stress testing chamber in NREL's Outdoor Test Facility allows researchers to replicate months or year of outdoor weathering in days or weeks by exposing modules to ultraviolet light, moisture, extreme temperatures, and other stresses. *Photo by Harrison Dreves, NREL 87677*

- **Photovoltaics and Solar Power:** Photovoltaics work at NREL includes both fundamental and applied R&D, 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 vehicle and engine manufacturers to develop advanced motor vehicle fuels for improved energy and environmental performance.

A Class 6, straight body, medium-duty propane autogas delivery truck deployed in a U.S. Postal Service mail delivery contractor fleet with a goal of providing a proof-of-concept demonstration for low-carbon mail delivery fleets nationwide. *Photo by Matthew Jeffers, NREL 85177*

A high school student from Colorado Springs tests her wave energy converter in the wave tank at the Sea Wave Environmental Lab at the Flatirons Campus. *Photo by Charles Candon, NREL 86094*

- **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.

1.2 Sites and Facilities

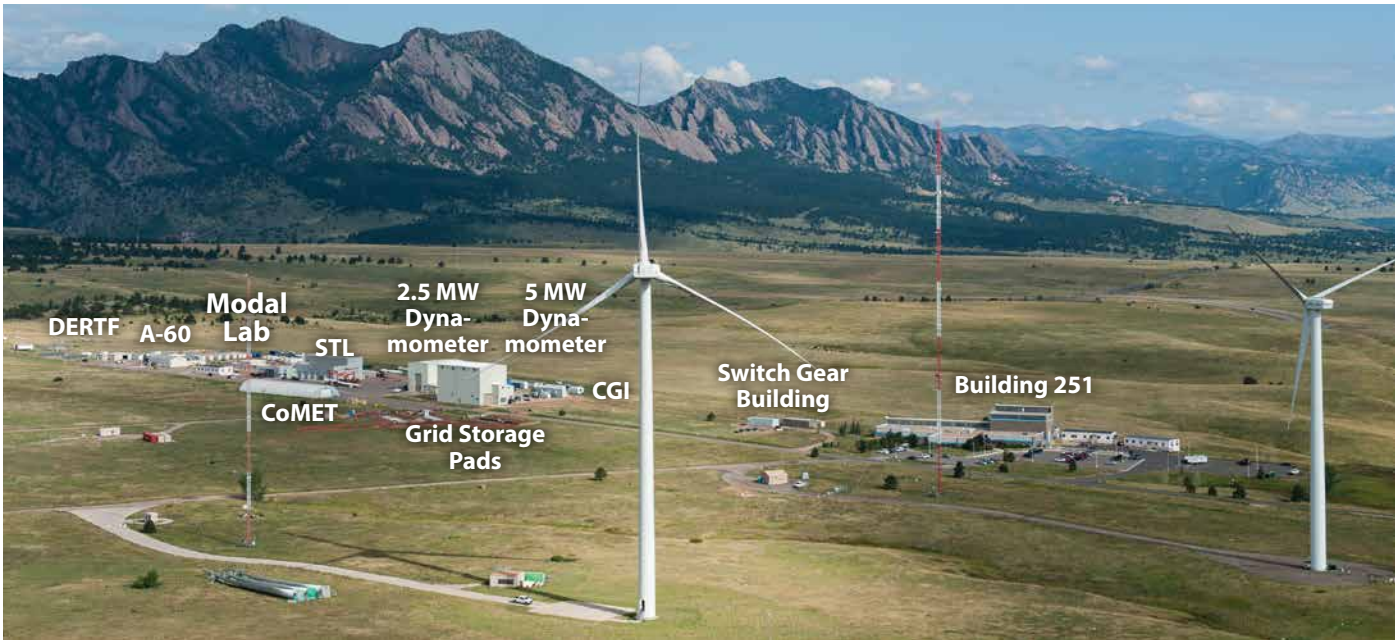
NREL's facilities occupy eight locations in Colorado, Alaska, and Washington, D.C., including:

Federally owned facilities:

- Flatirons Campus in Arvada, Colorado.
- South Table Mountain (STM) Campus in Golden, Colorado.
- South Table Mountain Energy Park (STEP) in Golden, Colorado.

Leased facilities:

- Building 16 in Lakewood, Colorado.
- Golden Warehouse in Golden, Colorado.
- Renewable Fuels and Lubricants (ReFUEL) Laboratory in Denver, Colorado.
- Research and Testing Facility in Fairbanks, Alaska.
- Washington, D.C., office.



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 border of Jefferson County and Boulder County 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.*

Vegetation

The Flatirons Campus is in the transition area between the Great Plains and the Rocky Mountains.[2] This location results in 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 there.

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.

STM 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 2 miles (3.2 km) east of Golden and 12 miles (19.3 km) west of downtown Denver.

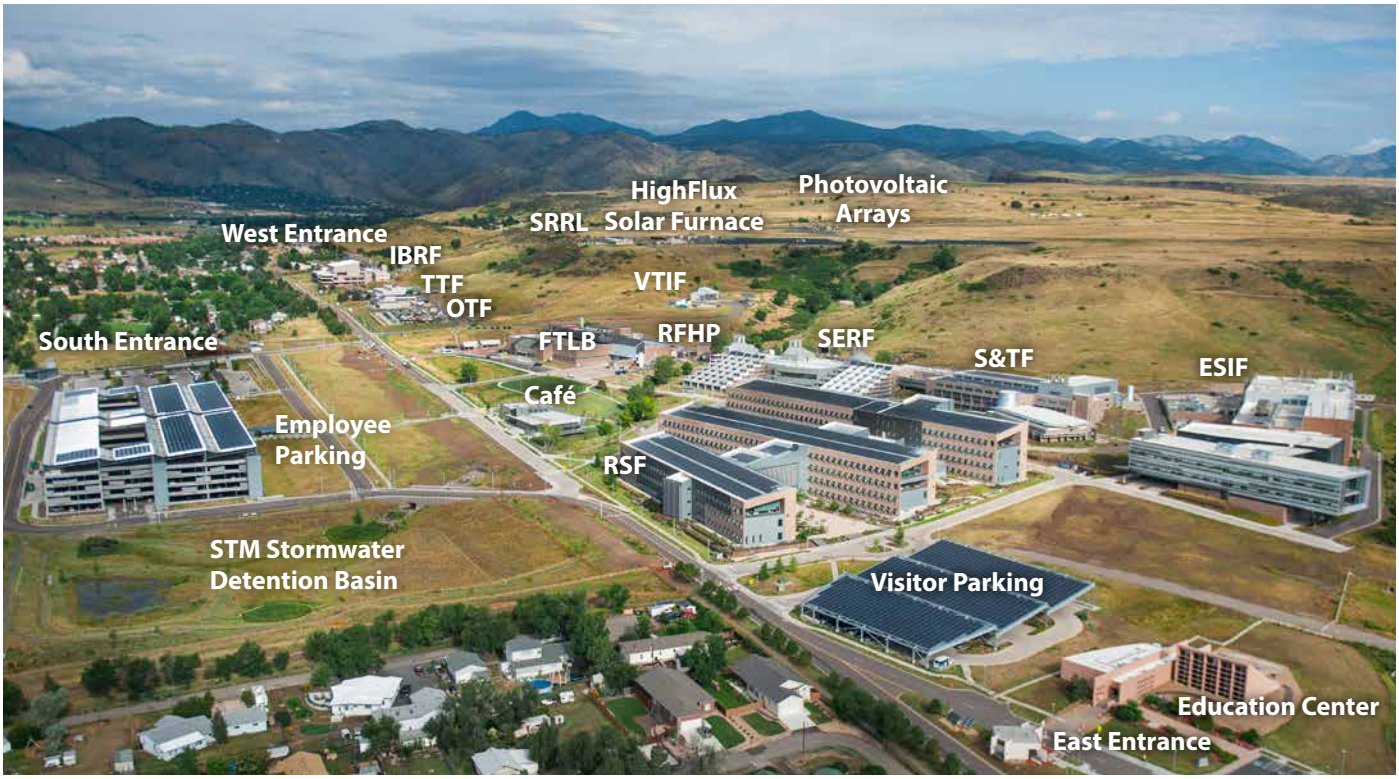
Land Use

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 ft (152 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 167-acre (67.6-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 Patrol pursuit driver-training track are located along the northwestern boundary of the STM Campus on top of the mesa. Jefferson

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.* doi.org/10.2172/1457673.



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

County open space wraps around the northern and eastern edges of the campus. Portions of the Denver West Business Park and apartment homes lie to the east.

Nineteen acres (7.7 hectares) of the STM Campus is preserved in a conservation easement. 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 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 bird species 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.

STEP

In early 2023, the state of Colorado, Jefferson County, and DOE finalized a land swap that granted DOE ownership of what is now STEP. The site, now the third DOE-owned NREL campus, is located on South Golden Road in Golden, just south of the STM Campus.

Like the STM Campus, STEP is within the boundary of former Camp George West, and more recently housed a state correctional facility. In the future, improvements will be made to buildings and infrastructure to support research and operations.

An aerial view of the NREL's STEP Campus. *Photo by Josh Bauer and Bryan Bechtold, NREL 77071*

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

Building 16

Building 16 is a leased office building within the Denver West Business Park, within Lakewood, approximately 2 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 Ave.) and on the west by the Camp George West facility and the STM Campus. In addition to office spaces, activities at Building 16 include fuel and battery characterization research, thermal analyses of vehicle cooling loops, vehicle electrical systems analysis, and photoelectrochemical hydrogen production research.

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*

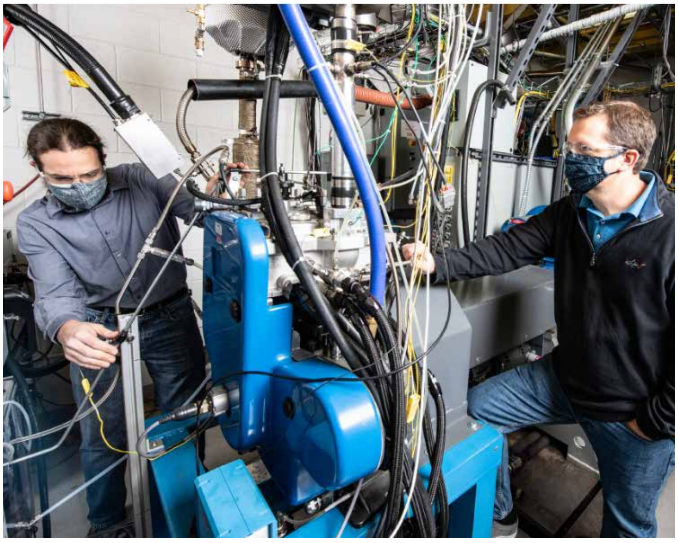
ReFUEL Laboratory

The ReFUEL Laboratory 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. 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. 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 Facility 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 in. (50 cm). Almost half the annual precipitation occurs from March to June. Summer showers contribute 33% of the annual



Researchers work on a test engine at the ReFUEL research lab. The advanced fuels research single-cylinder engine enables in-depth fuels research for compression-ignition combustion strategies. It has played a role in understanding fuel property effects on combustion and expanding capabilities to operate in advanced combustion ignition modes. *Photo by Dennis Schroeder, NREL 62752*

precipitation total. Precipitation begins to decrease significantly in the fall and reaches the minimum in winter. Winter is the driest season, contributing less than 10% of the annual precipitation, primarily in the form of snowfall.

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

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

Research and Testing Facility

NREL leases the Research and Testing Facility at the Applied Research for Communities in Extreme Environments 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 research, specifically as it applies to extreme climates.

Climate of Alaska Facility

The Research and Testing Facility is located in a subarctic climate characterized by typically long, cold winters (5–7 months) and short, cool summers (45–100 days at most). 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).

NREL's Fairbanks, Alaska, campus is home to the northernmost LEED Platinum building in the world, the Applied Research for Communities in Extreme Environments *Photo by Werner Slocum, NREL 81192*

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. Office

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 tides, storm surge, and runoff has been known to cause considerable property damage. The city's climate continues to warm, and rainfall continues to increase.

A black-billed magpie (*Pica hudsonia*) perched on a branch at the STM Campus. *Photo by Werner Slocum, NREL 88231*

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 EMS

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 commitments, 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 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 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 Performance Indicators and Progress.

Implementation

- **Structure and Responsibility:** NREL policies and procedures establish roles and responsibilities for environmental management within the organization.
- **Competence, Training, and Awareness:** NREL verifies that staff are competent based on education, training, or experience, and the laboratory implements a robust environment, health, and safety training program.
- **Communication:** NREL provides several avenues for communication between the laboratory and the community, including community meetings, lunch-and-learn events, publicly available websites, scientific publications, newsletters, and periodic community mailings. NREL tracks

Figure 1. NREL's continual improvement cycle

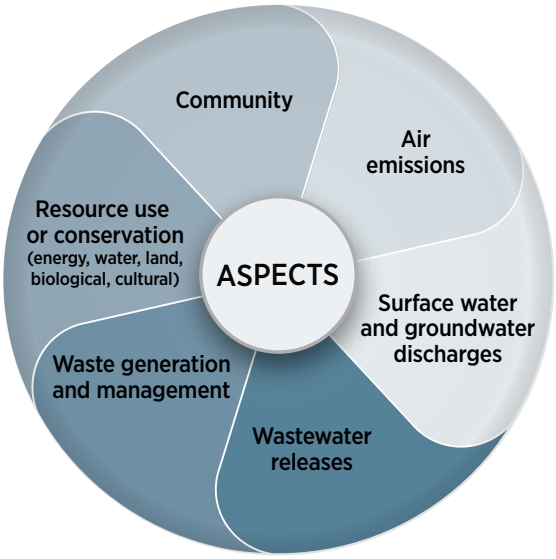


Figure 2. NREL's environmental aspects

and responds to all environmental concerns through the NREL Communications Office. Internal communications regarding environmental issues are provided via intranet sites, newsletters, emails, meetings, posters, trainings, and personal interaction with Environment, Safety, Health, and Quality 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 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 by public transportation, carpooling, and telecommuting.

NREL reduces waste in several ways, including by offering alternate waste streams near most trash receptacles. Here, an employee discards an NREL biodegradable takeout container in a compost-only receptacle. *Photo by Dennis Schroeder, NREL 27227*

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 (GHG) 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 Sustainability Goals.

Progress on each goal is tracked throughout the year, and results are reported annually. The following are examples of achievements in 2023 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:

- Completed drinking water sampling and evaluation at the STEP Campus and posted appropriate signage.
- Conducted a preliminary rare plant species survey for the Ute ladies' tresses orchid (*Spiranthes diluvialis*) prior to the construction of the Flatirons Campus waterline project.
- Submitted application to renew municipal separate storm sewer system (MS4) permit for second 5-year permit term (2023-2028).
- Revised STM, Flatirons Campus, and ReFUEL SPCC plans to update and verify oil volumes for new, removed, and existing equipment.
- Submitted Title V permit application for the STM Campus.
- Reviewed and updated training content for waste management and SPCC programs to reflect current operations.
- Added spill kits in areas of higher risk of spills.

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

- Coordinated the completion of an updated baseline comprehensive STEP Campus cultural resources report.
- Prepared a stormwater operation and maintenance manual for the STM campus.
- Developed a short video and several graphics of stormwater pollutants for educational purposes.
- Developed a geographic information system map of stormwater infrastructure on the STM Campus.
- Installed educational stormwater placards on specific inlets on the STM Campus.
- Developed an online environmental questionnaire tool to more efficiently collect NEPA project information from users.
- Deployed knapweed weevils (*Cyphocleonus achates*) to control diffuse knapweed (*Centaurea diffusa*) at the STM Campus and Flatirons Campus. This deployment at Flatirons Campus was the fourth done in six years.

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 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.

The following assessment activities that took place in 2023 allowed NREL to enhance program effectiveness and make substantial environmental performance improvements:

- **Internal Assessments:** Conducted two separate internal assessments for NREL's SPCC and Historic Resources programs. No major issues were identified, and actions to address the minor nonconformities and opportunities for improvement have been completed or are in progress.
- **External Assessments:** NREL underwent a maintenance assessment to verify conformance to the ISO 14001:2015 standard. A team of external auditors conducted the virtual assessment, including interviews with staff at all levels of the organization, observations of processes in place, and reviews of documents and records. No major issues were identified, and certification was maintained.

2.5 Awards and Recognition

In 2023, NREL received several awards and recognition for its environmental and sustainability achievements, including those described in this section.

Green Electronics Council Award

NREL is committed to purchasing products designated by the Electronic Product Environmental Assessment Tool (EPEAT), ENERGY STAR, and the Federal Energy Management Program, whenever feasible, to continue to positively impact the environment through such purchases. In 2023, NREL received the "5 Product Categories" EPEAT Purchaser Award from the Global Electronics Council for 2022 EPEAT purchases.

Colorado Green Business Network Recognition

NREL maintained its status as a Colorado Green Business Network[4] Gold-Level Leader, the highest level awarded by the program. The Colorado Green Business Network[5] is a voluntary partnership of the CDPHE and is intended to recognize environmental leadership and performance.

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.

This NREL shuttle bus shelter has been modified with a window film to reduce bird collisions. The film makes the glass visible to birds without sacrificing the ability to see an approaching shuttle. *Photo by Ray David, NREL 23113*

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.

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, collaborates 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.

4 The Colorado Green Business Network previously was named the Colorado Environmental Leadership Program.

5 Learn more about this voluntary program at the state's Colorado Green Business Network website: cdphe.colorado.gov/co-green-business.

Benefits of the EMS to NREL

- **Reduced Risk to Facility and the Organizational Mission:** NREL's hazard identification and control procedure incorporates an environmental risk assessment. System improvements also support the use of requirements to reduce the risk of noncompliance and potential enforcement actions.
- **Improved Fiscal Efficiency and Cost Avoidance:** Cost savings are realized through energy efficiency projects, new renewable energy installations, waste reduction and recycling, and reduced environmental incidents such as spills.
- **Greater Understanding and Recognition of Environmental Issues at All Levels of the Organization:** Staff are made aware of the potential environmental impacts of their work activities through 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. 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.

Construction crews work to install a wind turbine on the Flatirons Campus. This distributed wind system has an American Clean Power Association rated power of 15.6 kW. *Photo by Joe DelNero, NREL 85129*

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 and clean-burning fuels, as well as minimizing the quantity of chemicals used on-site, all contribute to improved air quality. NREL continually strives to protect water quality both on-site and off-site 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 on-site, 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:** Implementing 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.

2023 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 two separate internal assessments for NREL's SPCC and Historic Resources programs. No major issues were identified, and actions to address the minor nonconformities and opportunities for improvement have been completed or are in progress.

An NREL environmental researcher and policy director for state Senator Chris Hansen plants crops in a garden row at the bifacial agrivoltaics array on the STM Campus. The garden is part of a project that studies the effects solar panels and crops have on each other. *Photo by Joe DelNero, NREL 79521*

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 R&D, to campus facilities and infrastructure systems.

3.1 Sustainability Goals

In accordance with DOE Order 436.1A, *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 2023 is presented in Table 1. Sustainability Goals and Performance Summary, 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 the flow of materials, 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) 2023
Multiple Categories		
Achieve a net-zero-emissions building portfolio by 2045 through building electrification and other efforts	High	New facilities designed to net-zero emissions standards
Reduce Scope 1 and Scope 2 GHG emissions [a]	Medium	Increased Scope 1 and Scope 2 emissions 19% from FY 2008 baseline (fleet fuel emissions estimated)
Reduce Scope 3 GHG emissions [b]	Medium	Increased Scope 3 emissions 3% from FY 2008 baseline [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 increased 7% from FY 2022
Evaluate energy and water systems per Section 432 of the Energy Independence and Security Act on a continuous 4-year cycle [d]	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	Low	Integrated building energy tracking data with EPA's ENERGY STAR Portfolio Manager software platform Integrated power quality metering for STM Campus garage photovoltaic arrays Integrated metering from Flatirons Campus substation Installed and integrated metering for the new Research and Innovation Laboratory (RAIL)
Water Management		
Reduce potable water use intensity (measured in gallons per gross square foot)	High	Potable water intensity decreased by 10% from FY 2022
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	High	15% decrease to 47% diversion (composted or recycled) rate of nonhazardous solid waste
Reduce construction and demolition materials and debris sent to treatment and disposal facilities	Medium	13% decrease to 78% diversion (composted or recycled) rate of construction and demolition waste

DOE Goal	Risk Level	Performance in Fiscal Year (FY) 2023
Fleet Management		
Reduce petroleum consumption	Low	4% decrease in petroleum fuel from FY 2022 to FY 2023
Increase alternative fuel consumption	Low	22% increase in alternative fuel from FY 2022 to FY 2023
Acquire alternative fuel and electric vehicles	Low	In FY2023 NREL had 12 zero-emission vehicles in the fleet, with two more on order
Clean and Renewable Energy		
Achieve 100% carbon-pollution-free electricity on a net annual basis by 2030, including 50% 24/7 carbon-pollution-free electricity	Low	67% carbon-free electricity in FY 2023
Increase consumption of clean and renewable nonelectric thermal energy	High	38% decrease from FY 2022 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 Federal Buildings* [e]	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	Low	Signed the first task order for a new energy savings performance contract; projects focused on the Flatirons Campus
Electronic Stewardship		
Increase acquisition of sustainable electronics and promote sustainable operations and end-of-life practices	Low	EPEAT registered and ENERGY STAR[f] products purchased where possible Power management settings standard on all computers and displays Responsible recycling of all electronics
Increase energy and water efficiency in high-performance computing and data centers	Medium	Compliance with Data Center Optimization Initiative M-19-19 goals which develop and report on data center strategies to transition to more efficient infrastructure
Adaptation and Resilience		
Implement climate adaptation and resilience measures	Medium	Continued to use the Vulnerability Assessment and Resilience Plan to identify climate adaptation solutions

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 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.

e To advance sustainable building principles and practices, the Council on Environmental Quality issued a guidance document on how federal agencies could best design, locate, construct, maintain, and operate federal buildings in a sustainable manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, ensures the health of occupants, protects the environment, generates cost savings, and mitigates risks to assets, consistent with agency and department missions: Guiding Principles for Sustainable Federal Buildings and Associated Instructions (sftool.gov/learn/about/631/guiding-principles-sustainable-federal-buildings).

f ENERGY STAR products meet energy-efficiency specifications set by the U.S. EPA.

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 employee installs microinverters while volunteering for a rooftop solar installation project with a local solar energy nonprofit organization based out of Denver, Colorado. This installed 6.7-kW rooftop solar energy project should provide the home with $1,200 annual savings over the next 20 years. NREL frequently partners with this organization because they seek to install solar in low-income areas, with a vision of improving environmental justice through renewable energy solutions. *Photo by Joe DelNero, NREL 84002*

3.3 Environmental Justice

Federal facilities are subject to various requirements regarding environmental justice, which is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. NREL considers and addresses environmental justice concerns in planning, decision-making, and operations to ensure equitable protection of human health and the environment for communities that its activities may affect.

NREL addresses environmental justice concerns through implementation of the NEPA review process. Sitewide environmental assessments and environmental assessments for new projects identify environmental justice communities that could be affected and consider potential routes of impact to identified communities. Public outreach efforts solicit input from potentially affected communities. Mitigation actions may be identified through the NEPA process and implemented through the project.

NREL also has a dedicated Tribal energy program, working together Tribal governments to help facilitate accessible, small, renewable energy systems on Tribal lands to help ease the energy cost burdens in these areas. The Applied Research for Communities in Extreme Environments in Fairbanks, Alaska, is a NREL facility dedicated to pursuing sustainable building practices in subarctic climates for local Native people and low-income groups. This includes not only designing energy-efficient buildings, but also troubleshooting other building accessibility concerns including all of the energy, power, and water challenges cold and remote communities face. The facility's mission is not just about reducing energy costs, but also promoting the culture and resilience of local people.

An employee working at the Applied Research for Communities in Extreme Environments discusses a high-efficiency, NREL-designed building display for climate-threatened communities in Alaska. *Photo by Werner Slocum, NREL 81208*

2023 Accomplishments and Highlights

- Purchased 100% clean energy for the total grid electricity at the Flatirons Campus through Xcel Energy's Renewable Connect Flex green tariff program.
- Scored near the ideal 1.0 power usage effectiveness rating, including the High-Performance Computing Data Center scoring 1.04 and the 13-year-old RSF Data Center achieving an average monthly power usage effectiveness of 1.32. (Power usage effectiveness is the standard ratio used to calculate how efficiently data centers use energy.)

A herd of elk (*Cervus canadensis*) south of the Flatirons Campus roams Rocky Flats National Wildlife Refuge. *Photo by Dan Berteletti, NREL 90209*

4 COMPLIANCE SUMMARY

NREL is subject to many federal and state laws and regulations, executive orders, 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. Compliance Status for Federal, State, and Local Environmental Laws and Regulations includes a brief description of the statute or regulation and how compliance requirements were met in 2023. 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 Jan. 20, 2021, and Executive Order 14057, Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability, was established Dec. 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 436.1A, 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 has been 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 436.1A: 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 436.1A 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 2023. 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 19 acres (7.7 hectares) from a previous 177 acres (72 hectares) after a state of Colorado, Jefferson County, and DOE land swap. The Flatirons Campus protects 60 acres (24.3 hectares) 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 2023, NREL continued 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. 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 436.1A: Departmental Sustainability

Environmental Justice

Executive Order 12898 requires federal agencies to address environmental justice by identifying and mitigating disproportionately high and adverse impacts on minority and low-income communities. Executive Order 14008 requires agencies to consider environmental justice in climate policies and actions, particularly those impacting marginalized communities. Executive Order 14057 directs federal agencies to prioritize clean energy initiatives that promote equity and job creation in disadvantaged communities.	NREL addresses environmental justice concerns by utilizing the NEPA review process. Environmental assessments, both sitewide and for new projects, pinpoint communities vulnerable to environmental injustice and assess potential impacts on them. Engagement with these communities through public outreach ensures their voices are heard. Additionally, mitigation strategies are developed and integrated into projects via the NEPA process.	Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Population, Section 1-1 Executive Order 14008: Tackling the Climate Crisis at Home and Abroad, Section 219 Executive Order 14057: Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability, Section 402

Air Quality

For facilities and stationary sources that emit criteria air pollutants and hazardous air pollutants (HAPs), there are both federal and state requirements for permitting, reporting, emissions limits, and operation of emissions 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 Oct. 1, 2021, the U.S. Environmental Protection Agency (EPA) implemented hydrofluorocarbon (HFC) phasedown requirements authorized by the American Innovation and Manufacturing Act of 2020 that are intended to reduce the use of HFCs in manufacturing to 15% of a 2011–2013 baseline by 2036. As of 2024, the manufacture of HFC refrigerants in the United States has been reduced to 60% of the baseline amount.

EPA's Protection of Stratospheric Ozone includes repair, servicing, recordkeeping, and other requirements for appliances containing more than 50 lb (23 kg) of any regulated refrigerants, including chlorofluorocarbons, hydrochlorofluorocarbons, HFCs, and hydrofluoroolefins. Appliances containing 5 lb (2.3 kg) or more of these refrigerants are subject to end-of-life refrigerant recovery, recycling, and documentation requirements.

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.

Starting July 15, 2023, CDPHE requires all Title V applicable permit applicants to submit an environmental justice summary prior to submitting their permit application.

In 2023, 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 emissions control requirements. All facilities and individually permitted equipment items remain classified as 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 2023. Emissions tracking of all emitting equipment continued, whether the equipment was permitted or permit exempt.

Proposed EPA regulations for maintenance and repair of HFC-containing appliances are expected to be finalized in 2024 and will impact NREL. NREL uses at least 42 HFC-containing appliances that will be covered under this regulation.

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

Air Quality *continued*		
The Air Pollution Control Division (APCD) of CDPHE administers the federal Clean Air Act in Colorado and 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, HAPs, ozone-depleting substances, and GHGs. 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.	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 was filed in 2023 and a permit will eventually be issued. This permit application included an environmental justice summary. 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 2023, as required. The report confirmed that no sand was used at the STM Campus or the Flatirons Campus.	CDPHE 5 CCR 1001-15: Control of Emissions of Ozone Depleting Compounds 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 (WQCD) 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 383,455 gallons (1,451,535 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 2023, 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

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 WQCD 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 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.

Programs required by the MS4 permit have been developed. These programs are intended to reduce the discharge of pollutants in stormwater runoff from the STM Campus.

NREL continued coverage under the EPA's 2022 Construction General Permit for the STM Campus' RAIL.

NREL continued coverage under the EPA's 2022 Construction General Permit for the Flatirons Campus' Second Controllable Grid Interface project.

NREL obtained coverage under the EPA's 2022 Construction General Permit for the Flatirons Campus' Control Center Facility 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

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 WQCD.

On-site septic systems are regulated by the WQCD. Inspection and permitting of individual sewage disposal systems have been delegated to Jefferson County by CDPHE.

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

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 on-site 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 submitted for nitric acid in March 2023 at the STM Campus.

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 submitted for nitric acid as part of the Section 302 notification.

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 Business 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

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 (HMWMD) 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 that generate no more than 220 lb (100 kg) of hazardous waste and no more than 2.2 lb (1 kg) of acute hazardous waste per month. Small quantity generator: Those that generate less than 2,204.6 lb (1,000 kg) of hazardous waste and less than 2.2 lb (1 kg) of acutely toxic waste per month. Large quantity generator: Those that generate 2,204.6 lb (1,000 kg) or more of hazardous waste or more than 2.2 lb (1 kg) of acutely hazardous waste per month.	Program activities were in compliance with requirements. Applicable staff receive 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: large quantity generator. Flatirons Campus: very small quantity generator. Building 16: very small quantity generator. ReFUEL: very small quantity generator. Golden Warehouse: no hazardous waste generated. 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 (AST) Management

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 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

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 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 off-site 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, 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 yd^3 [1.5 m^3]) of low-level radioactive waste are in storage awaiting off-site 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 off-site 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 2023, the effective dose equivalent of radiation to the public was 0.040 mrem, which is far below the limit of 10 mrem per year. 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
NEPA		
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 large storage for megawatt charging at the Flatirons Campus, typical operations conducted at the STEP Campus, a thermal energy research facility at the Flatirons Campus, and a new Waste Handling Facility at the STM Campus.	40 CFR 1500-1508: Regulations for Implementing the Procedural Provisions of NEPA (Council on Environmental Quality) 10 CFR 1021: NEPA Implementing Procedures

Wildlife Management

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 436.1A 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 2023. 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 19 acres (7.7 hectares) from a previous 177 acres (72 hectares) after a state of Colorado, Jefferson County, and DOE land swap. The Flatirons Campus protects 60 acres (24.3 hectares) 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 2023, NREL continued 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. 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 436.1A: Departmental Sustainability

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 sitewide 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 was 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 2023 for the import of *Sphingobium* microorganisms to the STM Campus from within the United States and from Japan.

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

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.	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 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 multi-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 landholding.	National Park Service 36 CFR 60: National Register of Historic Places National Park Service 36 CFR 63: Determinations of Eligibility for Inclusion in the National Register of Historic Places National Park Service 36 CFR 79: Curation of Federally Owned and Administered Archaeological Collections National Park Service 36 CFR 800: Protection of Historic Properties 16 U.S.C. 470: National Historic Preservation Act State Historic Preservation Office 8 CCR 1504-7: Historical, Prehistorical, and Archaeological Resources

Small transformers outside the Renewable Fuel Heat Plant on NREL's STM Campus help power building operations.
Photo by Werner Slocum, NREL 64476

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 on-site 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, sulfur dioxide) and noncriteria pollutants (e.g., HAPs, GHG compounds, 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, startup 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.

A summary of the estimated annual air pollutant emissions in 2023 is included in Table 3. Estimated Annual Air Pollutant Emissions, U.S. Tons (and Metric Tons) Per Year, 2019–2023 a and includes those 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) 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 was filed with APCD in November 2023.

An ESIF research generator that had been permitted to operate at that STM Campus location was considered unnecessary by researchers. That generator, while permitted, had not been installed and was not operational. Thus, the permit to construct for the ESIF generator, which was due to expire in late 2023, was canceled. The emissions from this generator were removed from the NREL emissions inventory at the time of the permit cancelation. Current plans call for this generator to be installed as the standby generator for the Flatirons Campus' Control Room, which is under construction. It is anticipated that this generator will require submittal of an Air Pollutant Emission Notice (APEN) to APCD at the time of installation.

A new standby generator was installed at the newly developed RAIL on the STM Campus. This generator is equipped with emissions controls by the manufacturer and is exempt from emissions notice and air permits, as it is used for standby emergency power.

Table 3. Estimated Annual Air Pollutant Emissions, U.S. Tons (and Metric Tons) Per Year, 2019–2023 [a]

	Criteria Pollutants					GHGs			HAPs
Year	CO	NO_x	VOC	PM_{10}	SO_2	CO_2	CH_4	N_2O	All HAPs
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)
2023	7.67 (6.96)	15.50 (14.07)	0.71 (0.64)	3.21 (2.94)	0.46 (0.42)	10,550 (9,575)	0.51 (0.46)	0.38 (0.34)	0.54 0.49)

[a] CO: carbon monoxide; 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

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 HFCs, hydrofluoroolefins (HFO), and other EPA-approved alternative refrigerants are used to replace ozone-depleting refrigerants. Many HFC compounds are potent GHGs, and some EPA-approved alternates to HFC refrigerants are flammable or toxic compounds such as propane or ammonia.

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. NREL also conducts testing of appliances that use HFC and HFC-alternative refrigerants. 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 increased interest by the EPA and state regulatory agencies to reduce the use of HFC refrigerants because of their high level of use, increased release to the atmosphere due to leaks, and 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

A chiller system at the ESIF on the STM Campus. *Photo by Dennis Schroeder, NREL 64364*

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 by 2036. In October 2023, EPA published a proposed regulation that establishes maintenance and repair requirements for appliances containing 15 or more pounds of HFC refrigerants. 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 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 2023, 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.

2023 Accomplishments and Highlights

- Updated the refrigerant inventory to tabulate the number of HFC-containing appliances that would be regulated by the EPA-proposed repair and maintenance rule.
- Drafted an updated NREL refrigerant procedure that includes both ODS and HFC refrigerants.
- Attended a Jefferson County Health CFC inspection at the Flatirons Campus for continuation of refrigerant maintenance and repair certification on behalf of the Colorado APCD. The inspection went smoothly and there were no refrigerant compliance issues or violations identified during the inspection
- Prepared an updated fact sheet for refrigerants that includes requirements for both ODS and HFC refrigerants.

One of the water collection pools within the STM Campus' detention basin. This pool helps filter and collect stormwater from the middle drainage on campus while also providing habitat for local wildlife. *Photo by Agata Bogucka, NREL 88458*

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/STEP Campus and the Flatirons Campus are provided with potable drinking water by two different means.

STM Campus and STEP Campus

The STM Campus and STEP Campus are 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 Denver Water and transported by truck to the campus. The treated water originates from rain and snowmelt from across 4,000 mi^2 (10,360 km^2) of mountains and foothills west of Denver. Water is trucked-in approximately 3–4 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.

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 2023, monitoring results for residual chlorine and disinfection byproducts were within allowable regulatory ranges (Figure 3. Results of average monthly residual chlorine monitoring in drinking water at the

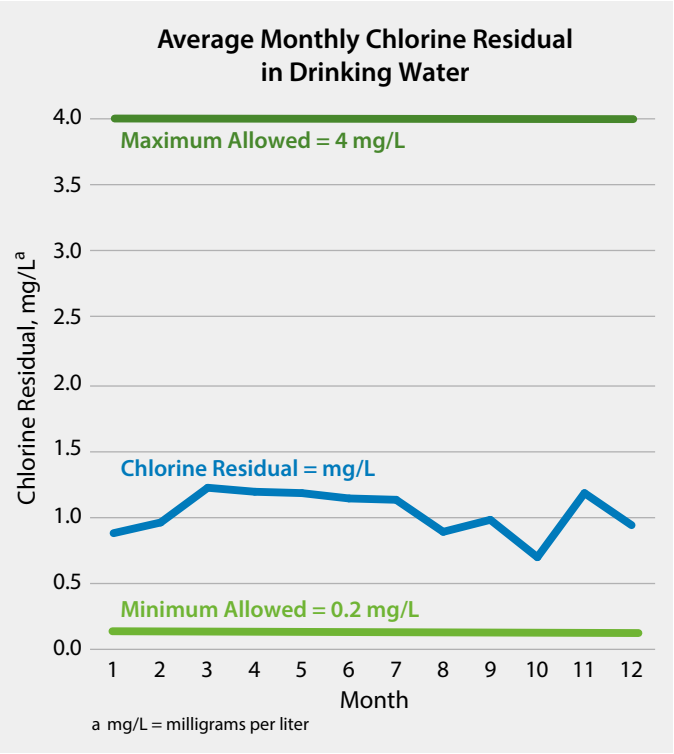


Figure 3. Results of average monthly residual chlorine monitoring in drinking water at the Flatirons Campus, 2023

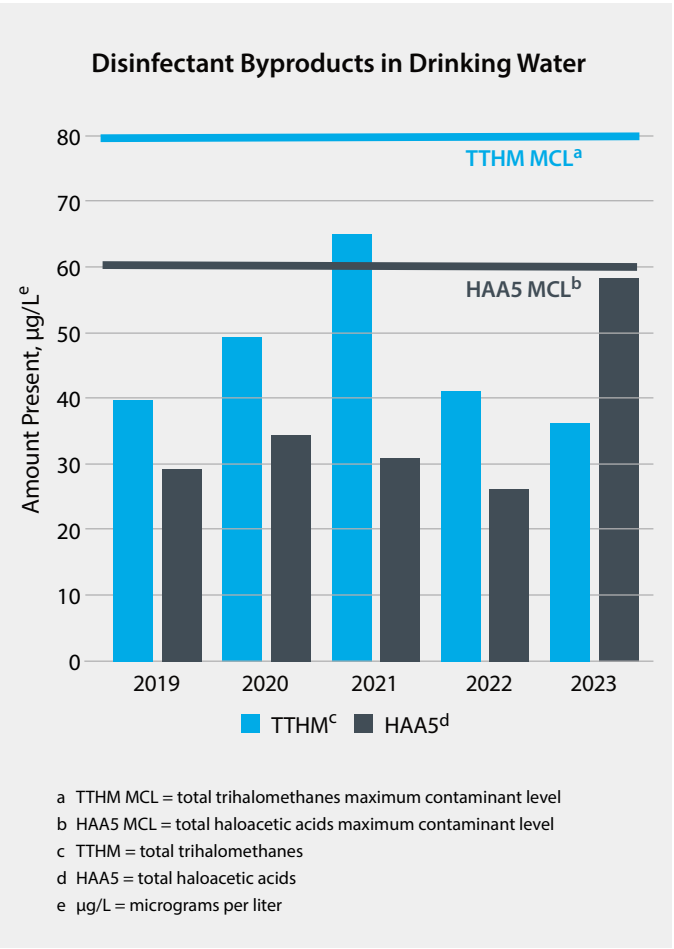


Figure 4. Results of disinfection byproduct concentrations in drinking water at the Flatirons Campus, 2019-2023

Flatirons Campus, 2023 and Figure 4. Results of disinfection byproduct concentrations in drinking water at the Flatirons Campus, 2019-2023). 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 Jan. 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 were absent from all monthly samples collected in 2023.

In 2023, 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 will be used to fill two new fire suppression water storage tanks and to feed a new drinking water treatment plant that will deliver potable water to campus buildings. The system will eliminate vulnerabilities associated with current trucked-in water and will provide sufficient fire suppression water storage for campus buildings.

2023 Accomplishments and Highlights

- Provided 383,455 gallons (1,451,535 L) of drinking water to the Flatirons Campus, a reduction of 59,651 gallons (225,804 L).
- Connected the new Control Center Facility building at the Flatirons Campus to the existing drinking water distribution system.
- Sampled drinking water fixtures at the STEP Campus to better understand the condition of water piping and aging fixtures of this newly acquired parcel. Results indicated a need for further study when upgrading infrastructure and renovating buildings.

6.2 Groundwater

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

A late afternoon rainstorm tested the STM Campus' storm drainage and detention system. Some stop to view the high volume of water coming off the mountain and passing the campus' cafe. *Photo by Bryan Bechtold, NREL 80714*

and Laramie-Fox Hills aquifers. The Dawson formation is the shallowest of the Denver Basin aquifers and is the one most relied on aquifers by the groundwater users in the basin. The northern extent of the Dawson aquifer is approximately 20 miles (33 km) south and east of the STM Campus and STEP Campus; consequently, wells drilled at any of the campuses would not intersect the Dawson aquifer, nor would a source of contamination on the affect the groundwater quality in this aquifer. Despite the low likelihood of contaminants reaching the Dawson aquifer, NREL's groundwater management program is focused on controlling potential pollutant sources that could affect this important resource. The program includes careful evaluation of all outdoor projects to eliminate, substitute, or control potential sources of pollution.

There are currently no open 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. Colorado's Division of Water Resources does not note any wells installed on the STEP campus.

PFAS and Emerging Contaminants

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

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

NREL previously identified one 500-gallon (1,893-L) fire suppression system, which contains a 3% PFAS solution, at the STM Campus. The fire-suppression system was evaluated and it was determined that if the system were activated the PFAS foam would be contained within the building and there would be little possibility of a release to the environment. Replacing the system with a non-PFAS product would require replacing the tank and associated infrastructure; this project has been added to a list of projects for future funding.

6.3 Surface Water

*T*hrough 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.

Programs have been developed addressing each of these control measures. Program development must be completed by the end of the first 5-year permit term, which ended in November 2023. A permit renewal application was submitted to the EPA in May 2023. The programs developed will be implemented in subsequent permit terms. Significant efforts were made in 2023 to address permit requirements.

2023 Accomplishments and Highlights

- Obtained coverage under the EPA's 2022 Construction General Permit for construction activities associated with the Control Center Facility project at the Flatirons Campus.
- Administratively extended the MS4 permit after a complete and accurate MS4 permit application was submitted to the EPA.
- Installed stormwater placards at many of the drains and inlets throughout the STM Campus to indicate which drains and inlets route to waterways.
- Developed an operations and maintenance manual for the STM and Flatirons Campus' stormwater structural control features, such as inlets, culverts, detention basins, swales, and channels.

6.4 Wastewater

Untreated or poorly treated wastewater can contaminate surface water 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 system, and ultimately to Metro Water Recovery's central treatment plant. Wastewater from ReFUEL also flows to Metro Water Recovery's central treatment plant.

Primary nondomestic wastewater discharge is generated at the STM Campus' IBRF, 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' S&TF 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.

2023 Accomplishments and Highlights

- Completed the construction of an on-site wastewater treatment system at the Flatirons Campus associated with the Control Center Facility. The on-site wastewater treatment system is anticipated to be operational in 2024.

Algae samples that will eventually be used to convert CO_2 into fuel are kept refrigerated at the Integrated Biorefinery Research Facility (IBRF) at the STM Campus. Research like this on bio-based fuels is often conducted at this facility, and the pH of the effluent from these research processes is adjusted to fall within the regulatory range before being discharged into the sanitary sewer system. *Photo by Werner Slocum, NREL 75551*

The Waste Handling Facility on the STM Campus. To accommodate campus growth, the construction of a larger waste handling facility is currently in the planning stage. *Photo by Larry Durbin, NREL 14003*

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 on-site are thoughtfully controlled with internal procedures designed to limit health and environmental risks. Waste is carefully managed and disposed of through fully permitted facilities.

Areas of focus for the laboratory include:

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

Additional information about program management for each of these five areas of focus can be found in Appendix A 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. EPCRA Reporting by EPCRA Section in 2023 summarizes EPCRA reporting requirements that were met in 2023. The reporting requirements for each EPCRA section are defined in Section 4: Compliance Summary.

Table 4. EPCRA Reporting by EPCRA Section in 2023

EPCRA Section	Description of Reporting	Status
302	Planning notification	Reported
304	Extremely hazardous substance release notification	Not required [a]
311	Safety data sheet notification	Reported
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.

Notable hazardous material occurrences

Notable hazardous material occurrences in 2023 included:

- During regular EPCRA Section 302 monthly checks, the STM Campus exceeded the threshold planning quantity of 1,000 lb (454 kg) of nitric acid. As such, a Section 302 notification and a copy of a nitric acid safety data sheet was provided to the Jefferson County Local Emergency Planning Committee, Colorado's State Emergency Response Commission, the Colorado Emergency Planning Committee, and West Metro Fire Protection District.
- The new chemical inventory software approval process has helped identify instances where a request for a high-hazard chemical could be replaced with a lower-hazard chemical to minimize risks to the researcher. The software helped identify a research sample that could form hydrofluoric acid; as a result, a hydrofluoric acid spill kit was delivered and available for use when a researcher was accidentally exposed to this highly toxic chemical.

A scanner being used to inventory chemicals inside a lab on the STM Campus. Chemicals are tracked for reporting and planning purposes. *Photo by Dennis Schroeder, NREL 33670*

2023 Accomplishments and Highlights

- Completed the physical chemical inventory audit efforts, which included accounting for nearly 6,000 chemical containers, for a wall-to-wall inventory that began in February 2020. The audit utilized new software that allows for chemical container barcode scanning and mobile device application.
- Implemented prescreening on all emergency planning and response and per- and polyfluoroalkyl substances (PFAS) materials to minimize the quantity of new materials arriving to any NREL site.
- Continued use of a new hazardous material screening process has led to more advanced information of hazardous materials intended to be brought on-site. This advanced notification has better prepared NREL to implement appropriate controls for the incoming materials. This process identified several more hazardous chemicals requested to be brought on-site. For each of these chemicals, safety staff and researchers worked together to discontinue the purchase, substitute the chemicals for less hazardous ones, or apply safety controls.

7.2 Hazardous Waste Management

R&D activities and sitewide 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 provides an overview of the waste generated at NREL between 2019 and 2023.

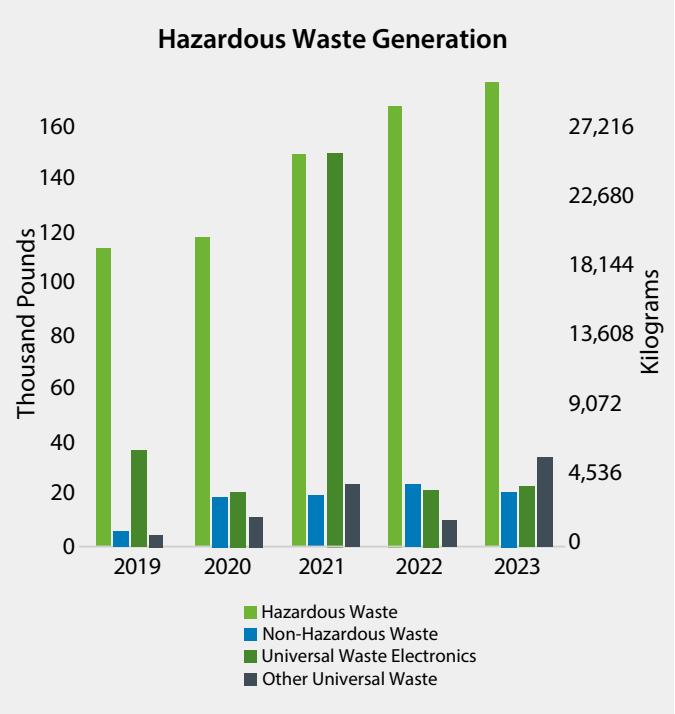


Figure 5. Comparison of four waste categories generated at NREL facilities by net weight, 2019–2023

2023 Accomplishments and Highlights

- Conducted multiple laboratory cleanouts throughout the STM Campus, overseeing the disposal of excess chemicals and hazardous waste.
- Collaborated with various research groups to facilitate the disposal of multiple fume hoods and ducting within the S&TF, SERF, and FTLB at the STM Campus.
- Completed preliminary planning for the design and construction of a replacement waste storage and handling facility. Construction is necessary to accommodate the anticipated growth of laboratory activities.

A hazardous waste collection area is in use at the Composites Manufacturing Education and Technology facility on the Flatirons Campus. *Photo by Werner Slocum, NREL 56889*

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 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.

NREL operates several petroleum-based ASTs, including:

- Fifteen on the STM Campus with a total capacity of 13,231 gallons (50,094 L).
- Five on the Flatirons Campus with a total capacity of 1,289 gallons (4,879 L).
- One at Building 16 with a capacity of 500 gallons (1,893 L).

A 540-gallon (2,006-L) standby diesel-fired electrical generator with an integrated AST was installed at the newly constructed RAIL on the STM Campus to support laboratory growth. *Photo by Werner Slocum, NREL 80091*

2023 Accomplishments and Highlights

- Installed a 540-gallon (2,006-L) standby diesel-fired electrical generator with an integrated AST at the RAIL to guarantee uninterrupted power supply to the facility during both planned and unplanned outages.
- Replaced a 560-gallon diesel AST at the FTLB that was found to have a leak in the interstitial space.
- Installed a 110-gallon (416-L) double-walled transfer tank onto an NREL fleet vehicle to facilitate on-site refueling of small maintenance and industrial equipment at the STM Campus.

7.4 Petroleum Spill Prevention and Response

Spills of petroleum products can result in contamination of soil, surface water, and groundwater, potentially impacting ecosystems, wildlife habitat, and human health.

Comprehensive planning using SPCC plans is 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 ReFUEL. Because fewer 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. Petroleum Spills in 2023 summarizes the petroleum spills that occurred in 2023. Six spills were recorded for a total of 2.8 gallons (10.6 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 NREL 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 2023

Location: Description	Estimated Quantity (gal, [L])
STM Campus: Hydraulic oil spill from campus shuttle vehicle	0.5 (1.9)
South Table Mountain mesa top: Equipment hydraulic leak	1.0 (3.8)
STM Campus maintenance building: Engine oil spill	0.13 (0.5)
STM Campus: Forklift hydraulic oil spill	0.25 (0.95)
STM Campus at North Loop Road bridge: Unknow spill source	0.25 (0.95)
Flatirons Campus: Snowplow hydraulic oil spill	0.5 (1.9)

2023 Accomplishments and Highlights

- Successfully completed an internal SPCC assessment. Findings from the assessment included one opportunity for improvement and several ideas for improvement. Progress to correct and improve the processes behind these findings are currently underway.

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, cabinets) removed during remediation remain on-site as preparations for final off-site shipment and disposal, in accordance with applicable state, federal, and DOE requirements, are completed.

Table 6. Total Activity and Effective Dose Equivalent, 2019–2023 [a] lists the total activity on-site 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, 2019–2023 [a]

Activity	2019	2020	2021	2022	2023
Total activity (millicurie)	3.88	3.89	3.87	3.87	3.87
Effective dose equivalent (mrem/yr)	0.037	0.039	0.043	0.040	0.040

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

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 56082*

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 2023.

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 deposits 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.
- **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 (310 mrem) from natural sources and another half (310 mrem) from human-caused sources of radiation, including medical procedures, consumer products, and industrial sources.[6]

2023 Accomplishments and Highlights

- Evaluated a lab inquiry into the feasibility of conducting new research activities involving the use of low-level radioisotopes on the STM Campus. Although NREL does not specifically prohibit new radiological work, careful evaluation of such requests occurs, and an assessment is made into the feasibility of performing these activities at a third-party facility prior to pursuing the resources required for taking on the work in-house. As a result, no new radiological work was approved in the subject reporting year.

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

NREL partnered with a 1.2-MW, 5-acre community solar farm in Longmont, Colorado, to grow and study agrivoltaic plants that attract pollinators such as honeybees (*Apis* spp.), bumble bees (*Bombus* spp.), and butterflies (*Danus* spp.). This project is the largest agrivoltaic research project in the United States. Prior to its construction, an environmental analysis was performed to analyze the project's environmental impacts. *Photo by Werner Slocum, NREL 65625*

8 NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE

NEPA 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.

Environmental Justice Within NEPA

NREL addresses environmental justice concerns through implementation of the NEPA review process. Sitewide environmental assessments and environmental assessments for new projects identify environmental justice communities that could be affected and consider potential routes of impact to identified communities. Public outreach efforts solicit input from potentially affected communities. Mitigation actions to address these communities may be identified through the NEPA process and implemented through the project.

2023 Accomplishments and Highlights

- Performed more than 200 NEPA evaluations to provide information on potential environmental impacts for potential projects.
- Updated the entire NEPA online training course provided to employees to make the information more clear, concise, and engaging to users.

A scenic view of wind turbines near Santa Isabel, Puerto Rico. NREL is assisting with Puerto Rico's grid resilience by assisting a 2-year study alongside five other national laboratories to comprehensively analyze stakeholder-driven pathways to Puerto Rico's clean energy future. Prior to construction, a NEPA evaluation on potential environmental impacts was conducted on the entire project, including other partners' involvement. *Photo by Joe DelNero, NREL 84664*

A female American kestrel (*Falco sparverius*) hunts for rodents on the STM Campus. The kestrel is the smallest falcon in North America. Falcons, hawks, owls, and eagles are among the raptors that are frequently spotted on the NREL campuses. *Photo by Werner Slocum, NREL 75698*

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 STM Campus: 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 prairie lizard (*Sceloporus consobrinus*) lives within the Colorado Amphitheater along rocky terrain within the STM Campus conservation easement.[7]

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

Raptor surveys conducted at the Flatirons Campus in 1994 and 1995 identified seven raptor species on or in the vicinity of the campus. An avian survey was again completed in 2003 and updated in 2011.[8] A 2016 survey included mammals, reptiles, and amphibians; 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 shrews (*Sorex cinereus*) continue to feed at and occupy the Flatirons Campus. Although they are seldom seen, western (prairie) rattlesnakes (*Crotalus viridis*), bull snakes (Pituophis catenifer), yellow-bellied racers (*Coluber constrictor*), and several other reptiles are also known to occupy the Flatirons Campus. Amphibians, including boreal chorus frogs (*Pseudacris maculata*), Woodhouse's toad (*Anaxyrus woodhousii*), and sand northern leopard frogs (*Lithobates pipiens*), occupy ephemeral wetlands at the Flatirons Campus.

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

Rattlesnake Safety and Research

Western (prairie) rattlesnakes (*Crotalus viridis*) are important to the native ecology of South Table Mountain and are commonly found on the STM Campus. Rattlesnakes can be found on campus in locations where human safety 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 snake removed.

A turkey vulture (*Cathartes aura*) perches on the top of a post near the Flatirons Campus. Turkey vultures on average measure 2.5 ft (0.8 m) tall and carry a 6-ft (1.8-m) wingspan. Despite their large size, adult turkey vultures typically weigh around 3 lb (1.4 kg).
Photo by Werner Slocum, NREL 81027

Security staff are 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 had 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. From 2018 to 2022, 27 rattlesnakes have been given a PIT tag and relocated

7 Walsh Environmental Scientists and Engineers, LLC. 2011. *2010-20117 Vegetation and Wildlife Surveys at the National Renewable Energy Laboratory, South Table Mountain. Jefferson County, CO.*

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

NREL staff are trained to be cautious and informed on western (prairie) rattlesnakes (*Crotalus viridis*), which live on South Table Mountain. Part of NREL's integrated sustainability is to safely move snakes to protect both the snakes and employees on campus. *Photo by Brent Nelson, NREL 23924*

In a moment of vulnerability, a stunned red-breasted nuthatch (*Sitta canadensis*) sits in front of the main entrance of the ESIF after striking the building. This facility has had windows retrofitted to reduce bird strikes. *Photo by Bryan Bechtold, NREL 72816*

to safer locations on the STM Campus. Although snake tagging was discontinued in 2023, NREL environmental staff still check captured snakes for PIT tags to document recaptures.

Wildlife Incidents at the STM Campus and the Flatirons Campus

A mule deer buck (*Odocoileus hemionus*) died from chronic wasting disease on the STM Campus near the IBRF. Chronic wasting 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 workspace at the RSF at the STM Campus. NREL provided guidance and assistance to safely capture the bird and release it outdoors.

Three great horned owl (*Bubo virginianus*) nestlings were discovered in the STM Campus employee parking garage. One nestling fell out of the nest and was taken to a wildlife rehabilitation center in Boulder, Colorado.

2023 Accomplishments and Highlights

- Captured eight western (prairie) rattlesnakes (*Crotalus viridis*) on the STM Campus; two male snakes were documented as recaptures, three were reported as dead and not checked, and three were relocated and did not have PIT tags.
- Completed the field portion of a sitewide wildlife survey at the Flatirons Campus. The final report is not due until mid-2024 but field results are included in Appendix C. Wildlife Species Observed at the STM Campus and the Flatirons Campus (Table C-2).
- Added 13 new avian species and one new mammal species to the list of observed species on the Flatirons Campus (Table C-2).

A honeybee (*Apis* spp.) loads up on pollen at the RSF on the STM Campus. Insects such as bees and butterflies do the bulk of pollination that affects our daily lives. Changing climate impacts pollinators by shifting growing and blooming seasons, and potentially weakening plant populations that pollinators depend on. Photo by Werner Slocum, NREL 82374

9.2 Endangered Species and Species of Concern

The federal ESA provides 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 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: 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 must 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

Thresher Pond is an ephemeral body of water on the Flatirons Campus. It provides important habitat for amphibians, including the northern leopard frog (*Lithobates pipiens*), a Colorado Species of Greatest Conservation Need. *Photo by Mark Murphy, NREL 88223*

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.

2023 Accomplishments and Highlights

- Conducted a Ute ladies' tresses orchid (*Spiranthes diluvialis*) survey within the proposed waterline project corridor at the Flatirons Campus. None were observed, and it was noted that the project area generally lacked characteristics supporting habitat for the species.
- Conducted threatened and endangered species surveys on the Flatirons Campus. These included small mammal trappings, bird surveys, rare plant searches, and general observations. No federally threatened or endangered species were observed. The results of these studies will help NREL plan for future development by understanding what species reside on the campus.
- Deployed bat ultrasonic recorders, which detected two bat species that are Colorado Species of Greatest Conservation Need: the fringed myotis (*Myotis thysanodes*) and little brown myotis (*Myotis lucifugus*).
- Surveyed amphibians on the Flatirons Campus but did not observe the northern leopard frog (*Lithobates pipiens*), a Colorado Species of Greatest Conservation Need. NREL recognizes that habitat for this species exists on the Flatirons Campus, and when moisture conditions are right, the frog can be present and perhaps breed on-site. However, conditions may not be met every year.

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*), Dalmatian toadflax (*Linaria genistifolia* subsp. *dalmatica*), and myrtle spurge (*Euphorbia myrsinites*) are examples of non-native plants that can have destructive effects on natural habitats.

An NREL environmental scientist released knapweed weevils (*Cyphocleonus achates*) on diffuse knapweed (*Centaurea diffusa*) to help control noxious weeds by the use of biological controls prior to using herbicides. *Photo by Kurt Schlomberg, NREL 88212*

Vegetation management at NREL encompasses 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 fungi that feed on specific weed species), and treatment using herbicides. For example, the laboratory has successfully used multiple control strategies

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 myrsinites*)	None identified
Class B [c]	Canada thistle (*Cirsium arvense*) Common teasel (*Dipsacus fullonum*) Dalmatian 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*) Dalmatian 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]	Common mullein (*Verbascum thapsus*) Downy brome (cheatgrass) (*Bromus tectorum*) Field bindweed (*Convolvulus arvensis*) Poison hemlock (*Conium maculatum*)	Chicory (*Cichorium intybus*) Common mullein (*Verbascum thapsus*) Common St. John's wort (*Hypericum perforatum*) Downy brome (cheatgrass) (*Bromus tectorum*) Field bindweed (*Convolvulus arvensis*)

[a] Species identified reflect the findings of sitewide 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.

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 sitewide 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. Noxious Weed Species Identified at the STM Campus and the Flatirons Campus a.

- **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 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 2023 for the import of *Sphingobium* microorganisms to the STM Campus from within the United States and Japan.

Seasonal wetlands appear annually following spring snow melt and rain. These shallow depressions are found on the South Table Mountain mesa top in various locations and are important habitat for insects and amphibians, especially Woodhouse's toad (*Anaxyrus woodhousii*). *Photo by Tom Ryon, NREL 33063*

2023 Accomplishments and Highlights

- Applied herbicides to a 40-ft (12-m) width centered on the access road within the transmission line corridor on the Rocky Flats National Wildlife Refuge, as agreed via permitting between DOE and USFWS.
- Applied herbicides to control B- and C-listed weeds on approximately 17.2 acres (7.0 hectares) at the Flatirons Campus. In addition, roadside mowing was employed to reduce the growth of Russian thistle (*Salsola* spp.), kochia (*Bassia scoparia*), and diffuse knapweed (*Centaurea diffusa*).
- Released seed-head-feeding weevils (*Cyphocleonus achates*) and lesser knapweed flower weevils (*Larinus minutus*) along the western boundary at the Flatirons Campus to combat diffuse knapweed (*Centaurea diffusa*) within pine tree (*Pinus* spp.) stands where use of herbicide is discouraged to avoid tree damage.
- Applied herbicides targeted to control the spread of Canada thistle (*Cirsium arvense*), diffuse knapweed (*Centaurea diffusa*), jointed goatgrass (*Aegilops cylindrica*), and myrtle spurge (*Euphorbia myrsinites*) in various locations across the STM Campus totaling approximately 5 acres (2 hectares).
- Mechanically removed the prolific species rabbit brush (*Chrysothamnus* spp.) within courtyards and along the outer perimeter buildings; where they were considered too dense, individual plants were treated with herbicide once they grew back. These efforts balance growth with other native plants and landscaping and fire risks while maintaining pollinator habitat.
- Conducted weed maintenance activities at the newly acquired STEP Campus in 2023. Weed management activities included a combination of hand pulling and herbicide applications within rock trim, around utility boxes, and in pavement cracks throughout the site. A total of 1.25 acres (0.51 hectares) were managed.

9.4 Wetlands and Floodplains

Wetlands are lands that are inundated or saturated by surface water 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, as 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,[9] significant historical resources were identified and recommended for further research and documentation. Three historical resources have been identified as significant cultural resources[10] 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 bunker 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

9 S.M. Nelson. 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.

10 W.B. Butler. 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.

West Parkway lies within the 98-acre (40-hectare) Camp George West Historic District.

Like the STM Campus, the STEP Campus is within the boundary of the Camp George West Historic District. As such, activities at the STEP Campus could have the potential to disturb cultural resources. The mess halls (building numbers 12–26), pedestrian underpass, orderly rooms (building numbers 96–97), and three tent pad structures are listed in the National Register of Historic Places. STEP Campus features also contribute to the overall character of the Camp George West Historic District, which is also listed in the National Register of Historic Places.

A formal survey of the Flatirons Campus conducted in 1995 did not identify any additional significant historical or archeological resources.[11]

2023 Accomplishments and Highlights

- Acquired a portion of the Camp George West Historic District, a 6.6-acre (2.7-hectare) parcel that includes mess halls, a pedestrian underpass, orderly rooms, and three tent pad structures that are listed in the National Register of Historic Places. The STEP Campus is within the Camp George West Historic District, which is also listed in the National Register of Historic Places. Prior to commencing projects planned at the STEP Campus, activities must receive a NEPA review and determination, including a review for potential impacts to cultural resources.
- Finalized a baseline comprehensive cultural resource survey at the STEP Campus updating a multi-property survey from 1992 for Camp George West and provided the report to DOE. This survey report provided important input to cultural resource management within the new DOE landholding.

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

Prairie thermopsis (*Thermopsis rhombifolia*) blooms in mid-April on the STM Campus' conservation easement.
Photo by Kurt Schlomberg, NREL 33337

10 CONSERVATION EASEMENT

In 1999, DOE granted Jefferson County a conservation easement of 177 acres (72 hectares) at the STM Campus. In early 2023, the state of Colorado, Jefferson County, and DOE finalized a land swap that granted DOE ownership of what is now the STEP Campus. As part of the land swap, DOE exchanged the majority of its land on the mesa top that was under a conservation easement to Jefferson County for use as open space. The remaining portion of DOE land under conservation easement (Figure 6) is now 19 acres (7.7 hectares).

A baseline inventory of the property was prepared in 1999 to document the condition of the easement property and to assess its conservation value.[12] 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 for 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

12 DOE Golden Field Office. 1999. *National Renewable Energy Laboratory (NREL) Site Conservation Easement Baseline Inventory.* Golden, CO.

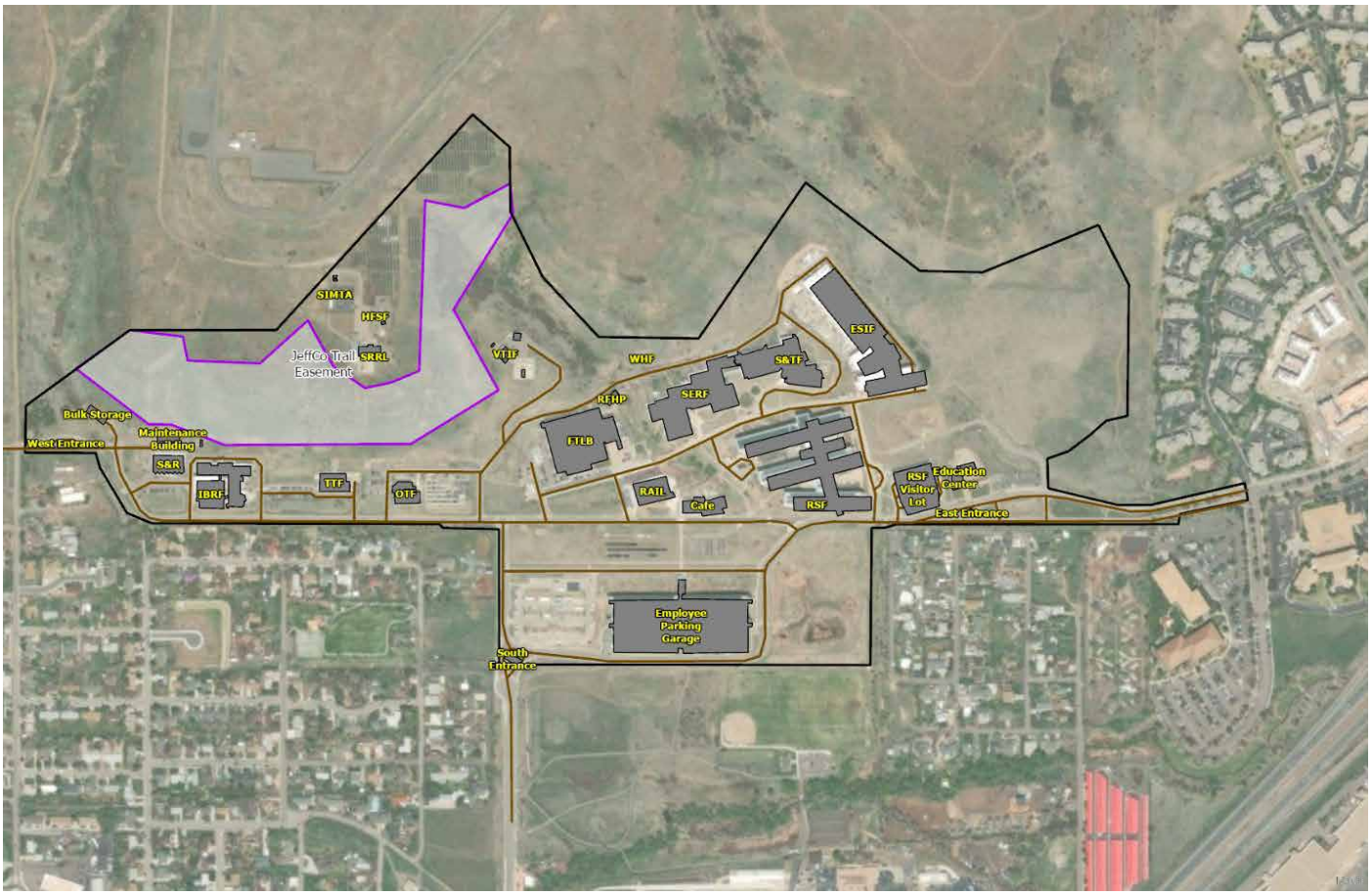


Figure 6. STM Campus New Boundary and Conservation Easement

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.

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.

2023 Accomplishments and Highlights

- Completed a land exchange with the state of Colorado and Jefferson County; conservation easement lands at the STM Campus now total 19 acres (7.7 hectares).

An employee on the environment team talks to a group of outside employees from the Office of Energy Efficiency and Renewable Energy about NREL's detention basin and how various groups across the lab came together to design a sustainable and natural area to control stormwater on the STM Campus. *Photo by Agata Bogucka, NREL 88480*

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.

EMS

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, 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 advancing the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies and providing 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.

Environmental Justice

NREL addresses environmental justice concerns through implementation of the NEPA review process. Sitewide environmental assessments and environmental assessments for new projects identify environmental justice communities that could be affected and consider potential routes of impact to identified communities. Public outreach efforts solicit input from potentially affected communities. Mitigation actions may be identified through the NEPA process and implemented through the project.

For information and current performance in this area, see Section 3.3: Environmental Justice.

Air Quality

For general information and current performance in this area, see Section 5: Air Quality Protection.

Criteria Pollutant and HAP Permitting

The laboratory maintains an air emissions 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 infrastructure projects and research experiments are evaluated, and air emissions 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, pollution control systems, and certain research activities) that are subject to 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 for new construction activity. The permit requires certain fugitive emission controls 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 and contributes to improved air quality for neighbors. This meets the Denver metropolitan area's requirement to control particulate matter emissions from on-site vehicle traffic. NREL submits an annual report to Colorado detailing how NREL complies with required particulate control and how deicer is used, and confirming sand is not used on NREL roadways.

For information and current performance in this area, see Section 5.1: Criteria Pollutants and Hazardous Air Pollutants.

GHG 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 CO_2e greenhouse gas emissions (from any source 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 CO2e emissions in the major source permit if CO2e emissions exceed 75,000 U.S. tons (68,000 MT) per year. The STM Campus is a "minor" source for most criteria air pollutants and is classified as a "major" source for NO_x emissions. Because CO2e emissions for the STM Campus and the Flatirons Campus are lower than both of the aforementioned limits, GHG and CO2e reporting is not required.

Certain GHGs are essential to safe operation of certain equipment. As an example, sulfur hexafluoride, a potent GHG, is used in certain high-voltage or high-amperage electrical equipment as a dielectric gas. Such use may include 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 resulting from 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 state of Colorado regulate refrigerants to reduce emissions of these compounds to the atmosphere. The NREL refrigerant management program is intended to achieve that goal.

Management of refrigerants includes ozone-depleting substances and HFC substances. This 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, (2) larger appliances containing ozone-depleting substances that are subject to specific detailed repair and documentation standards for ozone-depleting substances, and (3) larger HFC-containing appliances that are expected to be subject to EPA-proposed specific HFC 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.

NREL follows, to the extent practicable and consistent with research requirements, the requirements, guidelines, and suggestions of the EPA Significant New Alternatives Program, which recommends substitute refrigerants that have low or zero impact on global warming.

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 and STEP 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 on-site 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 and trihalomethanes) 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 off-site 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 hectares) 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 have been developed that are needed for compliance with the permit's six minimum control measures. The programs will be implemented in subsequent permit terms. The second-term MS4 has been applied for, and the current permit has been administratively extended.

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 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 7.1: Hazardous Materials 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.
- Providing 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 on-site 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 on-site 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 on-site 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 off-site for final disposal via incineration, treatment, or landfilling.

For information and current performance in this area, see Section 7.2: Hazardous Waste Management.

AST 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 facility. 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 the size of spills, and advance preparation for spill response speeds the response and helps 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, fuel transfer spills, and similar events 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. Spill kits are continually added as NREL continues to grow.

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 on-site.
- Monitoring equipment and facilities for removable contamination or sealed-source leakage.

No radioactive air emissions monitoring is conducted at the laboratory because of its extremely low use of radioactive materials. NREL demonstrates compliance with radiological air emissions standards by using the EPA's COMPLY model (Version 1.7.1) 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 radioactive waste that is federally regulated under the RCRA and is categorized as "mixed waste." Therefore, all radioactive waste generated is classified solely as low-level radioactive waste.

Waste is temporarily stored on-site until disposal is arranged at an off-site 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.

NEPA

Once a project is proposed, the NEPA process is initiated, and it must be completed before the proposed project or activity begins. In accordance with regulations, all NREL activities (both on-site and off-site) 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 sitewide 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 sitewide 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 R&D. The programmatic NEPA determinations are based on the existing sitewide environmental assessments or DOE categorical exclusions and are reviewed annually for applicability.

Using the sitewide 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. The DOE Golden Field Office must complete the NEPA review.

If a proposed activity has not already been evaluated in an existing sitewide 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:

- 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 sitewide 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, 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, which assesses impacts to natural resources from mission activities.

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.

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 sitewide 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 challenges of dynamic climate change.

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 fungi or insects that prefer certain weed species).
- Applying herbicides 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, applying herbicide in graveled areas, and removing shrubs and trees 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 archeologist evaluates its significance.

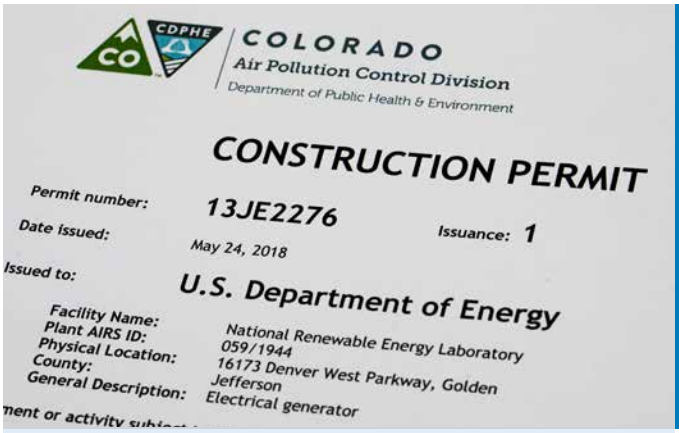
For information and current performance in this area, see Section 9.5: Cultural Resources.

Conservation Lands

Approximately 19 acres (7.7 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. Environmental Permits, Registrations, and Notifications in 2023 lists NREL's environmental permits including each permit's issuing agency, identification, and status.

Table B-1. Environmental Permits, Registrations, and Notifications in 2023

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	Canceled
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):[a] wood waste boiler	Permit	APCD	07JE0277	Active
STM Campus (RSF 1): diesel-fired standby electrical generator	Permit	APCD	10JE1400	Active
STM Campus (RSF 2): diesel-fired standby electrical generator	Permit	APCD	11JE1303	Active
STM Campus (SERF): two chlorofluorocarbon-containing stationary sources	Registration	APCD	647	Canceled
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):[b] standby diesel-fired electrical generator	APEN	APCD	13JE2271 XP	Active
Alcohol				
Laboratory-wide: tax-free alcohol use	Permit	TTB [c]	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 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	2023DFD- HZ-007415	Completed
STM Campus (ESIF): hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
STM Campus (FTLB): hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
STM Campus (IBRF): hazardous material storage and use permit	Permit	West Metro Fire Rescue	N/A	Completed
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):[d] 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 bunker	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
Flatirons Campus: Control Center Facility	Permit	EPA	COR10F09Z	Active
STM Campus: MS4	Permit	EPA	COR042009	Active
STM Campus: RAIL	Permit	EPA	COR10F075	Active

[a] Renewable Fuel Heat Plant.
[b] Structural Testing Laboratory.
[c] Alcohol and Tobacco Tax and Trade Bureau (U.S. Department of the Treasury).
[d] Waste Handling Facility.

The EPA's Enforcement and 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."[13] According to the ECHO database, no violations or enforcement actions are associated with NREL facilities.

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

13 EPA. n.d. "Enforcement and Compliance History Online." echo.epa.gov/.

A pair of great horned owls (*Bubo virginianus*) roost on the fourth floor of the STM Campus parking garage. *Photo by Werner Slocum, NREL 88234*

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. Wildlife Species Observed at the STM Campus) were observed by staff and/or were observed in surveys completed in 2005, 2011, and 2017.Species listed for the Flatirons Campus (Table C-2) were identified in surveys completed in 2003, 2011, and 2016.[14] The Flatirons Campus obtained preliminary results of the 2023 field surveys which are also presented in Table C-2.

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
Black-billed magpie	*Pica hudsonia*	X	X	X
Black-capped chickadee	*Poecile atricapillus*	X		X
Black-crowned night heron	*Nycticorax nycticorax*	X		
Black-headed grosbeak	*Pheucticus melanocephalus*		X	

14 For 1987 survey results, refer to: NREL. 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. www.nrel.gov/docs/fy17osti/68671.pdf.

STM Campus				
Common Name	**Scientific Name**	**2005 Survey**	**2011 Survey**	**2017 Survey**
Birds				
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	*Spizella pallida*			X
Cliff swallow	*Petrochelidon pyrrhonota*		X	X
Common grackle	*Quiscalus quiscula*		X	X
Common nighthawk	*Chordeiles minor*	X	X	X
Common raven	*Corvus corax*	X	X	X
Common yellowthroat	*Geothlypis trichas*			X
Cooper's hawk	*Accipiter cooperii*	X	X	
Dark-eyed junco	*Junco hyemalis*	X	X	X
Double-crested cormorant	*Phalacrocorax auritus*		X	X
Eastern kingbird	*Tyrannus tyrannus*		X	
Eurasian collared-dove	*Streptopelia decaocto*			X
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*			

STM Campus				
Common Name	**Scientific Name**	**2005 Survey**	**2011 Survey**	**2017 Survey**
Birds				
Green-tailed towhee	Pipilo chlorurus		X	
Hammond's flycatcher	*Empidonax hammondii*			X
Hepatic tanager	*Piranga flava*		X	
Hermit thrush	*Catharus guttatus*		X	
Horned lark	*Eremophila alpestris*		X	
House finch	*Carpodacus mexicanus*	X	X	X
House sparrow	*Passer domesticus*	X	X	X
House wren	*Troglodytes aedon*		X	X
Killdeer	*Charadrius vociferous*	X	X	
Lark bunting	*Calamospiza melanocorys*	X		
Lark sparrow	*Chondestes grammacus*		X	X
Lazuli bunting	*Passerina amoena*		X	
Lesser goldfinch	*Carduelis psaltria*		X	X
Lincoln's sparrow	*Melospiza lincolnii*			X
Loggerhead shrike	*Lanius ludovicianus*	X		
MacGillivray's warbler	*Oporornis tolmiei*	X		
Mallard	*Anas platyrhynchos*	X		
Mountain bluebird	*Sialia currucoides*	X		X
Mountain chickadee	*Poecile gambeli*		X	
Mourning dove	*Zenaida macroura*	X		X
Northern flicker	*Colaptes auratus*	X		X
Northern goshawk	*Accipiter gentilis*		X	
Northern harrier	*Circus cyaneus*	X		X
Northern mockingbird	*Mimus polyglottos*			X
Northern pygmy-owl	*Glaucidium californicum*			X
Northern rough-winged swallow	*Stelgidopteryx serripennis*			X
Northern saw-whet owl [a]	*Aegolius acadicus*			
Orange-crowned warbler [a]	*Oreothlypis celata*			
Osprey	*Pandion haliaetus*	X		X
Peregrine falcon	*Falco peregrinus*		X	
Pine siskin	*Carduelis pinus*		X	
Prairie falcon	*Falco mexicanus*	X		X
Red-breasted nuthatch	*Sitta canadensis*	X		X
Red-tailed hawk	*Buteo jamaicensis*	X		X

STM Campus				
Common Name	**Scientific Name**	**2005 Survey**	**2011 Survey**	**2017 Survey**
Birds				
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
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	

STM Campus				
Common Name	**Scientific Name**	**2005 Survey**	**2011 Survey**	**2017 Survey**
Mammals				
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 nuttallii*	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		
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 viridis*	X	X	
Woodhouse's toad	*Anaxyrus 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**	**2023 Preliminary Results**
Birds					
American crow	*Corvus brachyrhynchos*		X		X
American goldfinch	*Spinus tristis*	X	X		X
American kestrel	*Falco sparverius*	X	X	X	X
American pipit	*Anthus rubescens*		X		
American robin	*Turdus migratorius*	X	X	X	X
American tree sparrow	*Spizella arborea*		X		X
Bald eagle	*Haliaeetus leucocephalus*		X		
Barn swallow	*Hirundo rustica*	X	X	X	X
Bell's sparrow	*Artemisiospiza belli*				X
Black-billed magpie	*Pica hudsonia*	X	X	X	X
Black-capped chickadee	*Poecile atricapillus*	X	X		X
Blue-gray gnatcatcher	*Polioptila caerulea*	X		X	X
Blue grosbeak	*Passerina caerulea*				X
Blue jay	*Cyanocitta cristata*		X		
Brewer's blackbird	*Euphagus cyanocephalus*	X	X	X	X
Brewer's sparrow	*Spizella breweri*		X		
Broad-tailed hummingbird	*Selasphorus platycercus*	X	X	X	X
Broad-winged hawk a	*Buteo platypterus*				
Brown-headed cowbird	*Molothrus ater*	X	X		X
Bullock's oriole	*Icterus bullockii*		X	X	X
Canada goose	*Branta canadensis*		X	X	X
Cedar waxwing	*Bombycilla cedrorum*		X		X
Chipping sparrow	*Spizella passerina*	X	X		X
Cliff swallow	*Petrochelidon pyrrhonota*	X			
Common grackle	*Quiscalus quiscula*	X	X		
Common nighthawk	*Chordeiles minor*	X		X	X
Common raven	*Corvus corax*	X	X	X	X
Common yellowthroat	*Geothlypis trichas*				X
Cooper's hawk a	*Accipiter cooperii*				
Dark-eyed junco	*Junco hyemalis*		X		X
Double-crested cormorant	*Phalacrocorax auritus*	X		X	X
Downy woodpecker	*Picoides pubescens*		X		X
Eurasian collared-dove	*Streptopelia decaocto*		X		X
European starling	*Sturnus vulgaris*	X	X	X	X
Ferruginous hawk	*Buteo regalis*	X	X		
Franklin's gull	*Larus pipixcan*		X		

Flatirons Campus					
Common Name	**Scientific Name**	**2003 Survey**	**2011 Survey**	**2016 Survey**	**2023 Preliminary Results**
Birds					
Golden eagle b	*Aquila chrysaetos*	X	X		
Grasshopper sparrow	*Ammodramus savannarum*	X	X	X	X
Gray catbird	*Dumetella carolinensis*		X	X	X
Great blue heron	*Ardea herodias*	X	X	X	
Great egret	*Ardea alba*				X
Great horned owl	*Bubo virginianus*		X	X	
Great-tailed grackle	*Quiscalus mexicanus*				X
Green-tailed towhee	*Pipilo chlorurus*	X		X	X
Hairy woodpecker	*Picoides villosus*		X		
Horned lark	*Eremophila alpestris*	X	X		
House finch	*Carpodacus mexicanus*	X	X	X	X
House wren	*Troglodytes aedon*			X	X
Killdeer	*Charadrius vociferus*		X	X	X
Lark bunting	*Calamospiza melanocorys*		X		
Lark sparrow	*Chondestes grammacus*	X		X	X
Lesser goldfinch	*Spinus psaltria*				X
Loggerhead shrike	*Lanius ludovicianus*		X		
Long-billed curlew	*Numenius americanus*		X		
Mallard	*Anas platyrhynchos*	X	X		
Mountain bluebird	*Sialia currucoides*	X	X		X
Mountain chickadee	*Poecile gambeli*		X		
Mourning dove	*Zenaida macroura*	X	X	X	
Northern flicker	*Colaptes auratus*	X	X		X
Northern harrier	*Circus cyaneus*	X	X		
Northern rough-winged swallow	*Stelgidopteryx serripennis*				X
Peregrine falcon	*Falco peregrinus*	X	X		
Prairie falcon	*Falco mexicanus*	X			
Red-headed woodpecker	*Melanerpes erythrocephalus*		X		
Red-tailed hawk	*Buteo jamaicensis*	X	X	X	X
Red-winged blackbird	*Agelaius phoeniceus*	X	X	X	X
Rock pigeon	*Columba livia*				X
Rough-legged hawk	*Buteo lagopus*	X	X		
Ruby-crowned kinglet	*Regulus calendula*		X		
Sandhill crane	*Grus canadensis*		X		
Savannah sparrow	*Passerculus sandwichensis*		X		X
Say's phoebe	*Sayornis saya*	X	X	X	X
Sharp-shinned hawk	*Accipiter striatus*				X

Flatirons Campus					
Common Name	**Scientific Name**	**2003 Survey**	**2011 Survey**	**2016 Survey**	**2023 Preliminary Results**
Birds					
Song sparrow	*Melospiza melodia*		X	X	X
Spotted towhee	*Pipilo maculatus*		X	X	X
Swainson's hawk	*Buteo swainsoni*		X		
Swainson's trush	*Catharus ustulatus*				X
Townsend's solitaire	*Myadestes townsendi*		X		
Tree swallow	*Tachycineta bicolor*		X		
Turkey vulture	*Cathartes aura*	X	X		
Vesper sparrow	*Pooecetes gramineus*	X	X	X	X
Virginia rail	*Rallus limicola*				X
Western kingbird	*Tyrannus verticalis*	X	X	X	X
Western meadowlark	*Sturnella neglecta*	X	X	X	
Western wood-pewee	*Contopus sordidulus*			X	
White-crowned sparrow	*Zonotrichia leucophrys*				X
Wild turkey	*Meleagris gallopavo*				X
Wilson's snipe	*Gallinago delicata*		X	X	
Wilson's warbler	*Wilsonia pusilla*	X			
Yellow-rumped warbler	*Dendroica coronata*	X			X
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	X
Deer mouse	*Peromyscus maniculatus*		X	X	X
Desert cottontail rabbit	*Sylvilagus audubonii*		X	X	X
Eastern red bat	*Lasiurus borealis*		X	X	
Elk	*Cervus canadensis*		X	X	X
Fringed myotis [b]	*Myotis thysanodes*		X	X	
Hoary bat	*Lasiurus cinereus*		X	X	
Little brown myotis [b]	*Myotis lucifugus*		X	X	
Masked shrew	*Sorex cinereus*		X	X	
Meadow vole	*Microtus pennsylvanicus*		X	X	X
Mexican woodrat	*Neotoma mexicana*		X	X	X
Mountain lion	*Puma concolor*			X	
Mule deer	*Odocoileus hemionus*		X	X	X
Myotis bat	*Myotis* spp.		X	X	
Red fox	*Vulpes vulpes*				X
Prairie vole	*Microtus ochrogaster*		X	X	

Flatirons Campus					
Common Name	**Scientific Name**	**2003 Survey**	**2011 Survey**	**2016 Survey**	**2023 Preliminary Results**
Mammals *continued*					
Silver-haired bat	*Lasionycteris noctivagans*		X	X	
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*		X		X
Western harvest mouse	*Reithrodontomys megalotis*		X	X	
Western small-footed myotis	*Myotis ciliolabrum*		X	X	
White-tailed deer	*Odocoileus virginiana*			X	X
Yellow-bellied marmot [a]	*Marmota flaviventris*				
Reptiles and Amphibians					
Boreal chorus frog	*Pseudacris maculata*		X	X	
Bull snake	*Pituophis catenifer*		X	X	
Northern leopard frog [b]	*Lithobates pipiens*			X	
Painted turtle [a]	*Chrysemys picta*				
Tiger salamander	*Ambystoma tigrinum*			X	
Western (prairie) rattlesnake	*Crotalus viridis*	X	X	X	
Woodhouse's toad	*Anaxyrus 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.

Three distributed wind scale turbines operate within the mixed-grass prairie formation at the Flatirons Campus.
Photo by Gregory Cooper, NREL 90292

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. Land cover types at the STM Campus.

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 Class 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. *vivipara*). Well-drained hillocks often support thick stands of needle-and-thread grass (*Hesperostipa comata*) and yucca (*Yucca glauca*). Some short shrubs such as rubber rabbitbrush (*Ericameria nauseosa*), 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 (*Ericameria nauseosa)*. 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 willows (*Salix amygdaloides*) 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.

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

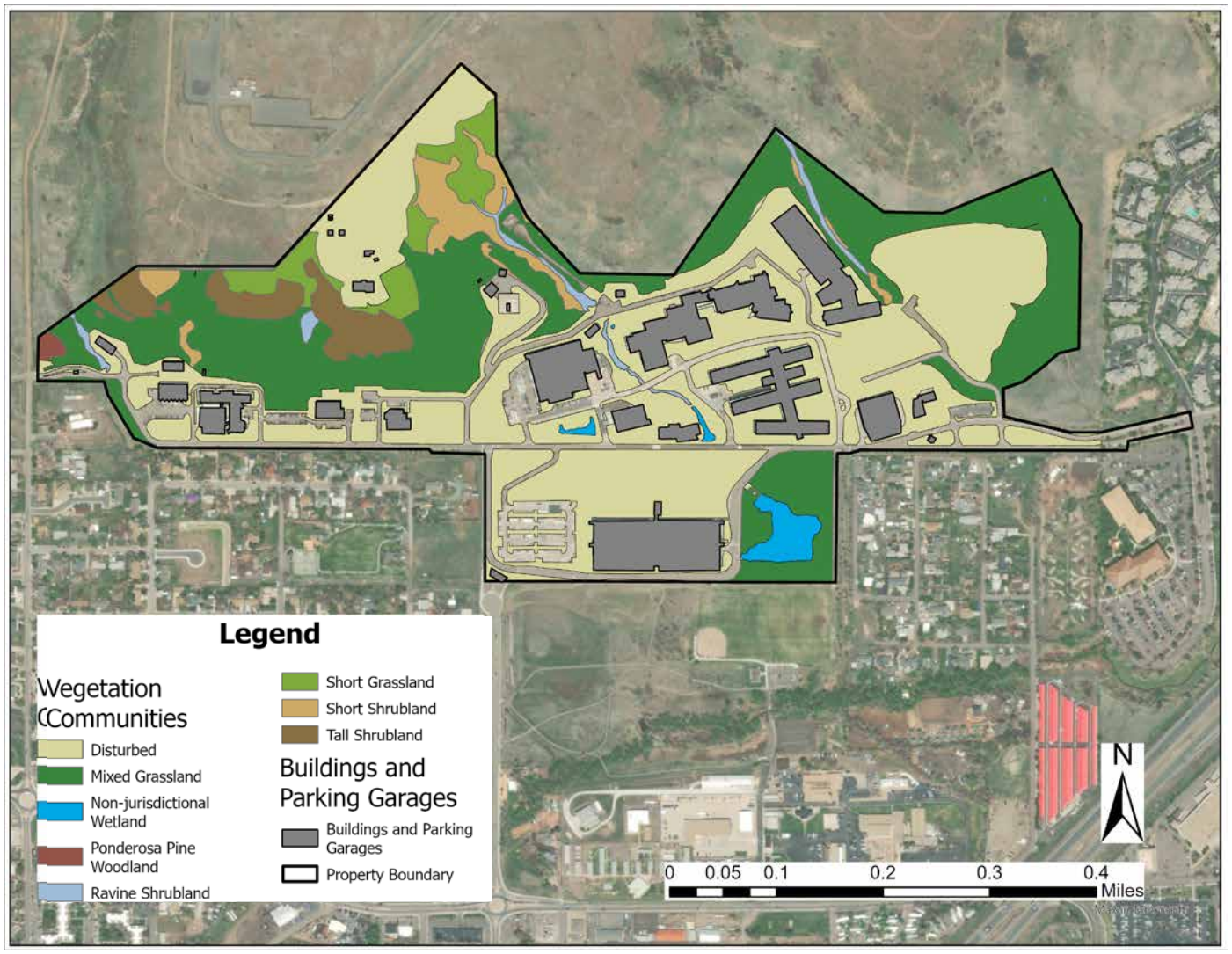


Figure D-1. Land cover types at the STM Campus

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. Wetland types and vegetation communities at the Flatirons Campus.

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.

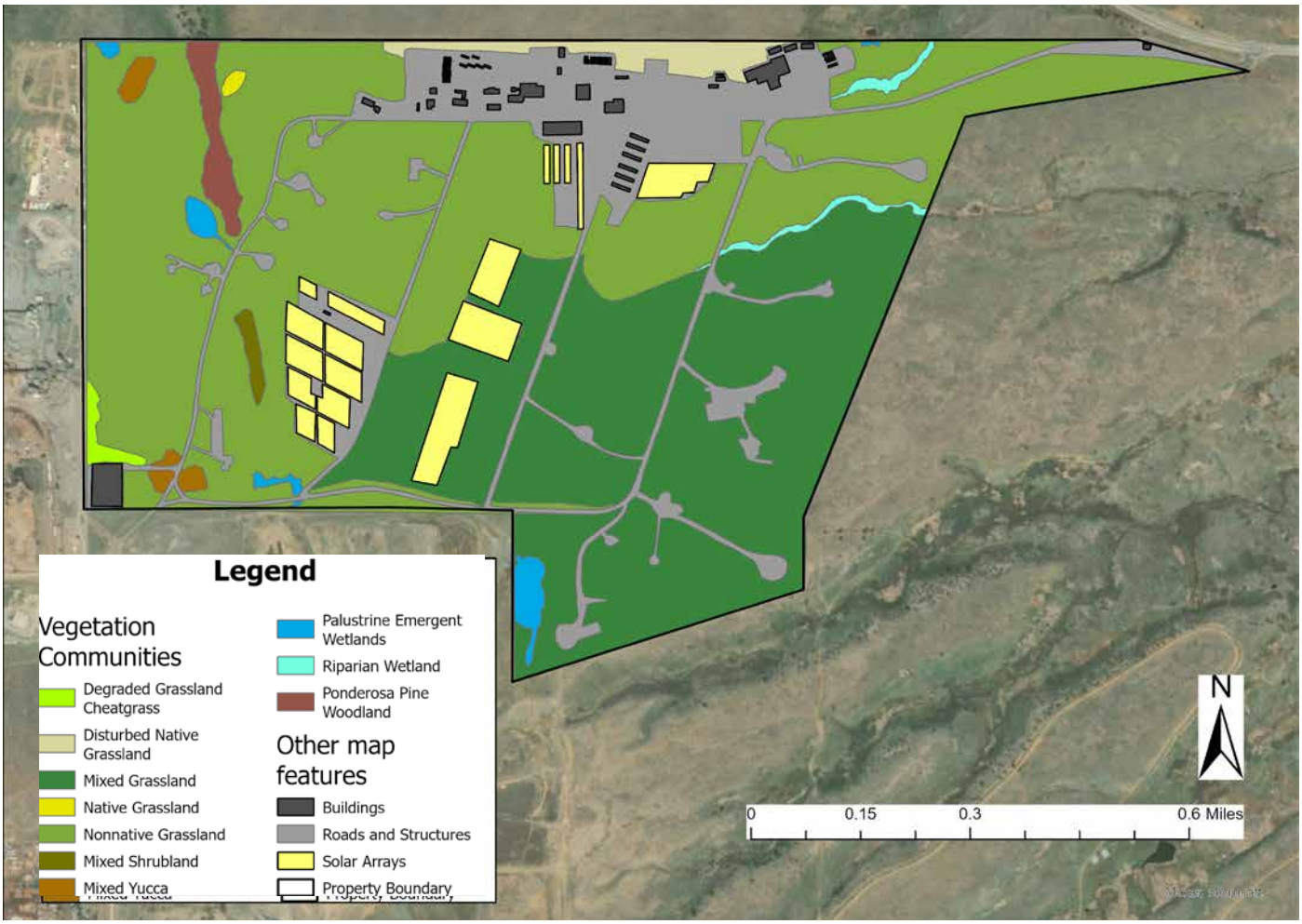


Figure D-2. Wetland types and vegetation communities at the Flatirons Campus

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 off-site 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 erythropoda*) occurs along the western site boundary within the Flatirons Campus site boundary. These trees are at the top of the slope, directly east of an active area of construction disturbance that is outside the Flatirons Campus boundary.

Palustrine Emergent Wetlands

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

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

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*).

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. Wetland types and vegetation communities at the Flatirons Campus), 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 Class B noxious weeds, occur within the northernmost drainage. Other observed species include short-beak sedge (*Carex brevior*), swordleaf rush (*Juncus ensifolius*), longstyle rush (*Juncus longistylis*), Torrey's rush (*Juncus torreyi*), common spikerush (*Eleocharis palustris*), and switchgrass (*Panicum virgatum*). Occasional plains cottonwood (*Populus deltoides)* trees and sandbar willow (*Salix exigua)* shrubs occur along these drainages.

Disturbed Areas and Non-Habitat

These cover types reflect surface disturbance 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. Wetland types and vegetation communities at the Flatirons Campus.)

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. Wetland types and vegetation communities at the Flatirons Campus.)

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