



# Environmental Performance Report 2011

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

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

**Cover Photo: Native, water efficient landscaping at the RSF.**

*Photo by Robb Williamson, NREL/PIX 20958*

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# Nomenclature

<b>ARRA</b> —American Recovery and Reinvestment Act	<b>JSF</b> —Joyce Street Facility
<b>AEO</b> —Annual Energy Outlook	<b>kg</b> —Kilogram
<b>AFUF</b> —Alternative Fuels User Facility	<b>kW</b> —Kilowatt
<b>AFV</b> —Alternative Fuel Vehicle	<b>LEED</b> —Leadership in Energy and Environmental Design
<b>APCD</b> —Air Pollution Control Division of CDPHE	<b>LEPC</b> —Local Emergency Planning Committee
<b>APEN</b> —Air Pollutant Emission Notice	<b>LOMR</b> —Letter of Map Revision
<b>ASHRAE</b> —American Society of Heating, Refrigerating, and Air-Conditioning Engineers	<b>LOS</b> —Level of Service
<b>AST</b> —Aboveground Storage Tank	<b>LQG</b> —Large Quantity Generator
<b>AWS</b> —Alternative Work Schedule	<b>MAP</b> —Mitigation Action Plan
<b>BMP</b> —Best Management Practice	<b>MBTA</b> —Migratory Bird Treaty Act
<b>CCR</b> —Colorado Code of Regulations	<b>MCL</b> —Maximum Contaminant Level
<b>CDLE</b> —Colorado Department of Labor and Employment	<b>MOU</b> —Memorandum of Understanding
<b>CDPHE</b> —Colorado Department of Public Health and Environment	<b>MMtC/Yr</b> —Million Metric Tons of Carbon Per Year
<b>CELP</b> —Colorado Environmental Leadership Program	<b>mrem</b> —Millirem
<b>CEQ</b> —Council on Environmental Quality	<b>MRR</b> —Mandatory Reporting Rule
<b>CERC</b> —Colorado Emergency Response Commission	<b>MSDS</b> —Material Safety Data Sheet
<b>CESQG</b> —Conditionally Exempt Small Quantity Generator	<b>MT</b> —Metric Ton
<b>CFR</b> —Code of Federal Regulations	<b>MW</b> —Megawatt
<b>CGP</b> —Construction General Permit	<b>NAAQS</b> —National Ambient Air Quality Standards
<b>CLOMR</b> —Conditional Letter of Map Revision	<b>NEPA</b> —National Environmental Policy Act
<b>CMS</b> —Chemical Management System	<b>NHPA</b> —National Historic Preservation Act
<b>CNHP</b> —Colorado Natural Heritage Program	<b>NREL</b> —National Renewable Energy Laboratory
<b>CO<sub>2</sub></b> —Carbon Dioxide	<b>NWTC</b> —National Wind Technology Center
<b>CO<sub>2</sub>e</b> —Carbon Dioxide Equivalent	<b>NESHAP</b> —National Emission Standards for Hazardous Air Pollutants
<b>CRADA</b> —Cooperative Research and Development Agreement	<b>NOI</b> —Notice of Intent
<b>CSP</b> —Concentrating Solar Power	<b>NO<sub>x</sub></b> —Nitrogen Oxides
<b>CWA</b> —Clean Water Act	<b>N<sub>2</sub>O</b> —Nitrous Oxide
<b>CX</b> —Categorical Exclusion	<b>ODS</b> —Ozone Depleting Substance
<b>DFD</b> —Denver Fire Department	<b>OPA</b> —Oil Pollution Act
<b>DNR</b> —Colorado Department of Natural Resources	<b>PEMP</b> —Performance Evaluation and Measurement Plan
<b>DSOC</b> —District Shops and Operations Center	<b>PM</b> —Particulate Matter
<b>DOE</b> —U.S. Department of Energy	<b>PPA</b> —Power Purchase Agreement
<b>DOE GO</b> —Department of Energy Golden Field Office	<b>PPI</b> —Pollution Prevention Initiative
<b>DOE O</b> —Department of Energy Order	<b>PSD</b> —Prevention of Significant Deterioration
<b>DOPS</b> —Division of Oil & Public Safety of the Colorado Dept. of Labor & Employment	<b>PUE</b> —Power Usage Effectiveness
<b>DWOP</b> —Denver West Office Park	<b>PV</b> —Photovoltaic
<b>DWP/DWMB</b> —Denver West Parkway/Denver West Marriott Boulevard	<b>RCRA</b> —Resource Conservation and Recovery Act
<b>EA</b> —Environmental Assessment	<b>REC</b> —Renewable Energy Certificate
<b>EEER</b> —DOE Office of Energy Efficiency and Renewable Energy	<b>ReFUEL</b> —Renewable Fuels and Lubricants Laboratory
<b>EHS</b> —Environment, Health, and Safety	<b>RFA</b> —Rocky Flats Alluvium
<b>EIA</b> —Energy Information Administration	<b>RFHP</b> —Renewable Fuels Heat Plant
<b>EIS</b> —Environmental Impact Statement	<b>RFP</b> —Request for Proposal
<b>EISA</b> —Energy Independence and Security Act	<b>RFS</b> —Renewable Fuel Standard
<b>EMS</b> —Environmental Management System	<b>RQ</b> —Reportable Quantity
<b>EPA</b> —Environmental Protection Agency	<b>RSF</b> —Research Support Facility
<b>EPCRA</b> —Emergency Planning and Community Right-to-Know Act	<b>RTD</b> —Regional Transportation District
<b>ERT</b> —Emergency Response Team	<b>SARA</b> —Superfund Amendments and Reauthorization Act
<b>ESA</b> —Endangered Species Act	<b>SDWA</b> —Safe Drinking Water Act
<b>ESIF</b> —Energy Systems Integration Facility	<b>SERF</b> —Solar Energy Research Facility
<b>ESPC</b> —Energy Savings Performance Contract	<b>SERI</b> —Solar Energy Research Institute
<b>EO</b> —Executive Order	<b>SF<sub>6</sub></b> —Sulfur Hexafluoride
<b>FEC</b> —Federal Electronics Challenge	<b>SHPO</b> —State Historic Preservation Officer
<b>FIFRA</b> —Federal Insecticide, Fungicide, and Rodenticide Act	<b>SITES</b> —Sustainable Sites Initiative
<b>FONSI</b> —Finding of No Significant Impact	<b>SO<sub>2</sub></b> —Sulfur Dioxide
<b>FOA</b> —Funding Opportunity Announcement	<b>SPCC</b> —Spill Prevention Control and Countermeasures
<b>FTLB</b> —Field Test Laboratory Building	<b>SQG</b> —Small Quantity Generator
<b>FY</b> —Fiscal Year	<b>SRRL</b> —Solar Radiation Research Laboratory
<b>GHG</b> —Greenhouse Gas	<b>SSP</b> —Site Sustainability Plan
<b>GP</b> —Guiding Principles	<b>SSPP</b> —Strategic Sustainability Performance Plan
<b>GWP</b> —Global Warming Potential	<b>S&amp;TF</b> —Science & Technology Facility
<b>HAP</b> —Hazardous Air Pollutant	<b>STM</b> —South Table Mountain
<b>HEPA</b> —High-Efficiency Particulate Air	<b>SWPPP</b> —Stormwater Pollution Prevention Plan
<b>HMIS</b> —Hazardous Materials Information System	<b>TDM</b> —Transportation Demand Management
<b>HMWMD</b> —Hazardous Materials and Waste Management Division of CDPHE	<b>TESC</b> —Threatened, Endangered or Species of Concern
<b>HP</b> —Horsepower	<b>TES</b> —Thermal Energy Storage
<b>IBRF</b> —Integrated Biorefinery Research Facility	<b>TPQ</b> —Threshold Planning Quantity
<b>ILA</b> —Industrial, Landscaping, and Agricultural	<b>TTB</b> —Alcohol & Tobacco Tax & Trade Bureau of the U.S. Department of the Treasury
<b>ISDS</b> —Individual Sewage Disposal System	<b>USACE</b> —U.S. Army Corps of Engineers
<b>ISM</b> —Integrated Safety Management	<b>USFWS</b> —U.S. Fish and Wildlife Service
<b>ISMS</b> —Integrated Safety Management System	<b>VOC</b> —Volatile Organic Compound
<b>ISO</b> —International Organization for Standardization	<b>WHF</b> —Waste Handling Facility

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## Executive Summary

### Purpose

The National Renewable Energy Laboratory's (NREL) Environmental Performance Report provides a description of the laboratory's environmental management activities for 2011 including information on environmental and sustainability performance, environmental compliance activities and status, and environmental protection programs, highlights, and successes.

This report is prepared in accordance with the U.S. Department of Energy (DOE) Order 231.1B, *Environment, Safety and Health Reporting*, which was implemented to ensure that DOE receives timely, accurate information about events that have affected or could adversely affect the health, safety and security of the public or workers, the environment, or the operations of DOE facilities.

### Mission and Programs

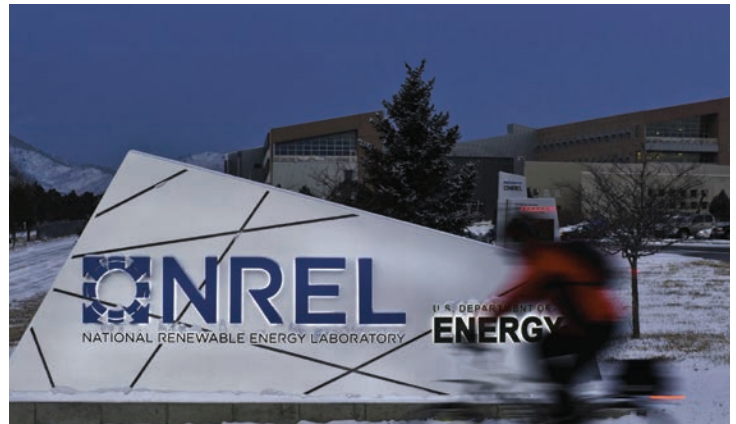
NREL is the principal research laboratory for DOE's Office of Energy Efficiency and Renewable Energy (EERE). The laboratory also conducts research for the Office of Science and the Office of Electricity Delivery and Energy Reliability. The laboratory is managed for EERE by the Alliance for Sustainable Energy, LLC, a partnership between the Battelle Memorial Institute and MRIGlobal.

NREL is the only national laboratory solely dedicated to advancing renewable energy and energy efficiency technologies from concept to commercial application. For 35 years, the laboratory's innovations, analysis, and expertise have enabled the emergence of a U.S. clean energy industry and led to numerous success stories from across the laboratory. The laboratory's 327-acre main campus at South Table Mountain (STM) in Golden, Colorado, is a living model of sustainable energy. The laboratory also operates the National Wind Technology Center (NWTC) on 305 acres located 13 miles north of its main campus.

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

NREL's areas of expertise include:

- Renewable Fuels—Biomass, hydrogen and fuel cells, and vehicle technologies
- Renewable Electricity—Solar, wind, water, geothermal, smart-grid technology, and building technology and efficiency
- Energy Science—Chemical and biosciences, scientific computing, and materials science
- Strategic Energy Analysis—Technology, markets, public policy, security, and government programs



Entrance to NREL's South Table Mountain campus. Photo by Dennis Schroeder, NREL/PIX 18298

### About NREL

NREL is the nation's premier laboratory for renewable energy research and development and a leading laboratory for energy efficiency research, with programs in wind energy, solar energy, plant and waste-derived fuels and chemicals, energy efficiency in buildings, geothermal energy, advanced vehicle design, hydrogen infrastructure, and fuel cells. NREL conducts research primarily for DOE EERE.

Established in 1974, NREL began operating in 1977 as the Solar Energy Research Institute (SERI). It was designated a DOE national laboratory in September 1991 as NREL. Since October 2008, NREL has been operated by the Alliance for Sustainable Energy, LLC, a partnership between MRIGlobal and the Battelle Memorial Institute. The new operating contract has a five-year duration and is overseen by DOE's Golden Field Office (DOE GO).

- Commercialization and Technology Transfer—Sponsored research and development agreements and licenses with private industry to develop commercial products
- Deployment—Information and tools to help communities, industry, and government select the most impactful technologies to reduce their fossil energy use.

## Significant Activities in 2011

Several major construction projects were in progress this year at the STM and NWTC sites. To manage the extensive development currently underway the laboratory uses a design-build approach that partners NREL with design-build industry leaders. This approach incorporates rigorous project controls and earned-value methodologies to provide the laboratory with world-class, energy-efficient, and sustainable facilities. These facilities are critical to conduct and support the energy research and development for our world's energy future. Some of the major projects in progress or completed include:

- The third wing of the Research Support Facility (RSF), an office building designed to house 800 employees, was completed in late 2011. The building produces as much energy as it consumes on-site, meets world-class energy and environmental design standards, and achieved the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Platinum certification.
- Construction of a new 1800 spot parking garage commenced and will meet the parking needs of the increased number of staff located at the STM site relocated from leased space at Denver West Office Park (DWOP).
- A major expansion of the Integrated Biorefining Research Facility (IBRF), formerly the Alternative Fuels User Facility (AFUF), was completed that enhances the capabilities of the facility and adds more office space. The facility received LEED Gold certification.
- A new south entrance to the STM campus commenced construction. The entrance includes a site entrance building designed to achieve LEED Platinum certification. Due to the relocation of staff from DWOP to the STM site, an increase in vehicle traffic to the site will occur. The new entrance is designed to improve traffic flow to the campus by redirecting much of the traffic from the current Denver West Parkway entrance when opened in 2012.
- Construction commenced on the Energy Systems Integration Facility (ESIF). The 183,000 square foot (ft<sup>2</sup>) building will house about 200 researchers. ESIF is being designed to achieve LEED Gold certification and construction is expected to be completed in late 2012.
- Construction of a detention basin was begun to improve stormwater management from STM site development.

## Environmental and Sustainability Performance

### INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO) 14001 REGISTRATION DEMONSTRATES LEADERSHIP

In 2011, NREL achieved ISO 14001:2004 certification for its environmental management system (EMS) after receiving a rigorous third-party assessment through NSF-International Strategic Registrations. ISO 14001 is a globally recognized standard that defines the structure of an organization's EMS to improve its environmental performance. The certification represents a major accomplishment and demonstrates the laboratory's leadership in environmental stewardship. The laboratory's EMS is integrated with its Integrated Safety Management System (ISMS).



Registered  
to ISO 14001

### Prestigious Environmental Sustainability Awards Received

The laboratory received several important recognitions in 2011 for its environmental and sustainability accomplishments. The prestigious GreenGov Presidential Award was achieved for the RSF green data center. The GreenGov Presidential Award is a federal government award that celebrates extraordinary achievement in the pursuit of President Obama's challenge to lead by example toward a clean energy economy.

Two DOE EStar Awards were received for the laboratory's overall sustainability planning and performance and for its waste reduction and laboratory-wide composting program. DOE EStar Awards highlight environmental sustainability projects and programs within the DOE complex that reduce environmental impacts, enhance site operations, reduce costs, and demonstrate excellence in pollution prevention and sustainable environmental stewardship.

### Assessments Identified Continual Improvement Opportunities

Several reviews were conducted during the year to determine conformance with internal procedures and with regulatory requirements.

## 2011 ENVIRONMENTAL OBJECTIVES AND RESULTS

Goal Type	2011 Objectives	2011 Results
PEMP	Further ISM, which includes environmental stewardship, through the development of improved management systems.	<p>Reviewed processes and activities and initiated actions such as:</p> <ul style="list-style-type: none"> <li>Achieved laboratory-wide ISO 14001 certification</li> <li>Initiated install of high-efficiency particulate air (HEPA) filtration on exhaust systems in a number of research facilities for purposes of controlling nano-material (very small particle) air emissions</li> <li>Completed wildlife and vegetation surveys</li> </ul>
PEMP	Transform environmental excellence into a sustainability strategy.	<ul style="list-style-type: none"> <li>Received two DOE EStar awards: <i>Cradle to Cradle—Waste Management and Living Laboratory—Sustainable Campus</i></li> <li>Received the White House GreenGov award: Green Innovation</li> <li>Completed green janitorial contract</li> <li>Negotiated purchase of renewable energy certificates (RECs) from on-site wind turbines</li> <li>Hosted numerous community and DOE sustainability groups meetings and tours</li> <li>The RSF achieved LEED Platinum and the IBRF expansion achieved LEED Gold.</li> </ul>
CELP	Demonstrate environmental leadership by attaining ISO 14001 registration for its EMS.	<ul style="list-style-type: none"> <li>Achieved laboratory-wide ISO 14001 certification.</li> </ul>
CELP	Reduce the impacts of employee commuting by reducing individual vehicle miles travelled and implementing a traffic mitigation plan for its STM campus. This will include alternative work schedules (AWSs) and telecommuting.	<ul style="list-style-type: none"> <li>The 2011 Commuter Survey indicates: <ul style="list-style-type: none"> <li>6% reduction in single occupant commute trips compared to 2007</li> <li>19% of staff telecommute at least one day per week</li> <li>25% of staff work AWSs.</li> </ul> </li> <li>To date, traffic volume thresholds identified in the Traffic Mitigation Action Plan (MAP) have not been exceeded (see section 13 Traffic Management for more information).</li> <li>NREL offers incentives for employees to participate in alternative commuting options such as access to mass transit, vanpool discounts, preferred parking for carpool/vanpool vehicles, rideshare coordination, and bicycle and pedestrian infrastructure (bicycle maintenance stations, bicycle parking, extension of sidewalks, etc.).</li> </ul>
CELP	The laboratory will support its long term goal of achieving a net-zero energy campus by seeking to reduce electricity use per square foot by 3% per year, starting with a 2008 baseline.	<ul style="list-style-type: none"> <li>In 2011, NREL exceeded its goal of 3% per year reduction in energy use per square foot, reducing energy use from 277 to 176 kBtu/ft<sup>2</sup>. The reduction was largely due to the RSF, which increased square footage with only a small increase in site energy consumption.</li> </ul>
CELP	The RSF at the STM campus will implement measures to seek certification in the Sustainable Sites Initiative (SITES)—Pilot Program on Landscaping Green Certification for Sustainable Landscaping.	<ul style="list-style-type: none"> <li>The RSF's landscaping features native Colorado plants and trees; landscaping walls built from stone repurposed from excavating the foundation of the RSF; pavers designed to infiltrate and enhance water quality for the area's watershed; and, a drip irrigation system with multiple zones providing efficient use of water.</li> <li>NREL's SITES participation is being expanded beyond the initial goal to certify RSF and will include two new major construction projects as well, the STM stormwater detention basin project and the new parking garage and south entrance.</li> </ul>



An internal compliance evaluation was conducted to verify compliance with environmental legal and other requirements applicable to the laboratory across a sampling of activities and programs. The review included compliance with federal, state, and local regulations and DOE requirements including permits, equipment and other registrations and certifications, and reports and notifications. The review also evaluated completion of requirements by environmental program area, including requirements for such activities as inspection, monitoring, training, certifications, etc. Program areas reviewed included Cultural Resources Protection, Drinking Water Quality, Endangered Species Act, EMS, Regulated Waste Management, National Environmental Policy Act (NEPA), Wetlands, and Wildlife Management. No actions were identified for follow up or correction.

In addition to the internal compliance evaluation, an internal assessment of sixteen environmental management program areas was conducted to verify conformance with the ISO 14001 standard and internal procedures, and identify opportunities for continual improvement. Interviews were conducted with program managers and document and records reviews were completed. Seven findings were made in the areas of document control and operational control and eleven opportunities for improvement were identified. The findings were related to documents not having version control and minor inaccuracies. The majority of the actions from this assessment have been completed and several remaining actions will be finalized in 2012.

To achieve ISO 14001 certification, the laboratory received a third-party certification assessment to confirm conformance with the standard. The assessment involved several rounds of review including a “desk audit” of EMS procedures and documentation, an “on-site readiness review” of the major elements of the management system, and a final audit conducted by a team of auditors involving site visits to all major facilities, interviews with staff at all levels of the organization, observation of processes in place, and review of documents and records. The extensive certification assessment resulted in several findings and opportunities for improvement. Corrective actions will address deficiencies in document version control and an internal procedure for identifying environmental aspects. All actions are expected to be completed in 2012.

### Progress Toward Objectives and Targets

Each year, the laboratory sets measurable objectives and targets for environmental improvement through its internal Performance Evaluation and Measurement Plan (PEMP), Site Sustainability Plan (SSP), and for the Colorado Environmental Leadership Program (CELP). Progress through the course of the year on each of these goals is tracked using an online software tracking system and results are reported annually. Some examples of performance for 2011 are shown in the Environmental Objectives and Results table on page 6.

### ENVIRONMENTAL COMPLIANCE

NREL is subject to many federal, state, and local environmental laws and regulations, as well as executive orders, DOE orders, and memoranda of understanding with government agencies. The laboratory continued its excellent record of environmental compliance in 2011.

- 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.
- There were no spills or releases of any materials requiring reporting in 2011.

### ENVIRONMENTAL MANAGEMENT SYSTEM (EMS)

NREL’s EMS implements a framework of policies, procedures, and programs that integrates environmental protection into daily work practices. Through the EMS, the laboratory commits to environmental stewardship, pollution prevention, compliance with environmental requirements, and continual improvement in environmental protection and sustainability performance. The EMS is structured based on a plan-do-check-feedback continual improvement framework depicted in the graphic and is implemented as part of an ISMS. Program highlights in 2011 include:

- The EMS became ISO 14001:2004 certified.
- Training was provided to staff regarding our commitments to the environment laid out in the environmental protection policy. Training and communication efforts included a 20-minute online course incorporating videos, graphics, and quizzes; employee badge cards updated policy commitments; regular emails and intranet articles; and “road shows” presented to hundreds of employees across at least 12 internal organizations.



- The laboratory's environmental protection policy was simplified to clearly state our key commitments to environmental protection. The EMS procedures underwent a comprehensive review and revision. This thorough review clarified, streamlined, and improved the effectiveness of the EMS procedures.
- The process used to identify potential environmental impacts from our activities was updated in 2011 to simplify and streamline management and communication.

## SUSTAINABILITY

Sustainability is integral to both our research and operations and we are committed to demonstrating federal leadership in sustainability and continuously improving performance. Sustainable NREL, an interdisciplinary initiative involving staff from across the organization, fosters environmental and social responsibility, working to establish the laboratory as a global model for sustainability. Sustainable NREL is responsible for advocating for all executive orders, federal regulations, DOE orders, and goals related to sustainable facility operations.

Each year, Sustainable NREL develops a SSP to report on steps taken to meet the national and DOE sustainability objectives and outline plans for the upcoming year. The laboratory has currently identified 20 objectives to enhance sustainability and continues to make significant progress toward these objectives.

## ENVIRONMENTAL MANAGEMENT PROGRAMS

The laboratory continues to meet or exceed compliance requirements and strives to make continual improvements in environmental management. Program highlights by major environmental media are provided below. A more complete discussion of the laboratory's environmental management programs, including compliance information and achievements are included in this report.

## AIR QUALITY PROTECTION

The laboratory maintains several air permits issued by the Colorado Department of Public Health and Environment (CDPHE) for "minor" sources including one site-wide permit for particulate air emissions from construction, two air emissions permits for pilot-scale research, one permit for the operation of the Renewable Fuel Heat Plant (RFHP), and five permits for emergency generators. An internal evaluation was conducted for compliance with Environmental Protection Agency (EPA) and state permitting and emissions control requirements which confirmed that the laboratory is in compliance with all Colorado and EPA requirements.

The laboratory has three chillers that are larger than 100 horsepower (hp), contain ozone depleting substances (ODS), and are thus registered with CDPHE. During 2011, the laboratory performed the required annual notification that maintenance activities occur, renewed the registration for the three chillers, and confirmed that all technicians servicing ODS-containing equipment are EPA-certified.

Due to a switch from sand to a deicer product, no sand was applied for traction control to the laboratory's roadways during the 2010 to 2011 winter season. This resulted in the reduction of 50 tons of sand used compared to the 2009 to 2010 season, providing a direct air quality benefit to both our neighbors and the Denver metro area by reducing particulate emissions. The required sanding report for the 2009-2010 season was supplied to the state.

The laboratory's annual greenhouse gas (GHG) emissions inventory showed that emissions were below the exempt level for EPA reporting and permitting rules. In 2011, carbon dioxide equivalent (CO<sub>2</sub>e) emissions were 4,020 U.S. tons, or 3,555 metric tons (MT). The laboratory's emissions of GHGs are not expected to meet reporting requirement thresholds into the foreseeable future.

## WATER QUALITY PROTECTION

NREL operates a drinking water distribution system at the NWTC, serving about 150 employees. Drinking water is purchased from local municipalities and transported by truck to the site. The drinking water system is subject to regulatory requirements to monitor for specific parameters. In 2011, all monitored parameters met applicable requirements and triennial sampling for lead and copper confirmed that the concentration of these metals was well below regulatory thresholds.

The laboratory seeks to preserve the quality of receiving waters to which the STM and NWTC campuses discharge stormwater. Water quality protection is accomplished through management of runoff emanating from active construction sites, inclusion of project design elements that promote infiltration and detention, and management of campus areas not under construction to minimize erosion and support infiltration. In 2011, several projects supported these goals:

- Completed the STM stormwater detention basin to a point where it can now temporarily detain a significant portion of the runoff from the site, thus greatly improving the quality and quantity of runoff leaving the STM campus, and helping to protect downstream areas from potential flooding. The project will be completed in 2012.
- Completed modifications to Denver West Parkway at STM to redirect accumulated runoff in the roadway toward drainage conveyance swales.
- Completed addition of curb and gutter along the north side of the STM Field Test Laboratory Building (FTLB) Service Road which will reduce sediment entrainment in runoff originating from adjacent areas.
- All projects, regardless of acreage, draw upon low impact design elements such as porous pavement and vegetated bioswales to improve stormwater detention.
- Seven construction projects at STM, and three at the NWTC, required coverage under the EPA Construction General Permit (CGP). Permit coverage was obtained or was continued for

each. Three permits for completed projects were terminated in 2011. All activities were conducted according to compliance requirements. Several construction sites received periodic monitoring from local regulatory officials; no non-compliances were noted.

### **HAZARDOUS MATERIALS AND WASTE MANAGEMENT**

As a major national laboratory, NREL has a variety of chemicals and materials, some of which are hazardous, for use in research activities. Hazardous materials are stored, used, and managed in a manner that is protective of laboratory personnel, the general public, and the environment.

NREL facilities are subject to the emergency reporting provision of the Emergency Planning and Community Right-to-Know Act (EPCRA) and in 2011 the laboratory submitted the required Tier II report to CDPHE for reporting year 2010, identifying diesel fuel, petroleum oil and sulfuric acid in lead-acid batteries. West Metro Fire Rescue conducted an annual hazardous material inspection and issued permits for all major research facilities on the STM campus. The inventory of materials at the Renewable Fuels and Lubricants Research Laboratory (ReFUEL) facility was provided to the Denver Fire Department. There were no releases of hazardous materials requiring reporting.

NREL maintains unique EPA Hazardous Waste Generator Identification numbers for each of its five facilities: STM, DWOP, NWTC, Joyce Street Facility (JSF), and ReFUEL. In accordance with state and federal regulations, annual hazardous waste generator notifications were made and applicable fees paid to the state based on monthly volumes of hazardous waste generated at each facility. Due to three calendar months of episodic hazardous waste generation at volumes totaling more than 1,000 kilograms (kg) per month and in anticipation of additional pilot plant research experiments, the waste generator status of STM changed to Large Quantity Generator in October 2011. The remaining facilities are categorized as Conditionally Exempt Small Quantity Generators.

The laboratory seeks to minimize the risk of underground soil and water contamination from storage tanks by utilizing only above-ground storage tanks (ASTs). Unlike underground tanks, above-ground installations provide access for regular visual leak inspections and allow for less costly repair and cleanup should that be necessary. In 2011, no spills or releases from ASTs or related fueling activities occurred and AST registrations were submitted to the state for two registered ASTs. All tanks were reviewed to confirm adherence to recently revised regulations. AST and spill prevention and response training was provided to all personnel identified as having responsibility for operating and fueling ASTs and those providing initial spill response.

The laboratory seeks to prepare for and continually improve spill response. Formal spill prevention, control, and countermeasures (SPCC) plans have been developed for three facilities. The plans are designed to minimize the number and size of spills from oil-containing equipment and reduce response and cleanup time. In

2011, the laboratory's SPCC plans were revised to address changes to EPA SPCC regulations and Colorado's AST regulations. No spills requiring reporting occurred in 2011. Staff responded to 31 minor spills of diesel or hydraulic fluids at the STM and two at the NWTC; the size of spills ranged from less than 0.1 gallon to 15 gallons. Each spill was cleaned up promptly and did not result in any significant impact to the environment.

NREL actively seeks opportunities to prevent pollution, going above and beyond compliance requirements to reduce potential impacts to our environment. The laboratory has made a formal commitment to pollution prevention through its laboratory-wide environmental protection policy. In 2011, three pollution prevention assessments were completed and the results are being evaluated for possible implementation. Sustainable NREL initiated a pilot Pollution Prevention Initiative (PPI), which provided staff with the opportunity to identify and implement new pollution prevention practices at the laboratory. Project proposals were submitted by staff to help achieve reductions in waste, materials, water, air emissions, and energy use. Three projects were funded including an idling reduction campaign, a research pump replacement, and a switch from hardcopy to electronic journals for a collection at NREL's library.

Unlike many DOE facilities, NREL does not conduct work involving nuclear materials and does not have legacy radiological contamination issues associated with past nuclear weapons production or research activities. However, the laboratory uses several x-ray diffraction analytical techniques and occasionally uses small quantities of radioisotopes for biological labeling in research. All materials used have very low activity levels and are used in extremely small amounts. In 2011, the estimated effective dose equivalent to the public from laboratory activities was 0.0054 mrem (millirem) per year, far below the 10 mrem per year regulatory limit. No low-level radioactive waste was generated. No radionuclides were released from the site for the reporting period.

### **NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)**

NREL's NEPA program provides a mechanism to consider environmental factors in the decision-making process and promotes sustainable and environmentally responsible operations. Staff members conduct reviews under the NEPA process for a wide range of activities prior to work commencing. Five hundred and fifteen NEPA reviews were conducted for project activities on and off site during 2011. Of these, 30 activities underwent a more in-depth environmental review given their potential to cause an environmental impact. For each of these, work commenced only after DOE reviewed the submittal and provided a signed NEPA determination which specified any mitigation actions needed to avoid impacts. Two projects were determined to require an Environmental Assessment (EA). The laboratory initiated a Supplemental EA to address a proposed action for enhancements to the RFHP and a site-wide EA was initiated for proposed continued and enhanced operations at the NWTC.

## NATURAL AND CULTURAL RESOURCES PROTECTION

NREL is committed to responsible stewardship of our natural ecosystems, native wildlife and vegetation, and important cultural resources. Natural resources at the STM and NWTC sites are managed appropriately to ensure research needs are met while protecting wildlife and vegetation. During 2011, STM and NWTC site-wide wildlife surveys, avian and bat mortality surveys, and vegetation surveys were completed. These surveys enable staff to compare current conditions to those found in previous studies, establish environmental conditions for future NEPA EAs, and make informed wildlife and vegetation management decisions. No protected species have been identified on-site.

A Migratory Bird Conservation Plan was developed to provide guidance for specific types of projects that have the potential to impact migratory birds and provide best management practices to eliminate or minimize impacts for identified risk areas including disturbance of vegetation, building maintenance, and collisions with buildings, windows, meteorological towers, and wind turbines. Bird-friendly glass was installed on the laboratory's new STM parking garage, which is scheduled to open in 2012. The glass in this structure is patterned with a 50% frit that appears etched but still allows for visibility. This special glass was installed on all glass breeze-ways and critical areas of glass stairwells to reduce the potential for bird collisions, lessening impacts on migratory birds.

NREL's approach to vegetation management is to:

- Conserve existing ecosystems
- Replace disturbed vegetation with native species
- Prevent the spread of noxious weeds and implement measures to control these species
- Develop and maintain sustainable landscaping.

Based on lessons learned from previous revegetation efforts, landscaping plans for current construction projects were adjusted to optimize plant establishment, withstand difficult shading and snow conditions, and deter animal browsing while providing wildlife habitat. Weeds were treated on approximately 200 acres at the NWTC and two acres at the STM.

Wetlands adjacent to Lena Gulch that were impacted by the construction of a new south entrance to the STM campus were delineated in 2011. Bridge construction activities associated with the project resulted in the permanent loss of 0.25 acres of wetlands along Lena Gulch. A U.S. Army Corps of Engineers (USACE) Nationwide Permit No. 14 for Linear Transportation Projects was obtained, and this loss was mitigated through acquisition of wetland banking credits through the South Platte Wetlands Bank in Brighton, Colorado. A Conditional Letter of Map Revision

(CLOMR) was filed with Jefferson County with Urban Drainage and Flood Control District concurrence for the bridge construction since a number of bridge elements such as abutments and headwalls would be in the floodplain. With Urban Drainage and Flood Control District approval, a Jefferson County Floodplain Development permit was obtained for the new bridge.

Three historic structures at STM are recognized as significant cultural resources and are listed on the National Register of Historic Places. These include an open-air amphitheater, a stone bridge spanning a natural drainage channel adjacent to the amphitheater, and a stone and concrete ammunition bunker below the amphitheater. The three structures were built during the Works Progress Administration era in the 1930s. The Camp George West Historic District, also listed on the National Register of Historic Places, includes the 25-acre parcel of the STM site south of Denver West Parkway. Two types of contributing historic archaeological resources have been identified on this parcel: firing range lines and a low rock wall. In 2011, the Colorado State Historic Preservation Officer (SHPO) concurred that construction of the south entrance to the STM would impact two firing lines that are contributing features of the Camp George West Historic District and that impacts should be mitigated. A memorandum of agreement was signed to mitigate impacts to these features and an interpretive sign will be placed in Pleasant View Community Park.

## TRAFFIC MANAGEMENT

The STM campus draws hundreds of commuter vehicles daily, as well as visitor and delivery traffic coming to and leaving the site. As the laboratory continues to relocate staff to STM from leased space, traffic in the area is expected to increase. A Mitigation Action Plan (MAP) addresses potential environmental impacts from changes in traffic at STM and supports an EA Finding of No Significant Impact for several projects at the laboratory. The MAP specifies the methods for implementing mitigation measures to ensure that the impacts of continued and expanded laboratory operations are not significant. The laboratory seeks to reduce traffic using such measures as:

- Mass transit, ridesharing (carpool and vanpool), and bicycling
- Telecommuting one or more days per week
- Flexible work schedules and AWSs
- Teleconferencing, video conferencing, and web-conferencing.

During 2011, 25% of staff daily commute trips were made with alternative transportation, up 8% from 2007. The laboratory measured traffic counts during 2011 and found that while traffic increased at monitored locations, MAP thresholds were not exceeded.

# 1 Introduction

## 1.1 PURPOSE

This report presents a summary of NREL's 2011 environmental management activities including:

- Environmental protection programs
- Environmental and sustainability performance
- Environmental compliance activities and status with respect to requirements that are applicable to NREL such as required permitting, notification, and monitoring
- Environmental management highlights and successes.

This report incorporates DOE's most recent guidelines for the Annual Site Environmental Report, as required by DOE Order (DOE O) 231.1B, *Environment, Safety, and Health Reporting*.

## 1.2 OUR MISSION

NREL's mission is focused on advancing DOE's and our nation's energy goals. This focus is captured in the mission statement:

*NREL develops renewable energy and energy efficiency technologies and practices, advances related science and engineering, and transfers knowledge and innovations to address the nation's energy and environmental goals.*

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

- Basic science. Fundamental research is conducted in the sciences that underlie NREL's renewable energy and energy efficient technologies.
- Bioenergy. NREL currently has major programs in biomass-derived fuels (biofuels) and biomass-derived electricity (biopower), and projects in biomass-derived chemicals and materials.



A researcher collecting algae samples. *Photo by Dennis Schroeder, NREL/PIX 18297*



Jr. Solar Sprint and Hydrogen Fuel Cell Car Competition. *Photo by Dennis Schroeder, NREL/PIX 19196*

- Building energy. NREL increases the use of energy efficiency technologies and expands the use of renewable energy technologies in the building sector by working to develop new, cost-effective, environmentally acceptable building equipment and envelope systems.
- Computational sciences. This area includes basic and applied research using high-performance computing and applied mathematics.



NREL creates fuel from renewable energy to power hydrogen fuel cell vehicles and buses. *Photo by Chris Ainscough, NREL/PIX 19512*

- Distributed power. Distributed power is modular electric generation or storage located near the point of use. NREL participates in the development of technologies, market structures, and policies that affect the incorporation of renewable and energy efficiency technologies in distributed power systems, thus maximizing the utilization of renewable energy and energy efficient products. As a part of this initiative, NREL is involved in the development, design, and facilitation of the application of renewable and renewable/fossil hybrid distributed power systems in grid-connected applications.
- Electricity technologies. These technologies include renewable energy, hydrogen, and superconductivity technologies, as well as utility resources.
- Energy analysis. Research at NREL includes energy analysis for various programs and initiatives.

- Hydrogen. NREL serves as a leader in renewable hydrogen production technologies. NREL also leads in the development of codes, standards, and advanced storage and sensors. Basic and applied research and material development using biology, physics, and chemistry enable and support the development of hydrogen production, storage, and end-use systems.
- Measurements and testing. NREL laboratories and facilities allow state-of-the-art testing on photovoltaic (PV) cells, building technologies, and wind turbines.
- PV. PV enables the direct conversion of sunlight to electricity using solid-state materials. The National Center for Photovoltaics develops and deploys PV technology for the generation of electric power.
- Renewable energy resources. Researchers develop resource information for solar, wind, biomass, and geothermal energy applications.
- Renewable thermal technologies. These technologies—including concentrating solar power (CSP), solar water heating, and geothermal heat and power—generate power from heat or utilize heat from renewable resources.
- Transportation. NREL works with industry experts to develop advanced vehicles and systems for transportation, and to develop viable vehicle systems that are integral to DOE transportation initiatives. NREL also works with energy companies and manufacturers of vehicles and engines to develop advanced motor vehicle fuels for improved energy and environmental performance. A systems approach is used to develop optimized engine management, fuel, and emission control technologies.
- Wind energy. Through the NWTC, NREL develops, improves, and demonstrates the viability of wind technology for electricity generation and facilitates its utilization throughout the world.

### 1.3 SITE AND FACILITY DESCRIPTION

NREL facilities occupy five separate locations in Jefferson County, Colorado, near the city of Denver, and one within the boundaries of the City and County of Denver. These include:

- Denver West Office Park (DWOP)
- Golden Hill
- South Table Mountain (STM)
- Joyce Street Facility (JSF)
- National Wind Technology Center (NWTC)
- ReFUEL (located within the city limits of Denver).

The STM and NWTC sites are the two main sites where research operations are conducted and will be addressed separately in the discussion of environmental features. DWOP is leased space used primarily for administrative functions and limited research activities. Similarly, Golden Hill is leased office space for administrative functions. The JSF is leased space currently used for storage. The ReFUEL facility is a leased facility that consists of a small shop

complex housed within the Regional Transportation District (RTD) District Shops and Operations Center (DSOC) facility in Denver. Laboratory staff also conduct work at additional locations as needed, for example at the Solar Technology Acceleration Center (SolarTAC) described below.

### SOUTH TABLE MOUNTAIN (STM) SITE

The STM site is the main research center for NREL. With new office facilities now occupied in 2011, roughly 78% of the laboratory's staff have their offices and laboratories at the STM site. The STM site is approximately two miles (3.2 km) east of Golden and 12 miles (19.3 km) west of central Denver.

### Geology, Soils, and Hydrogeology

The STM site is a roughly triangular parcel of land occupying portions of the top, sides, and lower south-facing slopes of STM. STM is composed of sedimentary rocks below a basalt lava cap, which is quite resistant to erosion. The STM feature is a mesa that stands about 492 feet (150 meters) above the adjacent lowlands. The mesa was formed as weak sedimentary rocks surrounding the lava were eroded away, leaving the lava-capped mesa in relief. Below the lava caprock, the sedimentary rocks are part of the Denver Formation that consists of layers and lenses of claystone, sandstone, and conglomerate. Sedimentary rocks of the Arapahoe Formation underlie the Denver Formation.



NREL's STM campus. Photo by Dennis Schroeder, NREL/PIX 19095

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

The soil covering the top of STM is lava 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 STM is also a loam consisting of extremely stony soils with significant amounts of clay. Much of the remainder of the site, including the area designated for major development, has a deep, well-drained soil referred to as Denver clay loam. It consists of clayey material containing some calcium carbonate. There are also two smaller soil areas on the southwestern portion of the site, both of similar character to other site soils—cobbley clay loam and very stony clay loam.

### Surface Water

About 90% of the surface drainage off the site, both from the mesa top and across the lower portions of the site, is in the southerly direction toward Lena Gulch (a tributary of Clear Creek). Surface water from two drainageways on the easternmost portion of the site ultimately flows into Lena Gulch.

There is no permanent stream flow on the STM site. Only occasional flow derived from extended periods of precipitation, usually during the late winter and early spring, is found in the drainage channels, with seasonal springs evident along some of the mesa slopes. There is one seep on the mesa top that is often active throughout much of the year, but the water infiltrates and evaporates quickly during the dry season.

### Vegetation

Two primary vegetation types are present on the STM site: grasslands and shrublands. The most common plant communities on the STM site are mixed grasslands, composing more than 80% of the vegetation on the site. These communities are generally dominated by short- and mid-grass species. Two primary upland shrub communities occur on the STM site: mountain mahogany shrublands, found on the shallow soils of the mesa, and upland shrublands, occurring in drainages lacking active channels as well as drainages with associated wetlands. Field surveys have identified limited wetland and riparian areas along drainages. The wetland communities identified on the STM site are a minor component of the total vegetation cover, accounting for less than 1% of the vegetation over an area of less than 0.3 hectares (0.75 acres). Riparian shrub communities also occur adjacent to the emergent wetlands. A vegetation survey of the STM campus was conducted in 2010 (see section 11.3 Vegetation Management for more information).

### Wildlife

Several comprehensive wildlife surveys have been conducted on the site, starting with the original study in 1987. Additional surveys were done in 1999, 2005, and 2011 (see section 11.1 Wildlife Management for more information).

Mammals seen using the site during the surveys included mule deer, coyotes, gray foxes, red foxes, raccoons, long-tailed weasels, striped and spotted skunks, badgers, bobcats, mountain lions, rabbits, yellow-bellied marmots, and various smaller mammals. More than 50 species of birds have been recorded on the STM site by the formal wildlife surveys and supplemental employee observations. A number of raptor species have been recorded at



Wildlife at an NREL PV installation. Photo by Dennis Schroeder, NREL/PIX 19912

or above the STM site, especially during spring migration. Two raptor species are resident at the site: American kestrel (*Falco sparverius*) and red-tailed hawks (*Buteo jamaicensis*). Reptiles and amphibians inhabit the area as well. Most notably, the western diamondback rattlesnake is routinely encountered around the campus area.

### Land Use

The STM site is a 327-acre area predominantly bordered by open space, a residential area, grassland zoned for recreation and light-commercial activity. Portions of the community of Pleasant View are located immediately to the south and west of the STM site. Pleasant View has constructed a recreational park immediately south of the STM site. Offices, shops, and a tree nursery owned by the Colorado State Forest Service are located at the far western edge. Undeveloped state land and a Colorado State Highway Patrol pursuit driver-training track are located along the northwestern boundary of the STM site on top of the mesa. Jefferson County open space wraps around the northern and the eastern edge of the site. Portions of DWOP and apartment homes lie to the east.

More than half of the STM site (177 acres) has been set aside in a conservation easement. No development is allowed on that land, with the exception of some existing utility easements and recreational trails to be established by Jefferson County Open Space (see section 12 Conservation Easement Lands for more detail).

### NATIONAL WIND TECHNOLOGY CENTER (NWTC)

The NWTC is the main facility for NREL's wind turbine technology research. Located on the Jefferson-Boulder County border just east of the foothills of the Rocky Mountains, the NWTC has abundant wind resources that are critical for the variety of projects conducted at the site. The NWTC is located near the intersection of Highways 93 and 128, between Boulder and Golden, and is approximately 15 miles (24.2 km) north of the STM site.

### Geology, Soils, and Hydrogeology

The NWTC site is located on a plain formed by stream deposits. The uppermost geological layer beneath the site is known as the Rocky Flats Alluvium (RFA). It is composed of cobbles, coarse gravel, sand, and gravelly clay. Below the RFA are the Laramie



Aerial view of the NWTC. Photo by Dennis Schroeder, NREL/PIX 19016

Formation, Fox Hills Sandstone, and Pierre Shale. These rock formations consist primarily of claystones with some siltstones. Unconfined groundwater flow occurs in the RFA toward the East/Southeast, and small perched zones are common. Groundwater occurs as confined aquifers in the deeper bedrock formations.<sup>1</sup>

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

#### Surface Water

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

The majority of the NWTC drains into a tributary to Rock Creek. Some of the northern portions of the site drain into Coal Creek or its tributaries.

#### Vegetation

The NWTC is located in the transition area between the Great Plains and the Rocky Mountains<sup>2</sup>. This location results in a flora that contains elements from both mountain and prairie ecosystems, and associations that represent residual tall grass prairie, short-grass plains, ponderosa pine woodland, and foothill ravine flora<sup>2</sup>.

Vegetation surveys conducted at the site have identified nearly 271 vascular plant species and defined five major habitat types on the NWTC site, including: seasonal wetlands/or ephemeral hydric soils, woodlands, shrublands, mixed grasslands, and disturbed areas.

Along the northwestern ridge is a ponderosa pine woodland area. Vegetation found in this area includes woody species with an understory of grasses, forbs, and shrubs. The most recent

vegetation survey was completed in 2011 (see section 11.3 Vegetation Management for more detail).

#### Wildlife

Prior to 1975, livestock heavily grazed the NWTC site, damaging a majority of the native vegetation. DOE prepared a biological characterization inventory in 1992 for the entire Rocky Flats plant including the NWTC site, which was part of the no activity buffer zone of the Rocky Flats plant at the time. Signs or tracks of bears and mountain lions were identified. Other mammals known to feed at the site are mule deer, coyotes, desert cottontail rabbits, white-tailed jackrabbits, black-tailed jackrabbits, deer mice, prairie voles, and thirteen-lined ground squirrels. Approximately 20 different species of birds were sighted at or near the site. Raptor surveys were conducted at the NWTC in 1994 and 1995, and identified seven raptor species on or in the vicinity of the site. An avian survey was also completed in 2002 and updated in 2011 (see section 11.1 Wildlife Management for more information). Although seldom seen, rattlesnakes, bull snakes, racers, and several other reptilian and amphibian species are known to occupy the area.

#### Land Use

The NWTC facility occupies a 305-acre area surrounded largely by open space and grazing land. The Rocky Flats National Wildlife Refuge borders the NWTC to the southeast, and a sand and gravel mining and processing operation is located along the southern and western boundaries of the site. A blasting company also has a small installation along the western site boundary. State Highway 128 borders the NWTC to the north. Boulder County Open Space lies to the north of the highway.

#### DENVER WEST OFFICE PARK (DWOP) AND GOLDEN HILL

DWOP is approximately two miles (3.2 km) east of Golden and 12 miles (19.3 km) west of central Denver. DWOP is a relatively flat, landscaped office complex occupied by a number of four-story buildings, parking lots, and common areas. NREL-leased facilities at DWOP are approximately located in the geographic center of the development, with the exception of one leased facility just north of I-70. DWOP is bordered on the south by commercial areas (West Colfax strip), and on the west by the Pleasant View residential area, Camp George West facility, and the STM site. DWOP is within the City of Lakewood. Golden Hill is an office building on the south side of West Colfax about one half mile east of DWOP. A small portion of the building is leased for office space.

#### JOYCE STREET FACILITY (JSF)

JSF is located in a commercial area surrounded by agricultural land, residential neighborhoods, and small businesses. It is currently used by NREL primarily as warehouse space only. Support activities and limited dry laboratory research activities are currently conducted at the facility, and there are no staff offices at JSF. The JSF is located at 6800 Joyce Street, about 5.5 miles (8.9 km) north of DWOP and STM sites.

<sup>1</sup> EG&G Rocky Flats, Inc. (1992). Rocky Flats Plant Site Environmental Report, January Through December 1992. Golden, Colorado.

<sup>2</sup> Plantae Consulting Services (2000). Vegetation Survey, NREL National Wind Technology Center. Boulder, Colorado.





King County Metro Transit bus being tested at ReFUEL. Photo by John Ireland, NREL/PIX 17948

### RENEWABLE FUELS AND LUBRICANTS LABORATORY (ReFUEL)

ReFUEL is used for research, testing, and support activities related to advanced fuels, engines, and vehicles to objectively evaluate performance, emissions, and energy efficiency impacts. The laboratory is also used to evaluate and develop heavy hybrid electric vehicles.

ReFUEL is a small shop complex housed within the RTD DSOC at 1900 31st Street, Denver, about 12 miles east of the STM and DWOP sites.

The RTD DSOC facility occupies approximately 22 acres of land and serves as the primary maintenance facility for RTD's bus and light rail train systems. The area around the RTD DSOC facility consists of commercial and light industrial development.

The site lies on relatively 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 on-site or in the immediate vicinity. There are trees and shrubs lining the South Platte River adjacent to the site's southern, eastern, and northeastern borders.

### ADDITIONAL LOCATIONS

Laboratory staff may also conduct work at additional locations as needed. One such location is SolarTAC, operated by MRIGlobal, located near Denver International Airport northeast of the intersection of East 26th Avenue and North Hudson Road in Aurora, Colorado. SolarTAC is a partnership of solar equipment manufacturers, research organizations and electric utilities that want to make use of a real-world outdoor site to develop, test, validate or showcase solar products. Approximately 33 miles east of the STM campus, the facility is comprised of 74 acres to provide users with readily accessible land and all the necessary infrastructure and resources needed to rapidly and economically install their technologies. NREL currently leases several acres at the site. The primary projects currently being developed by NREL include:

- Concentrator PV (CPV) Demonstration. This system will demonstrate and quantitatively compare performance of CPV systems installed in Japan and the U.S.



Aerial view of the SolarTAC test facility in Aurora, CO. Photo by Dennis Schroeder, NREL/PIX 19101

- Thermal Energy Storage (TES) Test Facility. This facility will provide a pilot scale TES demonstration project.

### 1.4 SITE ENVIRONMENTAL CONDITIONS/FEATURES

The climate for the geographic region of NREL operations is classified as semi-arid, typified by limited precipitation, low relative humidity, abundant sunshine, and large daily and seasonal temperature variations.

The area experiences moderate precipitation, with an average annual rainfall of less than 50 cm (20 inches). Almost half of the annual precipitation occurs from March to June. Summer showers contribute 33% of the annual precipitation total. Precipitation begins to decrease significantly in the fall, and reaches the minimum during 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 and the Front Range. The highest average snowfall occurs in March, and the STM site can generally expect to experience at least one heavy snowstorm with totals exceeding 15 to 25 cm (6 to 10 inches).

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

## 2 Significant Activities in 2011

In 2011, the most visible activity on the STM and NWTC campuses was construction. Several major and minor construction projects were underway throughout the year. From concept to design to occupancy, environmental stewardship is integrated into

construction project management to deliver world-class energy performance and environmentally sensitive and sustainable buildings.

## 2.1 MAJOR AND MINOR CONSTRUCTION PROJECTS

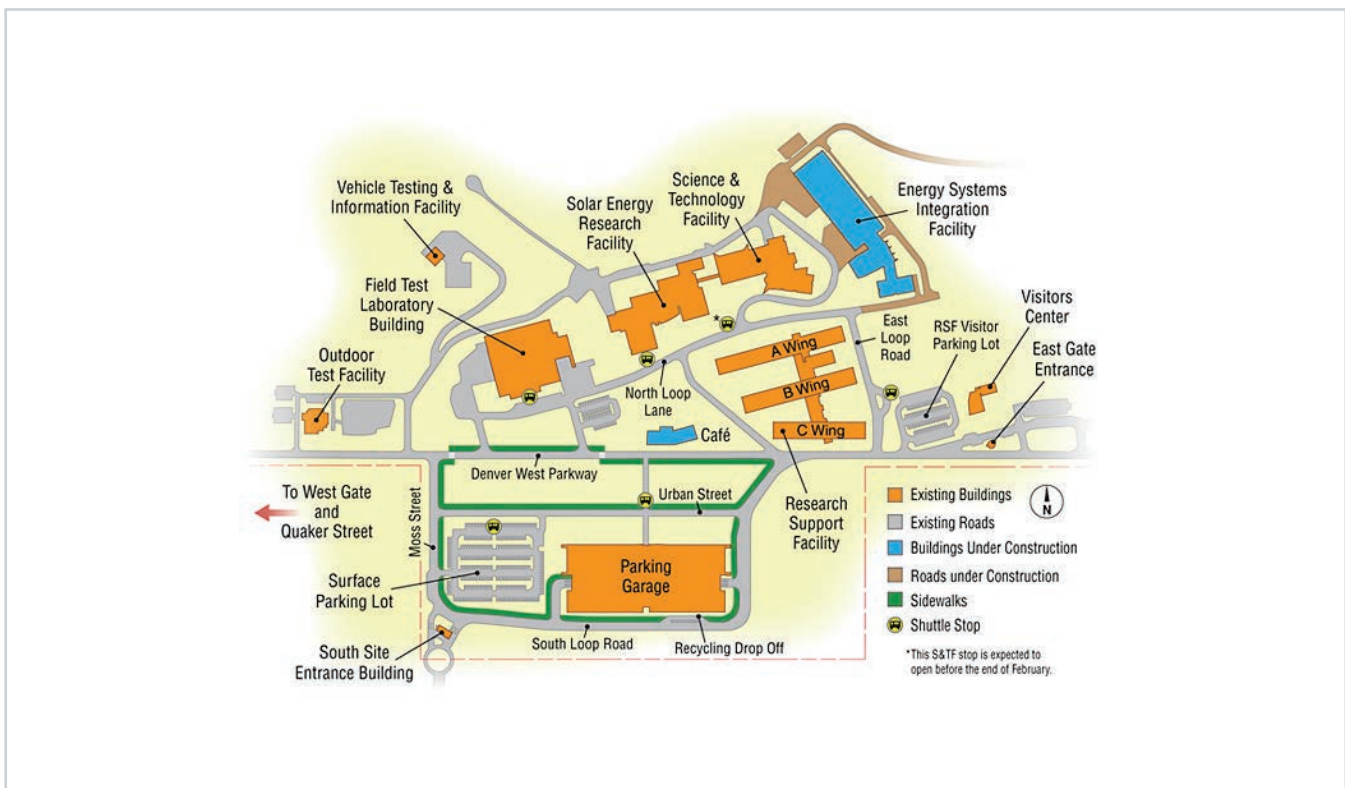
- At the STM campus, the third wing of the RSF was completed in late 2011. The RSF achieved the U.S. Green Building Council's LEED Platinum certification, indicating that the building meets world-class energy and environmental design standards. The RSF is a 222,000 ft<sup>2</sup> building constructed to house 800 employees and designed and managed to be highly energy efficient and consume only as much energy as can be generated by renewable power on or near the building. The RSF showcases numerous high-performance design features, many of which are a direct result of NREL's research efforts, including passive energy strategies and renewable energy technology. With the completion of the third wing, NREL has vacated nearly all of its leased space in DWOP.
- To meet the parking needs of the increased number of staff located at the STM site, construction of a new 1800 spot parking garage commenced in 2011 and will be completed in early 2012.
- A major expansion of the IBRF was completed to enhance the capabilities of the facility and add more office space. The IBRF received LEED Gold certification.
- A new south entrance to the STM campus, including a site entrance building designed to achieve LEED Platinum



The RSF showcases numerous high-performance design features. Photo by Dennis Schroeder, NREL/PIX 18477

certification, commenced construction. Due to the relocation of staff from DWOP to the STM site, an increase in vehicle traffic to the site will occur. The new entrance is designed to improve traffic flow to the campus by redirecting much of the traffic from the current Denver West Parkway entrance when opened in 2012.

- Construction commenced on the ESIF. The building will be about 183,000 ft<sup>2</sup> and will house about 200 researchers. ESIF is being designed to achieve LEED Gold certification and construction is expected to be completed in late 2012. The building will support:
  - High performance computing at the one-half petaflop scale



Map of STM main facilities



The ESIF laboratory under construction. *Photo by Dennis Schroeder, NREL/PIX 20047*

- State-of-the-art electric systems simulation and visualization
- Component and systems testing at MW-scale power
- Integration of functioning systems with utility system simulations for real-time, real-power evaluation.
- Construction of a stormwater detention basin was begun to improve stormwater management from STM site development.

Additional smaller projects completed or underway included:

- Infrastructure improvements including a new guard building at the west gate, sidewalk and curb and gutter improvements, and expansion of a multi-building shared heating and cooling system.
- Constructed the Vehicle Testing and Integration Facility used by engineers to develop strategies to meet the demands of electric vehicle-grid integration and minimize fuel consumption related to vehicle climate control.
- The SRRL was expanded to add office and research space on the mesa top at STM.
- A geothermal system was installed to supplement mesa top facility heating and cooling systems.
- Stormwater enhancements were made along roadways to improve drainage and reduce potential for erosion.
- FTLB Central Plant upgrades included six high efficiency condensing boilers and a variable speed 450 ton chiller.
- PV-covered visitor parking was constructed for the RSF.
- Construction of a cafeteria at the STM campus was initiated.
- The NWTC Dynamometer facility was expanded to allow for enhanced research and testing.
- NWTC pedestrian safety modifications and infrastructure improvements were completed including installation of hand-rails from trailers and parking areas for use during high winds, a walkway enclosure to shelter staff from high winds, additional parking for 50 vehicles, a bus pullout to provide a designated loading and unloading area, and improved outdoor lighting.

## 2.2 INTEGRATED ENVIRONMENTAL STEWARDSHIP IN CONSTRUCTION MANAGEMENT

NREL designs and builds new facilities using an approach that integrates planning, design, and construction. An interdisciplinary team collaborates on each project beginning with planning and selection of design and continuing through construction. This integrated approach allows the laboratory to achieve mission needs while addressing environmental, health, safety, and community considerations.



NREL takes an integrated approach to planning, design and construction. *Photo by Ben Kroposki, NREL/PIX 16598*

### PROJECT PLANNING AND DESIGN

Environmental management staff participate in an interdisciplinary team from a project's initiation and continuing through construction. These staff assist with the development and review of Requests for Qualifications and Requests for Proposals (RFPs), facilitate the inclusion of environmental requirements into project designs, and monitor proposed changes throughout the project to confirm potential environmental impacts are considered. Some examples of sustainable design features used in recent projects include:

- Producing energy on-site. New construction is designed to take advantage of the sun's rays by using angled roofs and awnings that can support PV panels in optimal conditions. The RSF was designed to be a net-zero energy building, using only energy produced on-site. To help the RSF achieve the goal to produce as much energy on-site as used by the building, a 1.6 megawatt (MW) PV system is being installed on the building and adjacent covered parking areas. The roof system incorporates more than 1,800 panels. A power purchase agreement (PPA) with Sun Edison and Xcel Energy will absorb the upfront installation costs.
- Heating and cooling strategies. Passive design allows buildings to stay cool in summer and warm in winter. Radiant heating and cooling use water as the cooling and heating medium instead of forced air. For example, 42 miles of piping courses through the RSF carrying water for radiant heating and cooling.



Operable windows minimize use of air conditioning. *Photo by Patrick Corkery, NREL/PIX 17092*

Waste energy from the data center is reused to maximize building heating. Evaporative cooling systems supplement passive cooling.

- Underfloor ventilation. Demand-controlled, dedicated outside air systems provide fresh air supplied via a raised floor distribution system.
  - Occupant controlled windows. Operable windows help reduce the use of air conditioning and give employees considerable control over their own comfort. When outdoor air conditions are temperate, employees are notified by automated systems on their computers that it's okay to open windows. Building control systems automatically operate remaining windows when optimum conditions are met.
  - No and low VOC materials. Only products that produce no, or low, amounts of volatile organic compounds (VOCs) are used in building interiors to maintain excellent air quality for occupants. Because employees spend most of their working hours indoors, the quality of indoor air is important for employee health and well being. To ensure that no, and low, VOC products are used, products are selected from reputable, certified product label systems such as Green Seal, EcoLogo, and EPA's WaterSense program.
  - Daylighting and lighting management. NREL strives to design buildings that utilize natural lighting to the extreme, resulting in tremendous energy savings, as well as health and wellness benefits for occupants. External lighting using timers, motion-sensors, and downward-facing, covered lights also minimizes light pollution impacts on neighbors.
  - Wildlife-friendly design. Selection of wildlife-sensitive features helps to minimize the impacts of buildings to birds and other animals. For example, the parking garage atrium, stair towers, and bus shelters have glass with specialized glazing designed to prevent bird collisions. Wildlife-friendly perimeter fencing was selected to allow wildlife to travel freely across property boundaries. Campus development carefully considers wildlife movement patterns and seeks to preserve existing travel zones.
- Site-sensitive drainage and vegetation. Design teams incorporate low impact design elements to retain stormwater on-site through infiltration. Features such as bio-swales, vegetated filters, and porous pavers and asphalt encourage stormwater and snowmelt to seep into the soil instead of running off. Native and drought-resistant vegetation and a smart irrigation system automatically adjust landscape watering based on plant needs and daily local weather conditions. Native plants are used because they are adapted to the local climate, can thrive without additional watering once established, and are beneficial to other native species.

## ENVIRONMENTALLY RESPONSIBLE CONSTRUCTION PRACTICES

During construction, staff continue to participate in weekly construction team meetings, monitor performance criteria, and provide ongoing feedback to the project team regarding environmental management. Some examples of environmentally responsible construction practices include:

- Pre-construction review of project plans. Staff conduct a pre-construction orientation with the project team to review the environmental elements of the project plan.
- Plan of the day. On a daily basis, subcontractors submit a "plan of the day" to the prime contractor the day before any work is to be performed. The prime contractor evaluates all plans for potential environmental and safety hazards and communicates these plans with all subcontractors on the job site.
- Stormwater controls. Erosion and sediment controls, proper chemical storage and fueling procedures, and good house-keeping practices are implemented during construction. Regular inspections by contractors and periodic site inspections by NREL staff are conducted to verify that the implemented controls are functioning properly. Any repairs are documented on an inspection report; prompt actions are required to correct any noncompliant conditions.
- Keeping wildlife safe. Prior to commencing construction, biologists conduct surveys for nesting birds and have the authority to delay construction or instruct workers to avoid sensitive areas if necessary until young birds fledge the nest. Areas with planned construction are mowed in the weeks prior to construction to discourage birds from nesting. When snakes are encountered they are safely relocated away from active construction areas.
- Waste reduction, reuse, and recycling. Construction contractors diverted 88% of their waste in fiscal year (FY) 2011 by recycling and reusing materials. Contractors are encouraged to retain materials on-site whenever possible to reduce transportation costs, fuel use, GHGs, and other air emissions. For example, excess excavated dirt is often used as fill on-site and may be shared between projects on campus. Instead of transporting excavated rock off-site, it's used in gabion retaining walls as an attractive landscaping feature.

- Minimizing and cleaning up spills. NREL specifies that new or like new equipment must be used during construction on-site to minimize the potential for drips, leaks, and spills of fuel, oil, and hydraulic fluids. When spills do occur, contractors are instructed to quickly stop the source, control spilled material, and contact NREL to monitor cleanup activities.
- Dust control. Contractors must control dust to minimize impacts to neighbors and adjacent habitat. Water trucks are used to spray down dust prone areas, driving speeds are limited, and excavation during high winds is restricted.

### 3 Environmental Management System

NREL's EMS provides effective environmental stewardship and minimizes the environmental impacts of laboratory activities and operations. The EMS is a framework of policies, procedures, and programs that integrates environmental protection into daily work practices. The laboratory's EMS efforts:

- Protect and enhance the vegetation, wildlife, and natural resources of the laboratory sites
- Prevent pollution
- Comply with environmental requirements



Registered to ISO 14001

In 2011, the EMS became certified to the ISO 14001:2004 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, to monitor and communicate environmental performance, and to establish a formal process for continually improving the system.

- Encourage continual improvement in environmental protection and sustainability performance.

While the EMS is managed by the Environment, Health, and Safety (EHS) Office, environmental protection must involve everyone at the laboratory to be effective. The EMS is implemented as part of an ISMS.

#### 3.1 ENVIRONMENTAL MANAGEMENT SYSTEM STRUCTURE

The EMS is structured based on a plan-do-check-feedback continual improvement framework described below and depicted in the graphic.

##### 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
  - Continual improvement of environmental and sustainability performance.
- Environmental aspects. NREL's environmental aspects are those activities, products, or services that have the potential to interact with the environment. The significance of an identified aspect is determined by assigning a frequency of occurrence and a severity. Using this method, EHS staff review potential impacts to the environment annually and activities in the EMS are prioritized by the identified significant aspects. NREL also utilizes a robust hazard identification and control process as part of its ISMS to manage environmental risks.
- Legal and other requirements. NREL maintains a formal process to identify regulations and standards that are necessary and sufficient to address specific environmental hazards, including federal laws and regulations, state and local requirements, executive orders, and DOE requirements.



- Objectives and targets. Regular planning of activities and programs are necessary to achieve NREL's environmental goals. The EHS Office and Sustainable NREL plan, implement, monitor, and report on environmental stewardship goals and actions to generate continual improvement (see section 3.2 Performance Indicators and Progress for more details).

### 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 workers are competent on the basis of education, training, or experience and implements a robust environment, health, and safety training program.
- Communication. NREL provides a number of avenues for communication between the laboratory and the community, such as community meetings, lunch-and-learn events, public-facing websites, periodic newsletters, and mailings. NREL tracks and responds to all environmentally related concerns through the Public Affairs Office.
- 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 have impacts to the environment and engineering and administrative controls are put in place to minimize or avoid impacts to the environment.
- Document and record control. Policies and procedures ensure that the current, correct versions of documents are available for use and that records are maintained to meet requirements.

### CHECKING AND CORRECTIVE ACTION

- Monitoring and measurement and evaluation of compliance. NREL monitors key activities, tracks performance and

In 2011, NREL conducted a thorough review and revision of its environmental aspects and developed a new list of significant environmental aspects:

- Air emissions
- Discharges to surface water or groundwater
- Wastewater discharges
- Waste generation and management
- Resource use or conservation (energy, water, land, biological, cultural)
- Community.

Each of these aspects is addressed by the environmental management system.

## 2011 Accomplishments and Highlights

- In 2011, NREL achieved ISO 14001:2004 certification for its EMS. In July, a team of external auditors from NSF-International Strategic Registrations conducted a comprehensive and rigorous independent assessment of the policies, procedures, tools and roles and responsibilities used in environmental management at NREL. NREL completed an integrated certification effort along with its safety and quality management systems, conserving staff time and cutting the costs of receiving these certifications. The certification represents a major accomplishment and demonstrates our leadership in environmental stewardship.
- In 2011, NREL invested considerable effort into communicating with staff regarding the ISO certification effort. In particular, staff focused on communicating our commitments to the environment laid out in the environmental protection policy. The key points of this policy were communicated to all staff through a variety of efforts. Some examples of this effort include:
  - A 20-minute online training was developed for all staff, including dynamically presented content with videos, graphics, and quizzes.
  - All employee badge cards were updated to include the newly revised continual improvement cycle graphic and policy commitments (shown above).
  - Regular emails and internal news articles were sent to all staff.
  - EHS and Quality Assurance staff presented "road shows" for hundreds of employees across at least 12 internal organizations.
- In 2011, NREL stepped up the number of assessments of its programs to focus on finding areas of continual improvement and in preparation for the planned 2011 ISO 14001 assessment. In addition, DOE conducted assessments of NREL's environmental programs. For details, see section 3.3 Assessments and Improvement.
- NREL's environmental protection policy was simplified to clearly state our key commitments to environmental protection.
- The EMS procedures underwent a comprehensive review and revision. This thorough review clarified, streamlined, and improved the effectiveness of the EMS procedures and helped prepare for certification in 2011.
- NREL's environmental aspects were updated in 2011. This update simplified and streamlined our aspects from a list of nineteen to six, making the aspects process easier to communicate.

progress toward environmental objectives, and conducts periodic assessments of compliance with legal requirements.

- Internal assessment. NREL periodically conducts assessments to verify that its EMS is operating as intended. A formal system for tracking corrective and preventive actions supports continual improvement of the management system (see section 3.3 Assessment and Improvement for details).

### MANAGEMENT REVIEW

- Management Review. NREL conducts regular management reviews of the EMS so that executive management can provide feedback and direction to the environmental management of the organization.

### 3.2 PERFORMANCE INDICATORS AND PROGRESS

Each year, NREL sets measurable objectives and targets for environmental improvement. Goals are set through several mechanisms including:

- PEMP. Each fiscal year, in collaboration with DOE GO, performance objectives are developed for the upcoming year.
- Colorado Environmental Leadership Program (CELP). As a member of CELP, NREL voluntarily sets three-year goals for environmental improvement. Each year progress toward these goals is reported to the state.
- Site Sustainability Plan (SSP). For 2011, Sustainable NREL developed a SSP to establish sustainability performance commitments for 2011 and document activities in support of Executive Order (EO) 13514 requirements. Results of the 2011 plan are presented in the next chapter of this report.

Goals are owned by individuals and groups throughout the laboratory, including the EHS Office and Sustainable NREL. Progress through the course of the year on each of these goals is tracked using an online software tracking system and results are reported annually. Some examples of performance for 2011 are described in the 2011 Environmental Objectives and Results table (shown on page 6 in the Executive Summary).

For FY 2012, NREL's environmental and sustainability objectives under the PEMP are:

- Maintain a safe and healthful workplace based on identified and managed risks.
- Further ISM through development of improved management systems.
- Maintain leadership in sustainable science and laboratory operations.

### 3.3 ASSESSMENT AND IMPROVEMENT

Assessments are key to supporting the continual improvement of environmental management at NREL. Periodic assessment of NREL's EMS and its components provide assurance that the EMS continues to be an effective tool to achieve and maintain compliance with regulatory and legal requirements, meet the established environmental goals of the laboratory, and demonstrate to ourselves and others that we are "walking the talk."

There are three different types of assessments performed to evaluate the functionality of the EMS at NREL:

- Internal assessment. NREL staff perform regular internal assessments of NREL's EMS against the ISO 14001 standard. The scope of internal assessments includes both the management of significant environmental aspects (areas where NREL activities have the potential for environmental effects, either positive or negative) and policy implementation.
- External assessment. Periodically, external third-party assessments may be conducted by technical experts for specific components of NREL's environmental programs or for the EMS as a whole. These assessments are conducted as a part of continual improvement efforts and to maintain ISO certification.
- Evaluation of compliance. Periodic internal environmental compliance evaluations are conducted to verify that NREL activities meet all applicable legal and other requirements. Improvements are developed and implemented as necessary based on the results of each evaluation.

### 2011 ASSESSMENTS

In 2011, a number of assessments were conducted, allowing NREL to focus on finding areas of continual improvement, improve program effectiveness, and make substantial environmental performance improvements.

The following assessment activities took place in 2011:

- Internal assessments. In January 2011, an internal assessment was conducted within the EHS Office by the EMS Coordinator. Scheduled interviews were conducted with environment program owners and document reviews of environment program procedures were completed. Programs reviewed included:
  - AST Program
  - Air Quality Protection Program
  - Cultural Resource Management Program
  - Drinking Water Program
  - Groundwater Protection Program
  - Emergency Response Team (ERT) Program
  - Hazardous Waste Management Program
  - Material Safety Data Sheets (MSDS) Program
  - NEPA Program
  - Natural Resource Conservation Program
  - Ozone-Depleting Substances (ODS) Management Program
  - SPCC Program
  - Sustainable Landscaping Program
  - Wastewater Management Program
  - Weed Management Program.

Four findings were made in the areas of document control and operational control and seven opportunities for improvement

were identified. Several documents did not have added version control indicating the current version of the document. Several procedures contained inaccuracies and needed to be updated. While the majority of the actions from this assessment have been completed, several are outstanding due to length of time needed to implement corrective actions. All actions are expected to be completed in 2012.

In November 2011, an internal assessment of NREL's Construction Stormwater Management program was conducted within the EHS Office by the EMS Coordinator. Interviews were conducted with the program manager and document and records reviews were completed. Several procedures and inspection forms contained deficiencies and needed to be updated. Three findings were made regarding operational controls and four opportunities for improvement were identified. All actions are expected to be completed in 2012.

- Evaluations of compliance. In February 2011, NREL conducted an internal evaluation of compliance. The evaluation was conducted to verify compliance with environmental legal and other requirements applicable to NREL across a sampling of activities and programs for 2010. No actions were identified for follow up or correction.

The review included compliance with federal, state, and local regulatory deliverables and DOE requirements including permits, equipment and other registrations and certifications, and reports and notifications. The review also evaluated NREL's completion of requirements by environmental program area, including requirements for such activities as inspection, monitoring, training, certifications, etc. Environmental areas reviewed included:

- Cultural Resources Protection
  - Drinking Water Quality
  - Endangered Species Act
  - EMS
  - Regulated Waste Management
  - NEPA
  - Wetlands Protection
  - Wildlife Protection.
- External assessments. In 2011, NREL sought and achieved certification under ISO 14001 and received a third-party certification assessment to confirm conformance with the standard. The assessment involved rounds of review including:
    - A "desk audit" of EMS procedures and documentation
    - An "on-site readiness review" of the major elements of the management system
    - A final audit involving site visits by a team of auditors to all major facilities, interviews with staff at all levels of the organization, observation of processes in place, and review of documents and records.

The extensive certification assessment resulted in several findings and opportunities for improvement. Corrective actions will address deficiencies in document version control and NREL's procedure for identifying environmental aspects. All actions are expected to be completed in 2012.

### **3.4 2011 AWARDS AND RECOGNITION**

In 2011, NREL received several awards and recognition of its environmental and sustainability achievements including:

- GreenGov Presidential Award
- DOE EStar Awards
- Federal Electronics Challenge (FEC) Platinum Award
- CELP Gold-level Leader.

#### **GREENGOV PRESIDENTIAL AWARD**

In 2011, NREL received the prestigious GreenGov Presidential Award for "Sustainable Information Technology Innovation at Work in NREL's RSF Green Data Center." The GreenGov Presidential Award is a federal government award that celebrates extraordinary achievement in the pursuit of President Obama's challenge to lead by example toward a clean energy economy.

#### **DOE ESTAR AWARDS**

In 2011, NREL received two DOE EStar Awards for its nominations including "Living Lab—Building the Sustainable Campus of the Future" and "Cradle to Cradle—Near-Zero Materials Waste and Beyond." DOE EStar Awards highlight environmental sustainability projects and programs within the DOE complex that reduce environmental impacts, enhance site operations, reduce costs, and demonstrate excellence in pollution prevention and sustainable environmental stewardship.

#### **FEC PLATINUM AWARD**

In 2011, NREL achieved the platinum-level FEC Award. FEC is a partnership program between the Office of the Federal Environmental Executive and the EPA. The FEC recognizes federal facilities that voluntarily:

- Purchase greener electronic products
- Reduce impacts of electronic products during use
- Manage obsolete electronics in an environmentally safe way.

Learn more about this voluntary program at the FEC Website at [www.federalelectronicschallenge.net/](http://www.federalelectronicschallenge.net/).

#### **CELP GOLD-LEVEL LEADER**

In 2011, NREL was again recognized as a CELP gold-level leader. CELP is a voluntary partnership between CDPHE and participating private and public Colorado facilities, and is intended to recognize environmental leadership and performance.

In early 2004, NREL was the first laboratory accepted into CELP as a gold-level leader and has maintained this leadership level since. As a component of CELP membership, NREL's voluntary environmental performance goals, described above, further enhance opera-



tions and performance at the laboratory. CELP recognizes facilities that voluntarily:

- Exceed regulatory requirements
- Implement EMS (which focus on incorporating environmental considerations into normal management processes and improving internal environmental management effectiveness)
- Work closely with their communities
- Establish three-year goals focusing on measurable results.

Learn more about this voluntary program at CDPHE Website, [www.cdphe.state.co.us/oeis/elp/index.html](http://www.cdphe.state.co.us/oeis/elp/index.html).



## Benefits of NREL's EMS

**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.

**Environmental and sustainability performance.** While NREL benefits as an organization from each of the efforts highlighted here, the larger benefit is in reduced impacts to the quality of the air, water, land, and to the flora and fauna that share the campus and community.

**Reduced risk.** NREL's Hazard Identification and Control Program incorporates environmental risk assessment.

**Cost savings.** Any avoided impact represents cost savings, specifically in the event of spills and incidents. Cost savings are realized through energy efficiency projects, new renewable energy installations, and waste reduction and recycling.

**Environmental awareness.** Staff are made aware of the potential environmental impacts from their work activities through the NREL Now newsletter, postings on the NREL intranet, new employee orientation and activity specific trainings, policies and procedures, management communications, Sustainable NREL communications, and special events such as Staff Awards (an annual employee recognition event), Earth Day, and Bike 2 Work Day.

**Empowered individuals.** Staff are empowered to reduce NREL's environmental footprint including participation in programs and events for recycling single-stream materials, batteries, electronic equipment, and shredded paper, as well as a composting program. Staff at the new RSF are able to support a new, ultra high-efficiency energy goal for the building by reducing their energy use in the office.

**Organizational culture and operations.** NREL strives to maintain a high level of awareness in the laboratory around safety, health, and environmental responsibilities. This is accomplished through a variety of means, including regular communications from executive management, as well as at-the-ground-level through daily EHS interaction with lab and operations staff in trainings, inspections, and risk assessments.

**Real property asset management.** NREL strives to achieve, at a minimum, LEED Gold certification for all new buildings and major renovations.

**Community relations.** NREL seeks to improve community relations by responding to, and tracking all community input through phone calls, email, community meetings, and the NEPA process. NREL takes proactive measures to engage the community with public tours, newsletters, and mailings to neighborhoods surrounding its facilities.

**Cooperative conservation.** NREL regularly works with community stakeholders to improve the community. For example, with the growth of the STM, NREL implemented a traffic mitigation plan to reduce forecasted impacts of increased traffic to the facility.

## 4 Sustainability

The Sustainable NREL Program was formed to implement sustainable applications within the laboratory. This collaborative and interdisciplinary initiative involves staff from across the organization to meet NREL's goals to maximize the efficient use of resources; minimize waste and pollution; and serve as a positive force in economic, environmental, and public responsibility. Environmental stewardship components include:

- Renewable energy and energy efficiency solutions
- High performance sustainable buildings, landscaping, campus planning, and transportation
- Water, electricity, and natural gas use efficiency and management
- GHG emission analysis and management
- Reduce, reuse, and recycle materials use
- Pollution prevention
- Sustainable acquisitions
- Sustainable policies and operating practices
- Public responsibility and community outreach.

Sustainable NREL:

- Provides technical knowledge and recommendations
- Oversees data collection and analysis of performance metrics for federal reporting
- Integrates energy, water and material resource conservation and efficiency applications into NREL's daily research and operations
- Generates short-term and long-term planning measures for building NREL's "Campus of the Future."

NREL integrates sustainability into its EMS. Technical experts from Sustainable NREL and the EHS Office work together regularly to improve operations and implement programs including:

- Site sustainability and pollution prevention data tracking and reporting to DOE
- Sustainability and environmental management planning
- Measurement and tracking of environmental objectives, targets, and actions
- Pollution prevention assessments and improvements
- Awareness and engagement of staff and community members.

### 4.1 SITE SUSTAINABILITY PLANNING

EO 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, specifies environmental sustainability performance goals for federal agencies. DOE O 436.1, *Departmental Sustainability*, implements the requirements of the executive order for DOE. Each year, DOE prepares a Strategic Sustainability Performance Plan (SSPP) that describes how the department will meet the requirements of EO 13514 and DOE O 436.1. Each DOE facility must then develop an annual SSP. Each site's plan is used to report on steps taken to meet the national and DOE sustainability objectives and also outlines plans for the upcoming year.

The following content has been extracted from NREL's SSP for FY 2012. The full report is located online at [www.nrel.gov/sustainable\\_nrel/](http://www.nrel.gov/sustainable_nrel/).

#### SITE MANAGEMENT VISION

Integral to both research and operations, NREL's sustainability efforts support the laboratory's mission—the innovative research, development, and commercialization of renewable energy and energy efficiency technologies. Leading by example, NREL operates in a manner that balances environmental, economic, and social values in the delivery of our mission.

Fostering environmental and social responsibility, NREL is working to establish the laboratory as a global model for sustainability. The laboratory strives to accomplish this by:

- Advocating for all executive orders, federal regulations, DOE orders, and goals related to sustainable facility operations
- Executing NREL-specific goals to reduce our impacts on the community and environment
- Providing technical expertise to other organizations within the laboratory
- Providing leadership within the federal government and our community by actively mentoring and collaborating with other organizations to move sustainability into a new paradigm.

NREL's campus is a living laboratory that showcases new technologies, design practices, and operating behaviors. In all campus development, NREL looks for opportunities to integrate energy efficiency and renewable energy, high-performance buildings, and sustainable transportation options. On-site deployment of technologies developed by NREL researchers is also emphasized.

#### MAJOR PLANNING ASSUMPTIONS, ISSUES, FUNDING STRATEGIES

NREL is planning for significant future growth as represented in our long term campus plan—with a projected 83% increase in staff and 300% increase in campus footprint from FY 2008 to FY 2020. While currently experiencing growth, the current economic climate is uncertain. In this context, NREL is preparing to accommodate future growth through the construction of new high-performance buildings and renewable energy systems that take

advantage of alternative financing mechanisms, including PPAs, energy savings performance contracts (ESPCs), partnerships with energy service companies, and cooperative research and development agreements (CRADAs). NREL also continues to review the use of overhead funds, cost savings reinvestment, and leveraging of alternative finance for retrofits or new projects.

#### 4.2 2011 HIGHLIGHTS AND ACHIEVEMENTS

As market demand for renewable energy and energy efficiency continues to expand, NREL responds. In FY 2011, our staff levels increased 20% from 2010, and NREL's campus square footage expanded 48%. This expansion was necessary to help support the growing market demand for energy efficiency and renewable energy technologies. This pace of campus construction will continue through FY 2012 with the addition of six new structures on campus. This growth poses challenges in NREL's pursuit of DOE's energy and sustainability goals. Even with all new construction meeting LEED Gold or Platinum certification standards, NREL's



PV panel installation on the roof at the RSF. *Photo by Dennis Schroeder, NREL/PIX 17843*

first net-zero energy building, and additional new on-site renewable systems, NREL's demand for energy and water will increase. Subsequently, GHG emissions from purchased energy and travel will continue to grow even though impacts are being reduced on a per capita basis. Scope 3 GHG emissions will continue to be a high priority for NREL in our development of innovative solutions.

Staffing increases affect energy and resource consumption. To mitigate our impacts on the community and the environment while strongly promoting the laboratory's mission, NREL is educating staff on behavior changes necessary to uphold sustainability goals that meet reductions required by EO 13514. Using a range of programs, procedures, and projects, Sustainable NREL supports the dynamic processes of creating a sustainable research campus.

#### 4.3 2011 SSPP GOAL PERFORMANCE

The following table summarizes each of DOE's SSPP goals and NREL's performance status.



The Gamesa G9X-2.0 turbine assembled at the NWTC is the latest addition to NREL's collection of multi-megawatt wind turbines. *Photo by Dennis Schroeder, NREL/PIX 20864*

### 2011 Highlights and Achievements

To reduce energy consumption with expected staff growth, NREL constructed two high-performance sustainable buildings and four on-site renewable energy installations in FY 2011. These buildings allow NREL to vacate leased space and move staff into a more efficient and sustainable work environment. In FY 2011, NREL:

- Achieved LEED Platinum certification from the U.S. Green Building Council for the new RSF
- Completed the IBRF, which achieved LEED Gold certification

In FY 2011, NREL also deployed new on-site renewable-energy systems, including:

- PV on the STM campus—a 524 kilowatt (kW) array on the roof over the RSF visitor's parking lot and a 449 kW array on the RSF itself.

Campus construction continues through FY 2012 with a new cafeteria, parking garage and associated roadway infrastructure, a new Site Entrance Building, a new wing addition to the RSF, and the ESIF on the STM campus, and a new 5 MW dynamometer at the NWTC.

FY 2011 also saw many innovative accomplishments for NREL, including:

- Communicating NREL's campus-wide no-idling policy
- Establishing NREL's first green janitorial contract
- Enhancing NREL's office supply contract for sustainable acquisition
- Completing the first interagency Sustainability Challenge with DOE, EPA Region 8, General Services Administration, and City of Lakewood, Colorado.
- Participating in the international Katerva Challenge
- Achieving net-zero energy performance for the RSF
- Implementing a campus-wide composting program.

As educators, NREL also hosted 233 tours of the net-zero energy RSF to share pioneering energy efficiency technologies, and sustainable practices.

## NREL'S PERFORMANCE STATUS TOWARD DOE SSPP GOALS

SSPP Goal #	DOE SSPP Goal	Performance Status in FY 2011
1.1	28% Scope 1 and 2 GHG reduction by FY 2020 from a FY 2008 baseline	NREL reduced Scope 1 and 2 emissions 86% from the 2008 baseline (including RECs).
1.2	30% energy intensity reduction by FY 2015 from a FY 2003 baseline.	Energy intensity decreased 35% since 2003.
1.3	Individual buildings or processes metering for 90% of electricity (by October 1, 2012); for 90% of steam, natural gas, and chilled water (by October 1, 2015)	NREL connected electricity, hot and chilled water, and natural gas meters to the Energy Dashboard.
1.4	Cool roofs, unless uneconomical, for roof replacements unless project already has CD-2 approval (New roofs must have thermal resistance of at least R-30.)	50% of NREL campus have cool roofs, a 27% increase from FY 2010.
1.5	7.5% of annual electricity consumption from renewable sources by FY 2013 and thereafter (5% FY 2010—FY 2012)	28% of NREL's total power comes from on-site sources.
1.6	10% annual increase in fleet alternative fuel consumption by FY 2015 relative to a FY 2005 baseline	Alternative fuel use has grown 143% since 2005.
1.7	2% annual reduction in fleet petroleum consumption by FY 2020 relative to a FY 2005 baseline	NREL established a campus-wide no-idling policy. Petroleum fuel usage has grown 92.6% since 2005.
1.8	75% of light duty vehicle purchases to consist of alternative fuel vehicles (AFVs) by FY 2000 and thereafter	One compressed natural gas vehicle was added to the fleet in FY 2011.
1.9	Fleet inventory reduction by 35% within the next three years relative to a FY 2005 baseline	NREL disposed of seven vehicles, 15% of the fleet in FY 2011.
2.1	13% Scope 3 GHG reduction by FY 2020 from a FY 2008 baseline	NREL Scope 3 emissions increased 10% from the 2008 baseline.
3.1	15% of existing buildings greater than 5,000 GSF to be compliant with the Guiding Principles (GPs) of HPSB by FY 2015	NREL currently has three buildings (13%) compliant with the GPs. NREL performed GP assessments on three additional buildings this year.
3.2	All new construction, major renovations, and alterations of buildings greater than 5,000 GSF to comply with the GPs; and where the work exceeds \$5 million, each are to be LEED Gold certified or equivalent	In FY 2011, NREL received LEED Platinum certification for RSF and LEED Gold certification for IBRF.
4.1	26% water intensity reduction by FY 2020 from a FY 2007 baseline	NREL reduced water intensity by 48% from FY 2007 baseline.

## NREL'S PERFORMANCE STATUS TOWARD DOE SSPP GOALS

SSPP Goal #	DOE SSPP Goal	Performance Status in FY 2011
4.2	20% water consumption reduction of industrial, landscaping, and agricultural (ILA) water by FY 2020 from a FY 2010 baseline	NREL does not use ILA water.
5.1	Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris, by FY 2015	NREL diverted 77% of campus waste from landfill; rolled out PPI Pilot Program; and performed three pollution prevention assessments.
5.2	Divert at least 50% of construction and demolition materials and debris by FY 2015	NREL diverted 88% of its construction waste from landfill in FY 2011.
6.1	Procurements to meet sustainability requirements and include sustainable acquisition clause (95% each year)	NREL awarded its first green janitorial contract. The office supply contract was enhanced to include EO 13514 sustainable acquisition requirements.
7.1	All data centers to be metered to measure a monthly power usage effectiveness (PUE) (100% by FY 2015)	NREL's RSF data center measures monthly PUE.
7.2	Maximum annual weighted average PUE of 1.4 by FY 2015	PUE for the RSF data center is 1.16.
7.3	Electronic Stewardship—100% of eligible PCs, laptops, and monitors with power management actively implemented and in use by FY 2012	Power management is enabled on 100% of devices.

## 5 NREL's Role in the Environment – Global and Local

As the nation's premier resource for renewable energy information, research, and technology, NREL has a unique role in supporting the nation's energy and environmental goals. NREL's mission is stated succinctly:

*NREL develops renewable energy and energy efficiency technologies and practices, advances related science and engineering, and transfers knowledge and innovations to address the nation's energy and environmental goals.*

Among the environmental imperatives addressed by NREL, carbon mitigation and a shift to a greater use of renewable energy are critical to the 21st century. Major changes in the nation's energy policy have spurred new research efforts at NREL to help address these issues. Renewable energy technologies will have a role in mitigating the effects of climate change and in moving forward to energy independence.

### 5.1 ENERGY POLICY UPDATES

In 2008, there was a major shift in the energy policy of the United States with the passage of the Energy Independence and Security Act (EISA) which mandated significant changes in the energy production and use in the United States over the coming decades. The EISA has numerous provisions impacting vehicle fuel efficiency, including:

- Transportation electrification
- Funding for increased biofuel research and production
- Expanded research on solar, geothermal, marine, and hydrokinetic renewable technologies
- Support for research into carbon sequestration technologies
- Revisions to the renewable fuel standard (RFS) provisions of the Clean Air Act
- Provisions that will result in a modernization of the electrical transmission system known as Smart Grid.

NREL has a critical role in helping the nation meet the legislative goals set in the EISA.

The Energy Information Administration (EIA), an independent arm of DOE, evaluates energy use and projections in the Annual Energy Outlook (AEO). The EIA tracks energy use by source and predicts changes in energy demands by gauging the effects of economic trends and the impacts of energy policy changes implemented

by new legislation and regulation. The EIA also assesses the impacts on energy demands from changes to tax credit structures as incentives to use alternative sources, such as the biofuels tax credit, and the effects of new or revised fuel standards, such as the Corporate Average Fuel Economy standard or the RFS, both now established by the EPA.

The AEO projects that the strongest growth in fuels in the outlook period would be in renewable fuels used for the generation of electricity and for liquid fuels used for transportation. Total U.S. consumption of liquid fuels, including fossil fuels and biofuels, are predicted to increase from 18.8 million barrels per day in 2009 to 21.9 million barrels per day in 2035.

Increased research activities at NREL, in response to changes in the national policy, are only one example of the interface of policy and renewable energy. In 2011, NREL continued to make advances in renewable energy technologies that will contribute to the growth of this segment of the overall energy economy and support the energy sector expected to have the strongest growth in the next 25 years.

## 5.2 NREL RESEARCH HELPING MEET LEGISLATIVE GOALS

Since its origination as SERI, NREL has been involved in the fundamental development of solar energy technologies. As a research institution, NREL ranks second among all U.S. laboratories in the number of energy-related publications and has the distinction of having published the number-one cited article in the energy field<sup>3</sup>. In 2009, a journal article co-authored by three NREL researchers currently ranks as one of the most read articles over the past 12 months by the *Environmental Science & Technology* journal<sup>4</sup>. With the addition of the NWTC, the IBRF, and a number of related facilities and organizations, NREL has increased the portfolio of research activities to include wind, biofuels, and energy efficiency technologies for residential, commercial, and industrial applications. Recently, NREL has increased the level of activity in energy delivery and storage, including energy transmission and distribution, alternative fuels, and hydrogen delivery and storage. For example, NREL has developed a wind-to-hydrogen project at the NWTC to demonstrate the technologies of converting wind and solar energy into hydrogen through the electrolysis of water. In addition, the Hydrogen Test Facility began operations in 2007, where research is aimed at reducing the delivered costs of electrolytic hydrogen. In 2011, construction began for the new ESIF, a laboratory that will house research into this critical area. Cost-effective energy conversion and storage will greatly enhance the viability of renewable energy technologies, particularly those where energy production is intermittent, such as wind and solar.

### BIOFUELS

EISA established rigorous goals for developing biofuel substitutes for petroleum-based fuels used for transportation (except

ocean-going vessels). The RFS has now been expanded to require the annual production of 36 billion gallons of renewable fuel in motor fuels by 2022. Of that, 21 billion gallons must be from advanced biofuels, which is defined as biofuel produced from feedstocks other than corn grain or corn starch. The EISA mandates that advanced biofuels include cellulosic fuels and biomass-derived diesel substitutes, and, further, that these fuels have at least 50% less GHG emissions than petroleum fuels. NREL is well positioned to contribute to the development of biofuels technologies that will facilitate meeting these ambitious goals. The EIA predicts that the 2022 goal will not be met—projecting a total of 25.7 billion gallons production capacity. The shortfall is attributed to economic and technical factors preventing cellulosic biofuels (i.e., biofuels derived from materials other than corn grain or corn starch) production from providing the credits needed to meet the requirement. However, the EIA continues to predict that the production of biofuels ultimately surpasses the RFS requirements by 2035.

In 2011, NREL completed construction of the new IBRF. The IBRF is designed to be a place for the laboratory and industry to test demonstration-scale projects and accelerate the commercialization of biofuels. The facility is a \$33.5 million pilot plant and facility upgrade capable of supporting a variety of advanced biofuels projects. The IBRF boasts a 27,000 ft<sup>2</sup> high bay with one area available to industry partners for equipment testing, as well as upgraded laboratories, additional office space, and access to NREL expertise.



The IBRF boasts a 27,000 ft<sup>2</sup> high bay with one area available to industry. Photo by Dennis Schroeder, NREL PIX 19805

### NREL RESEARCH MITIGATING CLIMATE CHANGE

The energy policy shift embodied by the EISA establishes rigorous goals to bring the nation to energy independence, but it also acknowledges the growing concern over climate change. The goals for reducing GHG emissions just begin to address the

<sup>3</sup> Contreras, M. A.; Egaas, B.; Ramanathan, K.; Hiltner, J.; Swartzlander, A.; Hasson, F.; and Nuff, R. (1999) Progress Toward 20% Efficiency in Cu(In,Ga)Se<sub>2</sub> Polycrystalline Thin-film Solar Cells. *Prog. Photovoltaic Res. Appl.* 7.311-316.

<sup>4</sup> Williams P. R, D.; Inman, D.; Aden, A.; and Heath, G. (2009). Environmental and Sustainability Factors Associated With Next-Generation Biofuels in the U.S.: What Do We Really Know? *Environ. Sci. Tech.* 43, 4763-75.

problem, however. In a 2007 report produced by the American Solar Energy Society, entitled, “Tackling Climate Change in the U.S.,” research indicates that GHG emissions in the United States must be reduced by the equivalent of 1,100 to 1,300 million metrics tons of carbon per year (MMtC/Yr) by 2030 to limit atmospheric CO<sub>2</sub> levels to between 450 and 500 ppm. A stabilized level of 450 ppm CO<sub>2</sub> is, according to this report, a level which can ward off the worst effects of climate change. The report goes on to say that this level of CO<sub>2</sub> reduction can be achieved with a combination of energy efficiency improvements in the building, vehicle, and industrial sectors (57%), and renewable energy installations (43%).

Of the 43% reduction (516 MMtC/yr) projected to be achieved through the deployment of renewable energy technologies, a majority of the GHG reduction would come from wind energy (181 MMtC/Yr). The additional reductions would be from CSP (63 MMtC/Yr), PVs (63 MMtC/Yr), biofuels (58 MMtC/Yr), biomass (75 MMtC/Yr), and geothermal (83 MMtC/Yr). A recent survey of the growth of the first generation of these technologies from 2002 through 2007 shows that the installed capacity for wind generation has had the greatest increase.

NREL is actively engaged in most of these research areas—particularly wind, PV, and CSP.

## WIND

NREL continues to advance wind energy technologies at the NWTC and elsewhere. In 2011, DOE announced that NREL would receive nearly \$4 million to help spur offshore wind development. NREL will receive \$1.5 million to improve computer-aided-engineering tools to design and assess a wide range of floating offshore wind platform concepts. Another \$1.2 million was awarded to produce an offshore wind farm simulation tool to improve designs by maximizing energy capture and minimizing structural fatigue from wave and wind impacts. NREL will also receive \$400,000 to develop software to simulate offshore conditions, including wind and waves associated with extreme events such as hurricanes, to help design more robust offshore wind turbines.



Installation of a 2.5 MW Alstom wind turbine at the NWTC. *Photo by Dennis Schroeder, NREL/PIX 18888*

## CONCENTRATING SOLAR POWER (CSP)

CSP technologies can be a major contributor to our nation's future need for new, clean sources of energy, particularly in the western

United States. Large CSP installations require substantial investments, with costs potentially exceeding \$1 billion. NREL has been deeply involved in the continuing effort to reduce the cost of CSP by improving thermal energy storage (TES). In May 2011, NREL, DOE, and Sandia National Laboratories held a TES workshop in Golden. The objective was to engage the university and laboratory research communities to identify research directions for developing new high-temperature materials and systems that advance TES for CSP technologies. To communicate the results, NREL recently published “Summary Report for Concentrating Solar Power Thermal Storage Workshop: New Concepts and Materials for Thermal Energy Storage and Heat-Transfer Fluids.”

The workshop enabled researchers to better define the challenges in this field, and clarified the direction of research needed on heat transfer fluids, sensible energy storage, phase-change storage, and thermochemical storage.

One motivation to conduct the workshop was the DOE SunShot Initiative. SunShot is a collaborative national initiative to make solar energy technologies cost-competitive with other forms of energy by reducing the cost of solar energy systems by about 75% before 2020. Among other things, SunShot calls for reducing the total levelized cost for utility-scale solar electricity to roughly 6 cents per kilowatt-hour, without subsidies, by 2020.



Concentrating solar power research lab on STM. *Photo by Patrick Corkery, NREL/PIX 17775*

## PHOTOVOLTAICS (PV)

The development of technology to capture solar energy is at the core of research conducted at NREL. Three solar technologies developed at NREL have been named among 2011's most significant innovations by R&D Magazine. The technologies—the Innovalight Silicon Ink process, the Flash Quantum Efficiency System for Solar Cells, and the Optical Cavity Furnace—were recognized with R&D 100 Awards. The awards, known as the “Oscars of Invention,” identify revolutionary technologies newly introduced to the market, and NREL has received 50 R&D 100 Awards since 1982.

- Silicon Ink Saves Money, Improves Quality. NREL scientists teamed with Innovalight, Inc., to invent the Innovalight Silicon

Ink process. The silicon ink, a liquid form of silicon, was developed for use in solar cells. This marks the first time that silicon has been sold in the marketplace as a liquid.

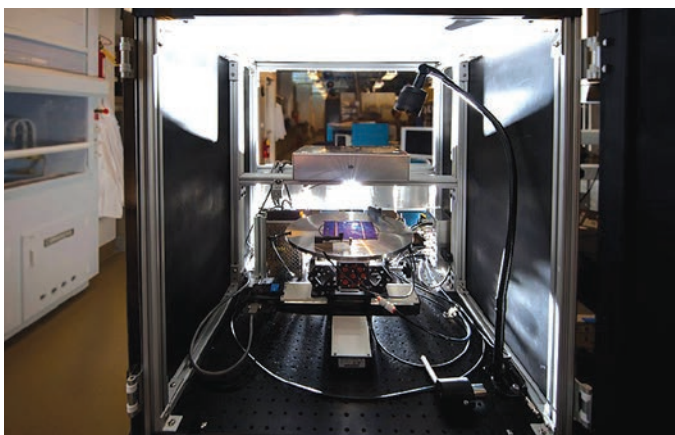
With the Innovalight Silicon Ink process, a screen printer is added to the manufacturing line, which produces an immediate increase in solar cell efficiency by allowing lighter doping, thereby enhancing response to the blue portion of the spectrum.

The new product boosts the bottom line of a typical solar production plant by 20%, which for an average-size factory is \$100 million, while boosting the efficiency of the cells by about 6%.

More information on this technology is available in the new report, "High Efficiency, Low Cost Solar Cells Manufactured Using 'Silicon Ink' on Thin Crystalline Silicon Wafers" by Homer Antoniadis, Innovalight, Inc. available at [www.nrel.gov/docs/fy11osti/50824.pdf](http://www.nrel.gov/docs/fy11osti/50824.pdf).

- **Faster Assessment of Solar Cell Quality.** NREL scientists teamed with Tau Science Corporation to develop "Flash Quantum Efficiency System for Solar Cells," a way to assess the quality of solar cells at a speed that is about 1,000 times faster than previous methods.

The instrument—marketed by Tau as FlashQE—uses light-emitting diodes, high-speed electronics, and mathematical algorithms to measure the quantum efficiency of solar cells orders of magnitude faster than before. What used to take 20 minutes, and therefore, could be done only with random samples of cells, now can be done in a second.



FlashQE is one of three NREL-developed, game changing technologies to be honored with a 2011 R&D 100 Award. *Photo by Dennis Schroeder, NREL/PIX 18965*

This means every single cell on a manufacturing line can be assessed, which can provide much needed process feedback information to the line and each cell can be sorted by its spectral response. Cells that respond best to a particular color of light can be connected to form a solar module. That way,

a mismatched cell on a module won't put the brakes on all the work the rest of cells are doing. And that means more efficient conversion of photons into electricity.

- **Furnace Bolsters Efficiency, Lowers Cost.** The NREL Optical Cavity Furnace could revolutionize the solar cell manufacturing industry in the United States by producing higher quality and higher efficiency solar cells at a fraction of the cost of conventional, thermal ovens. The new furnace, which uses photons to uniformly heat crystalline solar cells and semiconductor materials, has increased the efficiency of the cells by 3% to 4%. And it costs 75% less than an industrial thermal or infrared furnace. The Optical Cavity Furnace, licensed to AOS Solar, Inc., uses light enclosed within a highly reflective chamber to achieve a level of temperature uniformity that is impossible with other furnaces. It virtually eliminates energy loss by lining the cavity walls with ceramic materials of high reflectance and high thermal insulation, and by using an optimal geometric design.

AOS Solar manufactured the furnace, which the company branded as the Optical Processing Furnace, and it is operating at NREL's Process Development Integration Laboratory.

## 6 Compliance Summary

NREL is subject to many federal, state, and local environmental laws and regulations, as well as executive orders and DOE orders, and memoranda of understanding with government agencies. NREL continues its excellent record of environmental compliance. In 2011, NREL received no violation notices from any regulatory agency. All required permits were received or renewed, required registrations were completed, and required notifications and reporting were submitted. There were no spills or releases of materials requiring reporting in 2011.

The table titled Federal, State, and Local Environmental Laws and Regulations Applicable to NREL, page 31, includes a brief description of the statute or regulation and how compliance requirements were met this year. More detailed information for each area of compliance is found in the referenced sections of this report. Also, see the table below: Environmental Permits, Registrations, and Notifications Applicable to NREL During 2011.



## FEDERAL, STATE, AND LOCAL ENVIRONMENTAL LAWS AND REGULATIONS APPLICABLE TO NREL

Report Sections	Regulatory Program Description	Compliance Status and Highlights	Regulator & Requirement
Air Quality	<p>CDPHE administers the Clean Air Act implementing regulations for all point sources (facilities or other types of operations) in Colorado, under authority delegated by the EPA. Several main categories for air pollutants are regulated: criteria air pollutants, non-criteria pollutants, hazardous air pollutants (HAPs), and ozone-depleting substances.</p> <p>EPA regulation 40 CFR 82, Protection Of Stratospheric Ozone, requires that servicing records must be kept for appliances containing more than 50 pounds of Class 1 or 2 ODS refrigerant.</p> <p>CDPHE regulations require federal, state, and local government facilities to track street sanding in the wintertime, and to minimize sand use with the goal of reducing particulate pollution in the Denver area.</p> <p>EPA regulations require that certain facilities which emit GHG emissions track and report the amount of those emissions. Reporting and permitting of GHGs is required under the EPA Prevention of Significant Deterioration (PSD) regulation, Title V Tailoring Rule, and the EPA GHG Mandatory Reporting Rule.</p>	<p>NREL facilities did not exceed air permit standards or other regulatory requirements.</p> <p>For 2011, an internal evaluation of compliance confirmed that NREL is in compliance with all Colorado and EPA permit requirements and that all NREL facilities and individual permitted equipment are classified as minor sources.</p> <p>On behalf of the CDPHE Air Pollution Control Division (APCD), Jefferson County completed an air inspection of the NWTTC Site 4.0 emergency generator in November 2011. No issues were identified.</p> <p>All required registrations and permit renewals were performed during 2011 for air pollutant emitting equipment and ozone depleting substance-containing equipment. Operators must maintain records of service for appliances containing more than 50 pounds of ODS refrigerant. NREL facilities servicing refrigeration equipment were registered. Confirmed that all NREL refrigeration service personnel have obtained the EPA and Colorado required training and certification.</p> <p>Annual street sanding reporting was provided to the state and Jefferson County in 2011.</p> <p>NREL's 2011 GHG inventory shows that emissions are below the exempt level for EPA reporting and permitting rules.</p>	<p>EPA: 40 Code of Federal Regulations (CFR) 82</p> <p>CDPHE: 5 Colorado Code of Regulations (CCR) 1001-18, Reg. 16</p>
Drinking Water Quality	<p>The Safe Drinking Water Act (SDWA) establishes minimum drinking water standards and monitoring requirements for drinking water supplies. Drinking water quality is regulated for all public water suppliers in Colorado by CDPHE, under authority delegated by the EPA.</p>	<p>The NWTTC drinking water system is subject to the regulatory requirement. In 2011, all monitored parameters met applicable SDWA requirements.</p> <p>Triennial sampling for lead and copper was conducted in 2011; the concentration of these metals was well below the Maximum Contaminant Levels (MCLs) at all sample locations.</p>	<p>EPA: 40 CFR 141-149</p> <p>CDPHE: 5 CCR 1003-1</p>
Groundwater Quality	<p>Colorado groundwater quality standards are established by CDPHE. Permits for groundwater wells are issued by the Colorado Department of Natural Resources (DNR).</p>	<p>There are no compliance activities associated with the NREL Groundwater Program. NREL currently has five permitted monitoring wells at the STM site. The wells are not currently used for monitoring activities.</p>	<p>CDPHE: 5 CCR 1002-41 2 CCR 402-7</p>
Surface Water Quality	<p>Construction-related stormwater discharge regulations are administered by the EPA at federal facilities in Colorado.</p> <p>Non-federal facility construction-related stormwater discharges in Colorado are regulated by the Water Quality Control Division of CDPHE.</p>	<p>Ten construction projects required coverage under the EPA CGP. Coverage was obtained or continued for each project. Notices of Termination were filed with the EPA for three projects.</p> <p>A CDPHE National Pollutant Discharge Elimination System Program stormwater permit was obtained for the south entrance project as this project exists entirely outside of the STM site boundaries.</p>	<p>EPA: 40 CFR 122.26</p> <p>CDPHE: 5 CCR 1002-61 Reg. 61</p>

## FEDERAL, STATE, AND LOCAL ENVIRONMENTAL LAWS AND REGULATIONS APPLICABLE TO NREL

Report Sections	Regulatory Program Description	Compliance Status and Highlights	Regulator & Requirement
Wastewater Management	<p>The federal Clean Water Act (CWA) and Colorado Water Quality Control Act regulations apply to wastewater management at NREL's STM and DWOP. The Metro Wastewater and Reclamation District manages wastewater for much of the Denver metro area, receiving wastewater from a number of smaller wastewater districts, including the Pleasant View Water and Sanitation District.</p> <p>Inspection and permitting of individual sewage disposal systems (ISDSs) have been delegated to Jefferson County by CDPHE.</p>	<p>All program activities were in compliance with requirements.</p> <p>NREL coordinated with the Pleasant View Water and Sanitation District on large volume discharges related to construction activities. Water line flushing and sanitizing were conducted in accordance with requirements.</p> <p>Improvements to one ISDS at the NWTC were completed in accordance with requirements.</p>	<p>EPA: 40 CFR 122-136</p> <p>CDPHE: 5 CCR 1002-31</p>
Hazardous Materials Management	<p>EO 13423 outlines requirements for Superfund Amendments and Reauthorization Act (SARA) Title III, EPCRA compliance, and Toxic Release Inventory reductions for DOE facilities.</p> <p>Annual hazardous material permits are required by West Metro Fire Rescue for the STM and DWOP sites. ReFUEL, located within the City and County of Denver, is subject to the Denver Fire Dept. Hazardous Materials Information System (HMIS) requirements, including permitting, inventory, and annual inspection.</p>	<p>There were no releases of hazardous materials requiring reporting.</p> <p>EPRCA requirements including notification, release reporting, and MSDS/Chemical Inventory requirements were met. An EPCRA Sec 311-312 Tier II report was submitted for reporting year 2010, identifying diesel fuel, petroleum oil and sulfuric acid in lead-acid batteries.</p> <p>West Metro Fire Rescue conducted an annual hazardous material inspection and issued permits for all major research facilities on the STM campus. The inventory of materials at the ReFUEL facility was provided to the Denver Fire Department. A required permit was maintained and an inspection was conducted by Denver Fire.</p>	<p>EPA: 40 CFR 355, 370, 372</p>
Waste Management	<p>The Resource Conservation and Recovery Act (RCRA) established requirements for the management of regulated waste. In Colorado, CDPHE administers waste regulations under authority delegated by the EPA.</p>	<p>NREL holds five EPA generator identification numbers, one for each of its sites. All regulatory notifications were updated and applicable waste generator fees were paid.</p> <p>Due to three calendar months of episodic hazardous waste generation at volumes greater than 1000 kg per month and in anticipation of additional pilot plant research experiments, the STM facility revised its waste generator status to large quantity generator in October 2011.</p> <p>Four NREL facilities are categorized as conditionally exempt small quantity generators.</p>	<p>EPA: 40 CFR 260—280</p> <p>CDPHE: 6 CCR 1007-3</p>
Storage Tank Management	<p>ASTs are regulated in Colorado by the Colorado Department of Labor and Employment (CDLE) Oil Inspection Section under the Colorado AST regulation 7 C.C.R. 1101-14. Colorado requires that ASTs 660 gallons or larger be permitted prior to installation and registrations submitted annually.</p>	<p>No spills or releases from NREL's ASTs or related fueling activities occurred during 2011.</p> <p>Annual AST registrations were submitted to the CDLE for two registered ASTs.</p> <p>A 6,000-gallon stainless steel ethanol storage tank, which was temporarily removed from service in 2010, was placed back into service in June 2011, following replacement of piping.</p>	<p>CDLE: Division of Oil and Public Safety (DOPS) Storage Tank Regulations, 7 C.C.R. 1101-14</p>

## FEDERAL, STATE, AND LOCAL ENVIRONMENTAL LAWS AND REGULATIONS APPLICABLE TO NREL

Report Sections	Regulatory Program Description	Compliance Status and Highlights	Regulator & Requirement
Spill Prevention and Response	SPCC plans are required by EPA and Colorado regulations for facilities that meet certain oil storage criteria. In general, a facility must have an SPCC plan if the facility stores more than 1,320 gallons of oil or where a spill has the potential to enter a Water of the United States.	<p>Three SPCC plans (for the STM, NWTC and ReFUEL facilities) were revised to address changes to EPA SPCC regulations and the Colorado AST regulations.</p> <p>No spills requiring reporting occurred in 2011.</p> <p>NREL responded to 31 minor spills of diesel or hydraulic fluids at STM and two at the NWTC; the size of spills ranged from less than 0.1 gallon to 15 gallons. Each spill was cleaned up promptly and did not result in any significant impact to the environment.</p>	<p>EPA: Oil Pollution Prevention 40 CFR 112</p> <p>CDLE: DOPS Storage Tank Regulations, 7 C.C.R. 1101-14</p>
Radiological Materials and Waste Management	<p>Emissions are also regulated by Section 112 of the Clean Air Act and implemented by the EPA. 40 CFR Part 61 established National Emission Standards for Hazardous Air Pollutants (NESHAPs), and, more specifically, Subpart H, sets such standards for radiological materials.</p> <p>DOE O 458.1, <i>Radiation Protection of the Public and the Environment</i> cancelled DOE O 5400.5. This order establishes radiation emission limits for DOE facilities.</p>	<p>The effective dose equivalent to the public from NREL activities was 0.0054 mrem per year, far below the 10 mrem per year limit.</p> <p>Internal procedures govern generation, storage and disposal of radioactive wastes and incorporate the applicable provisions of DOE orders for low-level wastes.</p> <p>No low-level radioactive waste was generated. Small quantities of low-level radioactive waste are currently in storage awaiting off-site disposal. No other types of radioactive wastes are generated.</p>	<p>EPA: 40 CFR 61, Subpart H</p> <p>DOE: DOE O 5400.5 DOE O 458.1</p>
NEPA	NEPA requires that federal agencies determine environmental impacts of proposed federal actions and alternatives. DOE implements NEPA in 10 CFR 1021.	<p>NREL was in compliance with the DOE NEPA Implementing Regulations.</p> <p>Five hundred and fifteen NEPA reviews were conducted for project activities on and off site. Of these, a more detailed environmental review was conducted for 30 activities. Two projects were determined to require an EA.</p>	<p>Council for Environmental Quality: 40 CFR 1500–1508</p> <p>DOE: 10 CFR 1021</p>
Wildlife Management	<p>The Migratory Bird Treaty Act (MBTA) of 1918 is the main driver for protection of migratory birds in the United States. The MBTA and amendments implements several treaties between the U.S., Great Britain, Mexico, Japan, and the former Soviet Union. The MBTA prohibits the taking, killing, or possession of migratory birds, nests, and eggs.</p> <p>Under Colorado Revised Statute 33-6-128: Damage or Destruction of Dens or Nests—Harassment of Wildlife, no wildlife dens or nests, young or eggs may be damaged or destroyed unless permitted by the Colorado Division of Parks and Wildlife and it is unlawful for any person to willfully harass wildlife including birds.</p> <p>Under the “Memorandum of Understanding (MOU) between DOE and the USFWS Regarding Implementation of EO 13186, Responsibilities of Federal Agencies to Protect Migratory Birds” DOE agrees to integrate migratory bird conservation principles, measures, and practices into agency activities, and avoid or minimize adverse impacts on migratory bird resources and their habitats.</p>	<p>The Wildlife Management Program implements measures to allow NREL to meet or exceed regulatory requirements. In 2011, activities demonstrating compliance included:</p> <p>A Migratory Bird Conservation Plan for NREL sites was developed. This plan provides guidance for specific types of projects that have the potential to impact migratory birds and provides best management practices.</p> <p>Bird-friendly glass windows, designed to minimize bird collisions, were installed at the new STM parking garage scheduled to open in 2012.</p> <p>No migratory birds were taken intentionally during the conduct of any of the laboratory’s activities.</p> <p>Several wildlife surveys were conducted at the STM and NWTC sites to better inform wildlife management.</p>	<p>U.S. Fish &amp; Wildlife Service: MBTA 16 USC 703-712</p> <p>Colorado Division of Parks and Wildlife: CRS 33-6-128</p> <p>MOU between DOE and the U.S. Fish and Wildlife Service (USFWS) EO 13186</p>

## FEDERAL, STATE, AND LOCAL ENVIRONMENTAL LAWS AND REGULATIONS APPLICABLE TO NREL

Report Sections	Regulatory Program Description	Compliance Status and Highlights	Regulator & Requirement
Endangered Species and Species of Concern	<p>The Endangered Species Act (ESA) is intended to protect threatened and endangered wildlife and plant species and associated critical habitat.</p>	<p>The USFWS lists seven species in accordance with the ESA as threatened, endangered, or a candidate for listing that could potentially occur in Jefferson County. Of these, three have the potential to occur on the STM or NWTC sites including the Preble's meadow jumping mouse, the Ute ladies' tresses orchid, and the Colorado butterfly plant.</p> <p>NREL periodically conducts surveys for declining wildlife species and rare plants focusing on species that are federally protected, state protected, or otherwise considered imperiled or declining. In 2010 at STM and 2011 at the NWTC, surveys were conducted and no protected species were found at the STM or NWTC sites.</p>	<p>U.S. Fish &amp; Wildlife Service: 50 CFR 17</p>
Vegetation Management	<p>The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the use, storage, and disposal of herbicides and pesticides. For application of certain types of herbicides designated as "restricted use" by the EPA, a certified applicator must be used.</p> <p>EO 13112, Invasive Species requires the control of invasive species at federal facilities. In Colorado, the Department of Agriculture Commissioner 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 plans designed to support the efforts of local governing bodies to facilitate more effective integrated weed management on private and public lands.</p>	<p>Herbicide and pesticide applications are conducted in accordance with regulations and label requirements. Restricted-use herbicides are applied by certified applicators.</p> <p>Of the noxious weed species that have been identified on the STM site, three, Canada thistle, diffuse knapweed, and musk thistle, are Class B species and one, field bindweed, is on the Class C list.</p> <p>Approximately two-thirds of the NWTC was treated for noxious weeds by herbicide application. Approximately two acres of Canada thistle were treated at STM.</p> <p>Contractors and NREL workers doing landscape maintenance were asked to compost landscaping waste, including weeds, to reduce the propagation of listed weeds.</p>	<p>EPA: 40 CFR 162 —171(f) EO 13112</p>
Wetlands and Floodplains	<p>Under EO 11990, Wetlands Protection, federal agencies must provide leadership and take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. Wetlands that meet certain soils, vegetation, and hydrologic criteria, are protected under the CWA Section 404, which is administered by the USACE.</p> <p>Jefferson County requires approval of development proposed in floodplains within its jurisdiction.</p> <p>Under 10 CFR 1022, Compliance with Floodplain and Wetlands Environmental Review Requirements, for projects that occur in floodplains or could affect wetlands, DOE must determine the potential impacts, document this in a floodplain and wetland assessment, and complete notices of availability to appropriate government agencies and interested parties, as well as make a public notification in the local area.</p>	<p>None of the wetlands present at NREL facilities have been designated "jurisdictional" by the USACE. The STM and NWTC sites do not contain any floodplains. However, several actions were taken to maintain compliance with wetlands and floodplains requirements for the south entrance project, located off of DOE property.</p> <p>A USACE Nationwide Permit No. 14 for Linear Transportation Projects was obtained for the permanent loss of 0.25 acres of wetlands associated with the south entrance project. This loss was mitigated through acquisition of wetland banking credits via the South Platte Wetlands Bank in Brighton, Colorado.</p> <p>A Jefferson County Floodplain Development permit was obtained for the south entrance project due to the construction of bridge abutments, headwalls, wingwalls, riprap and other structural elements within the floodplain.</p> <p>In accordance with 10 CFR 1022, a floodplain and wetland assessment was prepared to describe the potential impacts associated with the construction of the new south access road to the STM campus. The public and federal and state agencies were notified of the availability of the assessment in May 2011 via letter and newspaper advertisement. DOE posted a Statement of Findings in June 2011 and determined that this project would not result in adverse impacts to the 100 year floodplain.</p>	<p>EO 11990 USACE: CWA Section 404 10 CFR 1022</p>

## FEDERAL, STATE, AND LOCAL ENVIRONMENTAL LAWS AND REGULATIONS APPLICABLE TO NREL

Report Sections	Regulatory Program Description	Compliance Status and Highlights	Regulator & Requirement
Cultural Resources	<p>Cultural resources are protected under Section 106 of the National Historic Preservation Act (NHPA). 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. NHPA is administered in Colorado by the Colorado SHPO.</p>	<p>Two structures at the STM site are listed on the National Register of Historic Places. There are no known eligible structures at the NWTTC.</p> <p>Construction activities were completed on the new addition to the RSF. During preliminary excavations, a few items were unearthed that were reviewed for cultural significance, though none were found to be of unique value.</p> <p>As part of the south entrance project, a memorandum of agreement was signed with the Colorado SHPO to address adverse affects to the two southern most firing lines that are contributing features to the Camp George West Historic District. To mitigate impacts to these, an interpretive sign will be placed in Pleasant View Community Park.</p>	<p>Advisory Council on Historic Preservation:</p> <p>36 CFR 60</p> <p>36 CFR 63</p> <p>36 CFR 79</p> <p>36 CFR 800</p> <p>16 USC 470</p>
EMS and Sustainability	<p>DOE O 436.1, Departmental Sustainability cancelled DOE O 450.1A, Environmental Protection Program and DOE O 430.2B, Departmental Energy, Renewable Energy and Transportation Management. The Order implements the objectives of EO 13423, Strengthening Federal Environmental, Energy, and Transportation Management, and 13514, Federal Leadership in Environmental, Energy, and Economic Performance, which direct federal agencies to conserve natural resources, reduce energy use, develop renewable energy, reduce GHG emissions, and manage buildings and transportation in a sustainable manner.</p> <p>DOE O 436.1 requires that DOE develop a SSPP to ensure that the sustainability goals established in EO 13423 and 13514 are met. Individual DOE facilities must develop site specific SSPs designed to set goals for the coming year and discuss performance for the prior year.</p> <p>DOE O 436.1 also requires that DOE facilities implement EMSs that are independently verified to meet the requirements of ISO 14001.</p>	<p>Each year, a SSP is developed to report on past performance and set goals for the coming year. These performance goals are integrated with the laboratory's EMS and progress is tracked throughout the year.</p> <p>NREL's EMS was registered in August 2011 to the ISO 14001:2004 international standard for environmental management systems by a third party registrar. Annual assessments by the registrar verify that NREL meets the ISO standard and is continually improving performance.</p>	<p>DOE:</p> <p>DOE O 436.1</p> <p>DOE O 450.1A</p> <p>DOE O 430.2B</p>
N/A	<p>DOE O 231.1B, Environment, Safety and Health Reporting was implemented to assure that DOE receives timely, accurate information about events that have affected or could adversely affect the health, safety and security of the public or workers, the environment, the operations of DOE facilities. The order requires that DOE facilities 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.</p>	<p>NREL reports annually via this Annual Site Environmental Report.</p>	<p>DOE:</p> <p>DOE O 231.1B</p>

## FEDERAL, STATE, AND LOCAL ENVIRONMENTAL LAWS AND REGULATIONS APPLICABLE TO NREL

Report Sections	Regulatory Program Description	Compliance Status and Highlights	Regulator & Requirement
Traffic	<p>A MAP, finalized in May 2008, was developed to address potential environmental impacts from changes in traffic at STM and to support an EA Finding of No Significant Impact (FONSI) for several projects at the laboratory. The MAP specifies the methods for implementing mitigation measures to ensure that the impacts of continued and expanded laboratory operations are not significant. The MAP requires that:</p> <ul style="list-style-type: none"> <li>• The Denver West Parkway/Denver West Marriott Boulevard (DWP/DWMB) intersection operates at a Level of Service (LOS) of D or better.</li> <li>• The Quaker St. /South Golden Road intersection operates at a LOS of D or better.</li> <li>• Traffic flow to and from the STM east entrance will be monitored semi-annually.</li> <li>• Specific Transportation Demand Management (TDM) strategies be implemented as needed to ensure the traffic thresholds are not exceeded. Strategies include AWS's, expanded shuttle services, expanded carpools, encouraging walking and bicycling, increased use of the Quaker St. entrance, infrastructure improvements, and traffic flow control measures.</li> </ul>	<p>TDM measures required by the MAP were continued in 2011.</p> <p>PM peak hour traffic averages at the DWP/DWMB intersection were 260 vehicle trips. The monitoring period was October 2010 through April 2011. The MAP threshold of LOS D or better is equivalent to a maximum of 387 vehicle trips per hour entering or leaving the site at the east entrance at the afternoon rush hour.</p> <p>PM peak hour LOS at the DWP/DWMB intersection was at LOS B, which does not exceed the MAP threshold of LOS D or better.</p> <p>PM peak hour LOS at the Quaker St. /South Golden Road intersection was at LOS B, which does not exceed the MAP threshold of LOS D or better.</p>	NEPA EA Traffic MAP

## ENVIRONMENTAL PERMITS, REGISTRATIONS, AND NOTIFICATIONS APPLICABLE TO NREL DURING 2011

Type	Location/ Description	Category	Issuing Agency	ID #	Permit or Registration Status
AST for petroleum storage	STM PDU AST	Registration	DOPS	2873-2	Completed
AST for petroleum storage	STM SERF AST	Registration	DOPS	2873-1	Completed
Air	Laboratory-wide servicing of CFC-containing equipment	Registration	APCD	647	Completed
Air	DWOP CFC-containing stationary source	Registration	APCD	647	Completed
Air	STM SERF CFC-containing stationary source	Registration	APCD	647	Completed
Air	STM FTLB waste gas combustor	Permit	APCD	99JE0400	Active
Air	STM RFHP wood waste boiler	Permit	APCD	07JE0277	Active
Air	STM fugitive dust from construction activities	Permit	APCD	08JE0889L	Active
Air	STM RSF diesel-fired emergency generator #1	Permit	APCD	10JE1400	Active
Air	STM RSF diesel-fired emergency generator #2	Permit	APCD	11JE1303	Active
Air	STM FTLB diesel-fired emergency generator	Permit	APCD	10JE1630	Active
Air	NWTC Site 4.0 diesel-fired emergency generator	Permit	APCD	10JE1712	Active
Air	STM parking garage diesel-fired emergency generator	Permit	APCD	11JE1997	Active
Air	STM ESIF diesel-fired emergency generator	Permit	APCD	11JE3542	Active
Alcohol	STM IBRF alcohol fuel production	Permit	TTB	AFP-CO-00255	Active
Alcohol	STM tax-free alcohol use	Permit	TTB	TF-CO-0331	Active
Drinking water system	NWTC drinking water system ID number	Registration	WCQD	CO0230860	In Effect; Does Not Expire
Earth disturbance	STM parking lot grading permit	Permit	Jefferson County	10-127351GP	Active
Earth disturbance	STM stormwater swale grading permit	Permit	Jefferson County	09-106687GP	Closed
Groundwater well	STM groundwater monitoring well MW-1	Permit	DWR	37232	Active

## ENVIRONMENTAL PERMITS, REGISTRATIONS, AND NOTIFICATIONS APPLICABLE TO NREL DURING 2011

Type	Location/ Description	Category	Issuing Agency	ID #	Permit or Registration Status
Groundwater well	STM groundwater monitoring well MW-2	Permit	DWR	37229	Active
Groundwater well	STM groundwater monitoring well MW-3	Permit	DWR	37228	Active
Groundwater well	STM groundwater monitoring well MW-4	Permit	DWR	37231	Active
Groundwater well	STM groundwater monitoring well MW-5	Permit	DWR	37230	Active
Hazardous materials	STM WHF hazardous material storage and use permit	Permit	West Metro Fire Rescue	4976	Active
Hazardous materials	STM SERF hazardous material storage and use permit	Permit	West Metro Fire Rescue	4982	Active
Hazardous materials	STM S&TF hazardous material storage and use permit	Permit	West Metro Fire Rescue	4979	Active
Hazardous materials	STM FTLB hazardous material storage and use permit	Permit	West Metro Fire Rescue	4977	Active
Hazardous materials	STM IBRF (AFUF) hazardous material storage and use permit	Permit	West Metro Fire Rescue	4978	Active
Hazardous materials	STM Shipping & Receiving hazardous material storage and use permit	Permit	West Metro Fire Rescue	4980	Active
Hazardous materials	DWOP building 16 hazardous material storage and use permit	Permit	West Metro Fire Rescue	4981	Active
Hazardous materials	ReFUEL hazardous material storage and use permit	Permit	Denver Fire Department	32178	Active
Hazardous waste	DWOP RCRA hazardous waste generator status EPA ID	Notification	HMWMD	CO4890000017	Completed
Hazardous waste	STM RCRA hazardous waste generator status EPA ID	Notification	HMWMD	CO3890090076	Completed
Hazardous waste	JSF RCRA hazardous waste generator status EPA ID	Notification	HMWMD	COD980805162	Completed
Hazardous waste	NWTC RCRA hazardous waste generator status EPA ID	Notification	HMWMD	COD983802448	Completed
Hazardous waste	ReFUEL RCRA hazardous waste generator status EPA ID	Notification	HMWMD	COR000207563	Completed
Historic registration	STM amphitheater	Registration	NPS	93000378	In effect; does not expire



## ENVIRONMENTAL PERMITS, REGISTRATIONS, AND NOTIFICATIONS APPLICABLE TO NREL DURING 2011

Type	Location/ Description	Category	Issuing Agency	ID #	Permit or Registration Status
Historic registration	STM stone bunker	Registration	NPS	93000379	In effect; does not expire
Stormwater	NWTC pedestrian safety construction project	Permit	EPA	COR10E52F	Active
Stormwater	STM stormwater detention basin construction project	Permit	EPA	COR10EL5F	Active
Stormwater	STM stormwater detention Basin A construction project	Permit	EPA	COR10EU5F	Active
Stormwater	STM ESIF construction project	Permit	EPA	COR10EH4F	Active
Stormwater	STM parking garage and south entrance construction project	Permit	EPA	COR10EE0F	Active
Stormwater	NWTC dynamometer expansion construction project	Permit	EPA	COR10EP6F	Active
Stormwater	STM RSF1 infrastructure Zone 1 construction project	Permit	EPA	COR10CY5F	Closed
Stormwater	STM RSF infrastructure Zone 2 construction project	Permit	EPA	COR10DH3F	Closed
Stormwater	STM RSF II Construction Project	Permit	EPA	COR10E21F	Active
Stormwater	STM IBRF construction project	Permit	EPA	COR10DA6F	Active
Stormwater	STM west gate improvements construction project	Permit	EPA	COR10E08F	Active
Stormwater	STM vehicle test pad construction project	Permit	EPA	COR10E12F	Active
Stormwater	NWTC PV installation construction project	Permit	EPA	COR10DD2F	Closed
Stormwater	NWTC row 4 infrastructure construction project	Permit	EPA	COR10DB4F	Closed
Stormwater	NWTC site entrance construction project	Permit	EPA	COR10E06F	Active

## 7 Air Quality Protection

The Air Quality Protection program is intended to achieve a number of goals including minimization of all types of air emissions, tracking of air emissions from the larger on-site sources, confirmation that on-site sources have air permits as required, and meeting EPA and Colorado air emissions and permitting requirements.

NREL's goal is to maintain its air emissions at a low level, maximizing air quality and minimizing permitting and compliance requirements. Minimizing air emissions creates direct health benefits to both surrounding neighbors and the Denver metropolitan area in general. In general terms, the more air emissions a facility puts into the air, the more complex the air permit must be that allows such emissions. Such permits also require more extensive and expensive emission tests and reporting of those emissions.

NREL environmental staff actively participate in project planning, safety evaluations, readiness verifications, and operations activities. This participation results in awareness of planned air emissions and allows environmental staff to obtain necessary regulatory approval for those emissions and to maintain a current and accurate air emission inventory.

### 2011 Accomplishments and Highlights

- Updated NREL's air emissions database including new sources and the use of equipment specific emission factors where possible. This has resulted in a more accurate emission inventory.
- Created an inventory of HAP emissions associated with PV laboratory research activities. This allows more accurate assessment of NREL compliance with HAP reporting and permitting requirements.

### PROGRAM MANAGEMENT

The EPA Clean Air Act requires specific permitting and emission controls when specific facility emission levels are exceeded or individual equipment sizes are reached. For example, a Title V air permit would be required if an NREL facility emission level were to

exceed 100 tons per year for a criteria pollutant such as: nitrogen oxides (NO<sub>x</sub>), VOC, particulate matter (PM<sub>10</sub>), carbon monoxide (CO), or sulfur dioxide (SO<sub>2</sub>). Under that same regulation, a Title V permit would be required if a single HAP level were to exceed 10 tons per year, or the total emissions of all HAP pollutants at one facility were to exceed 25 tons per year.

The Colorado APCD requires reporting of HAP emissions at much more stringent limitations. The limitations vary for different HAPs based on their toxicity and the distance of the release from a facility property boundary. The reporting levels can vary from 50 to 5,000 pounds per year.

Colorado reporting of air emissions is required for an item of equipment that emits 1 ton per year or more of any criteria air pollutant. A Colorado air permit may be required if an item of equipment emits as little as 1 ton per year of any criteria pollutant. The trigger level varies from 1 to 10 tons per year depending on the pollutant and whether the source is located in an attainment or non-attainment area for that specific pollutant.

During 2011, NREL maintained nine Colorado air permits. Five of these permits are for emergency generators, one is for the RFHP, two are for specific research activities, and an additional permit is for fugitive emissions from construction.

### Criteria, Hazardous, Non-Criteria Pollutants, and ODS

The Clean Air Act and State of Colorado laws and regulations delineate several main categories for air pollutants:

- Criteria air pollutants, e.g., carbon monoxide, nitrogen oxides, sulfur dioxide, particulate matter, respirable particulate (PM<sub>10</sub> and PM<sub>2.5</sub>), ozone, and lead, all of which have been issued National Ambient Air Quality Standards (NAAQS) by the EPA
- Non-criteria pollutants (e.g., ammonia, hydrogen sulfide, pesticides, certain VOCs classified as ozone precursors, metallic compounds, GHGs, and corrosives). Non-criteria pollutants are not associated with an EPA-specified NAAQS.
- HAPs (includes a specific list of organic compounds, metals, corrosives, asbestos, radionuclides, and pesticides established by the EPA)
- Ozone-depleting substances (e.g., chlorofluorocarbons or "Freon" and hydro chlorofluorocarbons that are being phased out of use in comfort heating and cooling systems and equipment)
- GHG compounds that have been implicated in global warming.

There are various Colorado and EPA notification, permitting and reporting thresholds for criteria, non-criteria, hazardous, and GHG pollutants. The primary potential sources of these pollutants at NREL include process heat boilers, process cooling systems, comfort heating and cooling systems, emergency generators, experimental laboratory hoods and ventilation systems, pilot and large-scale research projects, and small equipment with gasoline or diesel engines. NREL maintains an air emission inventory to

track potential air emissions and identify whether notification and permitting could be required for a particular facility or activity. Certain equipment and emissions are exempt from reporting and permitting by CDPHE APCD. NREL maintains several air permits issued by CDPHE for “minor” sources including emergency generators and pollution control systems at the STM and NWTC sites. All of these individual emission sources and each NREL facility are considered by the EPA and APCD to be minor sources with minimal permit and compliance requirements.

Fugitive particulate emissions from construction activities occur at NREL’s STM and NWTC sites. Particulate emissions from construction sites larger than 25 acres are subject to APCD fugitive particulate emissions permits. Appropriate permits have been obtained and are in effect for construction activities at the STM and NWTC facilities. One such Air Pollutant Emission Notice (APEN) was in effect for construction at the NWTC at the beginning of 2010. As the construction area at the NWTC became smaller, the APEN was no longer needed and was allowed to expire by its own terms and conditions. A fugitive particulate emissions permit is not currently needed for the NWTC.

### Permitting

Most sources of air emissions from NREL laboratory and facility operations in 2011 were of small scale and did not require permitting. While permitting thresholds may vary, depending on the pollutant, the APCD must be notified if more than one ton per year of one or more criteria pollutants is emitted from an individual item of equipment. Emergency generators generally require permitting even if criteria emissions are less than one ton per year. Projected emissions for new sources were evaluated and air emission reporting and permitting was performed as required.

NREL holds one site-wide permit for particulate air emissions from construction, two air emissions permits for pilot-scale research, one for the operation of the RFHP, and five permits for emergency generators.

An evaluation of HAP emissions for NREL activities indicated that those emissions were well below all reporting and permitting threshold values. HAP emissions reporting and permitting trigger levels vary with the HAP compound, the height of the emission point and distance of that point from the nearest property boundary. Those trigger levels can vary from approximately 50 pounds per year to more than 2,000 pounds per year. The expected ammonia emissions from the IBRF project previously mentioned will exceed the applicable Colorado reporting criteria. Therefore, an air permit to install and operate an ammonia scrubber is being obtained from CDPHE APCD. That permit is expected to be issued by the APCD in 2012.

Additional air permit applications were submitted to the APCD during 2011 for the new STM parking garage emergency generator and an emergency generator for the ESIF laboratory (currently under construction). The APCD is expected to issue these air permits during 2012.

### Ozone-Depleting Substances

EPA regulation 40 CFR 82, Protection Of Stratospheric Ozone, requires that appliances and stationary appliances containing more than 50 pounds of Class I or II ODS refrigerant must meet specific EPA record keeping, ODS recovery, leak monitoring and leak repair requirements.

There are three categories of ozone-depleting substances (ODSs) registration and certification in Colorado (5 CCR 1001-19, Regulation 15, Control of Emission of Ozone Depleting Compounds):

1. Facilities where maintenance activities are performed on refrigeration equipment containing ODS are required to file an annual notification with CDPHE
2. Technicians that service ODS-containing equipment must be EPA-certified
3. Refrigeration equipment larger than 100 hp containing ODSs must be registered annually with CDPHE. Refrigeration equipment that uses non-ODS compounds are not required to be registered.

The laboratory has a total of three chillers that are larger than 100 hp, contain ODS compounds and are thus registered with CDPHE—two located at the Solar Energy Research Facility (SERF) on the STM site, and one at DWOP. During 2011 NREL performed the necessary annual notification that maintenance activities occurred, renewed the registration for the three chillers and confirmed that all technicians servicing ODS-containing equipment are EPA-certified.

While the vast majority of refrigeration appliances at NREL contain non-ODS refrigerants or only very small amounts of ODS refrigerants, the laboratory does have several appliances containing more than 50 pounds of ODS material. As such, operators must maintain records of service for this equipment.

### Street Sanding

CDPHE regulations (5 CCR 1001-18, Regulation 16, Street Sanding Emissions) require federal, state, and local government facilities to track street sanding in the wintertime, and to minimize sand use. Sanding of roads followed by vehicle activity turns sand and gravel into ever finer particulate which becomes airborne easily due to that traffic. The resulting fine particulate (PM<sub>10</sub> or smaller) is a significant contributor to particulate pollution in the Denver area. That pollution contributes to breathing and health problems for susceptible individuals and prompted EPA and Colorado to issue regulations to minimize this source of air pollution.

NREL complies with the Colorado sanding requirements and files an annual sanding report with CDPHE. From October 2009 to May 2010, NREL used 50 tons of sand and 36 tons of deicer in 25 deployments while maintaining 12 miles of roadway. From October 2010 to May 2011, NREL applied 50.5 tons of deicer during 20 deployments while maintaining the same length of roadway. The deicer used does not contain sand and minimizes fugitive particulate emissions from snow removal operations. No sand was used

during the 2010-2011 winter season and the reduction of 50 tons of sand compared to the 2009—2010 period provided a direct air quality benefit to both NREL neighbors and the Denver area.

### GHG Emissions Tracking and Permitting

EPA regulations require that certain facilities which emit GHGs track and report the amount of those emissions. The purpose of this reporting is to better identify actual emissions of such gases across the United States and provide the EPA with data upon which to base future GHG regulations. The reporting and permitting of these emissions is required under the EPA PSD regulation, Title V Tailoring Rule (Tailoring Rule), and the EPA GHG Mandatory Reporting Rule (MRR). The Tailoring Rule requires air emission permitting of GHG emissions if CO<sub>2</sub>e emissions are greater than 100,000 U.S. tons per year. The MRR requires annual GHG reporting to EPA if CO<sub>2</sub>e emissions are greater than 25,000 MT per year.

GHGs include CO<sub>2</sub>, methane, nitric oxide (N<sub>2</sub>O), and ODS chlorofluorinated hydrocarbons including hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and certain other fluorinated gases. For more information on how NREL is reducing its emission of GHGs, please see section 4 Sustainability.

### 2011 COMPLIANCE SUMMARY AND ACTIVITIES

Compliance with the wide variety of air permit and emission limitation requirements is an on-going and significant activity at NREL. The nature of research experimental activity may require significant changes in technical direction and equipment based on the results obtained during those experiments. Such changes may alter air emissions. Achieving compliance in a research environment is both necessary and challenging.

The following compliance activities were performed during 2011, assuring compliance with air regulations and improved implementation of the Air Quality Protection program:

- All program activities were in compliance with requirements.
- NREL did not exceed any air permit standard or other air regulatory requirement at any facility.
- On behalf of the CDPHE APCD, Jefferson County completed an air inspection of the NWTC Site 4.0 emergency generator in November 2011. No issues were identified.
- Completed an evaluation of NREL's compliance with EPA and APCD permitting and emissions control requirements. It was confirmed that NREL is in compliance with all Colorado and EPA permit requirements and that all NREL facilities and individual permitted equipment items are classified as minor sources.
- Obtained air permits for two emergency generators necessary for newly constructed laboratory facilities. Obtained an air permit for an ammonia scrubber and particulate baghouse used to eliminate ammonia and particulate emissions from the IBRF cellulose digestion large pilot-scale project. Performed emission testing and submitted necessary forms to the APCD to convert construction permits to final air permits for two

emergency generators. All existing NREL air permits were renewed during 2011.

- All required registrations and permit renewals were performed during 2011 for Ozone Depleting Substance-using equipment. NREL facilities servicing refrigeration equipment were registered. Confirmed that all NREL refrigeration service personnel have obtained the EPA and Colorado required training and certification.
- Evaluated NREL's 2010 CO<sub>2</sub>e and GHG emissions. The GHG inventory shows that NREL GHG emissions are below the exempt level for EPA reporting and permitting rules. NREL's 2011 CO<sub>2</sub>e inventory is 4,020 U.S. tons, or 3,555 MT. NREL emissions of GHGs are not expected to meet reporting requirement thresholds into the foreseeable future.
- The required street sanding report was provided to the APCD and Jefferson County in 2011.

## 8 Water Quality Protection

Water quality is critical to human health and the health of our natural ecosystems. At NREL, the focus of water quality protection is on four main areas:

1. Drinking water
2. Wastewater
3. Groundwater
4. Surface water.

### 8.1 DRINKING WATER

NREL operates a drinking water distribution system at the NWTC, serving about 150 employees. Drinking water is purchased from local municipalities and transported by truck to the site, where it is transferred to a large holding tank with a capacity of 15,000 gallons. Water is pumped from the holding tank to a day tank from which it is circulated around the site for use. There is no treatment of the water, but chlorine is added to boost disinfectant levels. The system is permitted by the State of Colorado, which requires monitoring for a number of parameters on an annual basis. The water is tested for residual chlorine levels, bacteria, disinfectant by-products, and lead and copper in the same ways municipal water systems are tested. NREL provides good, safe drinking water to the NWTC employees, and has not exceeded any of the drinking water standards over the past five years.

There are a number of organizations that can take credit for the success of the NWTC water system. NREL's Site Operations Office provides primary oversight for the day-to-day operation of the

system, aided by a state-licensed contract operator who visits the site weekly to check the details of the system operation and performance. The NREL EHS Office assists Site Operations in tracking state requirements and completing required reports and managing contacts with regulators. NREL's management of the drinking water system is subject to assessments by DOE and compliance inspections by CDPHE.

## 2011 Accomplishments and Highlights

- In 2011, 400,000 gallons of drinking water was safely provided to NWTC users.

### PROGRAM MANAGEMENT

As a public water system regulated by the state of Colorado, the NWTC water system must comply with the SDWA and federal and state regulations based on the SDWA authority. EPA has established allowable levels for drinking water constituents known as MCLs, which can be found at 40 CFR 141. Colorado has adopted these MCLs into the Colorado Primary Drinking Water Regulations at 5 CCR 1003-1. These regulations establish the state's authority to regulate drinking water providers to assure safe, reliable water supplies, and to implement EPA's special rules.

The primary requirement is to test the water quality following a monitoring plan issued by the state each year. The plan identifies which tests are to be performed and at what frequency. Monthly tests are required for bacteria and disinfectant levels, while disinfectant by-products (DBPs) are sampled for once a year, and lead and copper are tested on a three-year rotating basis. The figure shows the results of the chlorine monitoring for 2011.

The NWTC has not exceeded any of the SDWA's MCLs in the past five years. Once, in 2006, NREL exceeded the MCL for

trihalomethanes, a class of DBPs. One sample taken was 0.1 part per billion over the maximum of 80. The levels dropped below the MCL in the next quarterly sample and have remained there, allowing the monitoring frequency to return to an annual basis.

### 2011 COMPLIANCE SUMMARY AND ACTIVITIES

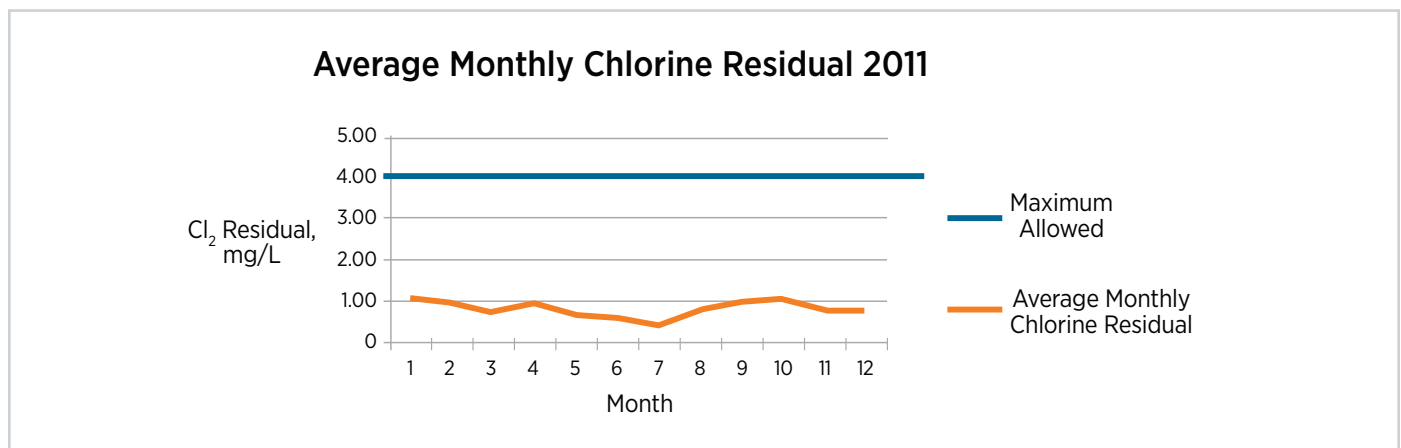
- All monitored parameters in 2011 met applicable SDWA requirements.
- Triennial sampling for lead and copper was conducted in 2011; the concentration of these metals was well below the MCLs at all sample locations.
- An external assessment of the drinking water system in 2011 found no non-conformities with program or regulatory requirements. Several recommendations for program improvements were made, each of which is being addressed.

### 8.2 GROUNDWATER

Groundwater protection in the West is particularly important because these resources are limited yet relied upon by increasing numbers of residents for water supplies. NREL's groundwater protection program is based on the philosophy that the prevention of groundwater contamination is far better than remediation.

Both the STM and the NWTC sites are located at the western edge of the Denver Basin aquifer system that supplies water to urban, rural, and agricultural users along the Front Range of the Rocky Mountains in northeastern Colorado. The aquifers within the Denver Basin, 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 site overlies the shallowest portions of the Denver, Arapahoe and Laramie-Fox Hills aquifers. The NWTC site overlies the shallowest portions of the Arapahoe and Laramie-Fox Hills aquifers. The Dawson formation is the shallowest of the Denver Basin aquifers and is the one most relied upon by the groundwater users in the basin. The northern extent of the Dawson aquifer is located approximately 20 miles to the south and east of the STM site; consequently, wells drilled at either the STM site or the NWTC



Results of 2011 chlorine monitoring

would not intersect the Dawson aquifer, nor would a source of contamination affect the groundwater quality in this aquifer.

Because of the sensitive nature of the groundwater resource, NREL carefully evaluates all outdoor projects to eliminate potential impacts to groundwater quality. If any materials are used that pose a risk to groundwater, the laboratory typically insists that safeguards to protect groundwater be established. Safeguards include, but are not limited to, secondary containment for equipment with the potential to leak oil, double-walled tanks with leak detection for diesel fuel storage of NREL facilities' emergency generators, and bermed areas, either temporary or permanent, to contain materials associated with construction activities or on-going research.

## 2011 Accomplishments and Highlights

A major administrative improvement for groundwater protection was made in 2011 when NREL revised its procedure for management of ASTs and completely rewrote spill prevention, control and countermeasure plans for the STM and NWTC sites (see section 9.3 Aboveground Storage Tank Management for details). The spill plans describe in detail all areas where petroleum oil products are stored, potential pathways should there be a release, and the immediate actions to be taken in such an event. Careful planning and preparation for events such as spills from ASTs bolster NREL's defenses against groundwater contamination.

### PROGRAM MANAGEMENT

The state of Colorado regulates the installation of groundwater wells through the state engineer's office, which requires a permit for drinking water, groundwater monitoring, or geothermal installations.

There are currently five permitted monitoring wells at the STM site and none at the NWTC. There are currently no ongoing groundwater monitoring activities being conducted, however these wells remain open for possible future use. Should we conduct activities that could impact groundwater, a groundwater monitoring program would be implemented and additional groundwater monitoring wells would be installed as needed.

### 2011 COMPLIANCE ACTIVITIES

There are no compliance activities associated with the Groundwater Program.



Receiving waters include Lena Gulch southeast of the STM campus. Photo by Genny Braus, NREL/PIX 20953

### 8.3 SURFACE WATER

NREL's Surface Water Protection program seeks to preserve the quality of receiving waters to which the STM and NWTC campuses discharge. These receiving waters include Lena Gulch at the STM site and Coal Creek and Rock Creek at the NWTC site. Water quality protection is accomplished through management of runoff emanating from active construction sites, inclusion of project design elements that promote infiltration and detention, and management of campus areas not under construction to minimize erosion and support infiltration.

Due to the large number of active construction sites at both campuses, the focus of NREL's water quality protection program during 2011 has been to manage construction site runoff which



Rain water from the RSF passes through landscaped areas before release to the storm sewer. Photo by Robb Williamson, NREL/PIX 20954

has the potential to significantly impact rivers, lakes, ditches, and other waters of the United States. Sediment, debris, and chemicals transported to these water bodies via stormwater runoff can harm or kill fish and other wildlife either directly or by destroying aquatic and riparian habitat. High volumes of sediment can result in stream bank erosion and clogging of waterways.

Prior to construction, NREL implements an interdisciplinary planning and design process that involves NEPA reviews and approvals, and the assessment of design documents for potential impacts to stormwater and receiving waters. Design teams are encouraged to incorporate low impact design elements to retain stormwater on-site through infiltration and promote evapotranspiration. NREL continues to monitor final design documents and construction implementation to look for additional opportunities to reduce runoff quantity 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 plans developed by contractors and reviewed by NREL EHS staff. Regular inspections by contractors and periodic site inspections by NREL staff are conducted to verify that the 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.

Management of campus areas not under construction is intended to minimize erosion, support infiltration of rain water and snowmelt, and prevent contamination of stormwater with hazardous materials. Vegetation and landscaping are maintained to prevent erosion. Infiltration of precipitation is achieved through detention basins and grassy swales as well as design elements including porous pavement and diversion of roof and perimeter drains to landscaped areas. Dumpsters are kept covered, hazardous wastes are stored indoors or in covered areas, and outdoor spills of fuels, hydraulic fluids, and other materials are cleaned up immediately.



Erosion control blanket and hydromulch stormwater BMPs at the STM campus. *Photo by Kurt Schlomberg, NREL/PIX 21210*



Melting snow from the roof of the RSF flows into containment structures and then into landscaping around the building. *Photo by Dennis Schroeder, NREL/PIX 18640*

## 2011 Accomplishments and Highlights

- Completion of the STM stormwater detention basin to a point where it can now detain runoff from the STM Middle Drainage Basin, thus greatly improving the quality and quantity of runoff leaving the STM campus. The project will be finalized in 2012.
- Modifications to Denver West Parkway in the STM West Campus to redirect accumulated runoff in the roadway toward the NREL drainage conveyance swales, thus reducing the potential for surpassing the available volume of off-site conveyances.
- Addition of curb and gutter along the north side of the STM FTLB service road which drastically reduces sediment entrainment in runoff originating from the roadside parking areas, Vehicle Testing and Integration Facility and the adjacent steep slopes. Riprap was also placed on the upper banks of the Middle Drainage where the roadway runoff enters the middle drainage to further drop any sediment load and protect bank stability.
- All projects, regardless of acreage, draw upon low impact design elements such as:
  - Porous pavement. Porous pavers were included in the STM RSF courtyards and driveways, the North and East Loop Roads, and in the new garage entryway to promote infiltration.
  - Vegetated bioswales. These landscape elements were used in the RSF courtyards to promote infiltration and to filter roof drainage and stormwater runoff diverted from perimeter drains and in select areas surrounding the new parking garage for infiltration and pollutant uptake by vegetation.
  - Native prairie grasses, shrubs, and trees. Vegetation was planted to prevent erosion and sedimentation due to stormwater and snowmelt, especially on steep slopes. Native plants are used as they are adapted to the local climate and can thrive without additional watering once established.



Layers of stormwater BMPs preventing erosion and controlling sediment. *Photo by Kurt Schlomberg, NREL/PIX 21211*

## PROGRAM MANAGEMENT

The federal CWA, amendments, and implementing regulations in 40 CFR Part 122 apply to stormwater discharges from construction activities that disturb greater than one acre. As a federally owned facility, the EPA is the regulating authority for stormwater at the NREL campuses. For construction sites that disturb greater than one acre, a Notice of Intent (NOI) must be filed with the EPA to be covered under the CGP and a site-specific Stormwater Pollution Prevention Plan (SWPPP) must be prepared.

At NREL, the SWPPP implements both the requirements of the EPA's CGP and NREL-specific requirements. The SWPPP is developed by the subcontractor using a template provided by NREL which includes the required elements that must be incorporated. The SWPPP must be signed and certified per EPA CGP signatory requirements and must be accepted by the EHS Office prior to filing of NOIs.

While construction sites less than one acre are not regulated by the EPA and typically involve minimal disturbance within a short timeframe, these sites still have the potential to contribute pollutants to stormwater runoff. For these sites, NREL may require subcontractors to comply with basic elements of stormwater pollution prevention including development of an abbreviated SWPPP to document basic contact, project, and best management practice (BMP) information, as well as a site-specific erosion and sediment control plan showing the locations of key site characteristics and BMPs.

EISA Section 438 requires agencies reduce stormwater runoff from federal development projects to protect water resources. Agencies can comply using low impact design elements such as porous pavers, cisterns, and bioswales. In addition, EO 13514, Federal Leadership in Environmental, Energy and Economic Performance sets requirements for efficient water use, reuse, and stormwater

management. The laboratory's efforts to conserve water and preserve water quality through low impact design are described above, with additional information provided in the Sustainability chapter.

## 2011 COMPLIANCE SUMMARY AND ACTIVITIES

- Seven construction projects at STM, and three at the NWTC, required coverage under the EPA CGP. Permit coverage was obtained or was continued for each. Three permits were terminated in 2011. For a list of permits, see section 6 Compliance Summary.
- In addition, a state stormwater permit was obtained for the construction of a new south entrance to the STM campus. Because this project exists entirely outside of the STM site boundaries, a CDPHE, National Pollutant Discharge Elimination System Program stormwater permit was required.
- For construction activities that did require permits, all activities were conducted according to compliance requirements. Several construction sites received periodic monitoring from local regulatory officials; no non-compliances were noted.
- Drainage studies for the NWTC and the STM central drainage were conducted as part of master planning efforts and to demonstrate compliance with both EISA Section 438 and local drainage regulations. Both studies identified existing and estimated buildout runoff volumes. The new STM stormwater detention basin outfall plate, originally sized for local jurisdictional release rates, was redesigned to slow the outflow of water to historic release rates, thereby meeting EISA requirements.
- Two assessments were conducted of the program. An internal assessment identified three non-conformities with internal program requirements. Several procedures and inspection forms contained deficiencies and needed to be updated. In addition, an external assessment was conducted on the program. No non-conformities with program requirements were identified and three opportunities for improvement were noted, along with several best practices. All non-conformities and opportunities for improvement from each assessment are being addressed.

## 8.4 WASTEWATER

The majority of wastewater from the STM and DWOP facilities flows into the Pleasant View Water and Sanitation District's (Pleasant View) system, and ultimately to the Metropolitan Wastewater Reclamation District's (Metro) central treatment plant. Wastewaters from the JSF and the ReFUEL facility also flow to Metro's treatment plant. There is a small septic system consisting of a tank and leach field on the mesa top at STM, serving the Solar Radiation Research Laboratory (SRRL), because there is no sanitary service to that area. The NWTC also lacks sanitary service, so the site has two septic systems that include tanks and leach fields for the treatment of wastewater.



## 2011 Accomplishments and Highlights

While most of the wastewater discharged from NREL facilities is domestic, one facility occasionally discharges wastewater under an agreement with the Metro District. NREL endeavors to minimize non-domestic wastewater discharges, but when the sanitary system is the best option for waste management, NREL works with the districts to ensure that there are no adverse impacts to their facilities or the environment.

In 2011, the IBRF, formerly the Alternative Fuels User Facility, was significantly expanded to accommodate an increase in research activities in the area of biofuels. The IBRF has pilot scale operations that take cellulosic materials such as switch grass or corn stover and convert the cellulose to fermentable sugars that lead to ethanol production. These operations generate wastewater, which is discharged to the sanitary collection system.

Representatives of the Metro District and Pleasant View were invited to tour the new facility and review the discharge agreement. Because no change had been made to the discharge point or the processes generating wastewater, the districts were satisfied that the existing agreement to use the approved kill method for fermentation wastes and to monitor the discharge for pH were adequate controls for the IBRF discharge. As future projects involve new and different materials and treatment regimes, the district will be notified and the discharge monitored to their specifications.

Improvements were also made to one of the NTWC septic systems in 2011. The system received a larger tank and an expanded leach field. The system upgrades improved flow through the system and increased the capacity of the leach field, improving system operation.

## PROGRAM MANAGEMENT

Non-domestic wastewater discharges to the Metro District must comply with the district's rules and regulations, which incorporate a number of requirements of the CWA, specifically the provision of the Pretreatment Program. Pretreatment is the set of regulations applied to industries and commercial operations that generate non-domestic wastewaters with potentially high levels of pollutants that could have an impact on treatment facilities and the environment. NREL does not have any of the types of operations that CWA regulations have targeted, nor does the laboratory discharge a volume of water that would make NREL a Significant Industrial User, which would require a formal discharge permit from the Metro District. The discharge agreement in place for NREL gives the laboratory direction for using the system, and provides assurance to the Metro District that the laboratory-generated wastewaters are compatible with their requirements.

It is NREL policy to comply with all requirements of Metro's Pretreatment Program, including the list of general prohibitions that protect the collection and treatment systems. The list of prohibitions includes hazardous materials, highly viscous substances, radioactive material, excessive oil and grease, and similar substances that could cause material harm to the sanitary system. NREL staff is trained in this policy. In addition, NREL sites have design criteria for waste drains in laboratory areas to minimize the possibility of a hazardous material discharge. These criteria include measures such as secondary containment for any chemicals used near sinks in laboratory exhaust hoods, no floor drains in laboratory areas unless a specific need can be shown, and caps for any floor drains that are installed in laboratory areas. New research and operations activities as well as ongoing activities that undergo significant modifications are reviewed for their potential effect on wastewater character through NREL's risk assessment process.

## 2011 COMPLIANCE SUMMARY AND ACTIVITIES

- In addition to the program improvements described above, NREL also worked with the Pleasant View District on large-volume discharges related to construction activities. Water lines included in new construction must be sanitized prior to use and these lines were disinfected and the water used in that process was discharged with Pleasant View's approval. Large flows over small time periods can be problematic to sanitary collection systems, so the laboratory worked with the district to minimize impacts.
- All wastewater activities in 2011 were in compliance with the Metro District's rules and regulations.

## 9 Hazardous Materials and Waste Management

At NREL, responsible acquisition, use, and disposal of materials and wastes is critical to meeting our commitments to compliance, preventing pollution, and environmental stewardship. NREL seeks to purchase materials that are sourced responsibly and contain recycled content and lower impact materials. Use of materials is thoughtfully controlled with internal procedures designed to limit health and environmental risks. Wastes are carefully managed and disposed of through select contractors. These elements, if mismanaged, have the potential to increase disposal costs, generate cleanup costs, and increase potential for spills and contamination. Areas of focus include:

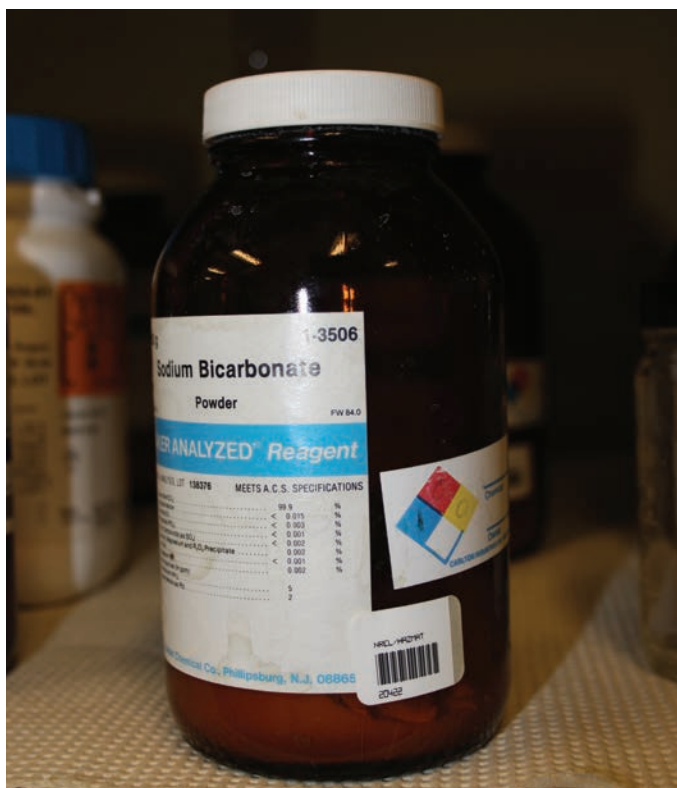
- Hazardous materials management
- Regulated waste management
- Storage tank management
- Pollution prevention
- Radiological materials and waste management.

### 9.1 HAZARDOUS MATERIALS MANAGEMENT

As a major national laboratory, NREL has a variety of chemicals and materials, some of which are hazardous, for use in research activities. Hazardous materials are stored, used and managed in a manner that is protective of laboratory personnel, the general public and the environment. NREL has also taken steps to plan emergency responses in the event there is a spill or release of a hazardous material; these plans are coordinated with local emergency responders, such as the West Metro Fire Protection District and the Jefferson County Local Emergency Planning Committee (LEPC).

NREL has a laboratory-wide chemical management system (CMS) that serves as a centralized chemical inventory as well as a tool for managing and reporting on chemicals used at the laboratory. Using an electronic bar-coding system, the CMS tracks chemicals from the point of receipt through end-use and disposal. The system also contains technical data and reporting information for many of the chemicals in the CMS database. Key functions of the system include:

- Providing current inventories by room, building, and/or site
- Improving research efficiency and minimizing hazardous waste generation by allowing staff to determine if needed chemicals are already available on-site prior to making chemical purchases
- Providing quick access to chemical inventories and hazard information during emergency responses



Properly labeled chemical, including NREL barcode. *Photo by Bob Fiehweg, NREL/PIX 21213*



The laboratory manages its inventory of chemicals using its CMS. *Photo by Bob Fiehweg, NREL/PIX 21214*

### 2011 Accomplishments and Highlights

Software upgrades for the CMS were installed in 2011 that improved the system's functionality, accessibility, and reporting capabilities.

- Facilitating accurate and efficient reporting to external agencies (e.g., fire districts, LEPC, EPA, and DOE).

Hazardous materials are rigorously managed, starting with the chemical inventory system that tracks chemical amounts, locations and hazards. Each week, laboratory safety personnel receive a list of all chemicals and their hazards shipped to the laboratory for the previous week. Researchers and safety personnel ensure that chemicals are properly stored in locations suitable for any hazards, such as storing flammable materials in designated flammables cabinets. In addition to the measures taken to safely transport, transfer and store these materials without releases to the environment, there are reporting requirements triggered by certain quantity levels, discussed below.

### PROGRAM MANAGEMENT

NREL facilities are subject to the emergency reporting provision of the EPCRA, Section 302, which requires a facility to notify the State Emergency Response Commission (the Colorado Emergency Response Commission, CERC) if any extremely hazardous substances in the facility's inventory are stored in quantities greater than prescribed threshold planning quantities (TPQ). NREL facilities first became subject to planning and notification requirements in 1988.

EPCRA Section 304 requires facilities to immediately notify the LEPC if there is an accidental spill or release of more than the predetermined reportable quantity (RQ). In accordance with Section 311 and 312 of EPCRA, NREL provides MSDS for chemicals that are stored on-site in quantities greater than TPQs, and provides inventory reporting for these same chemicals in the form of a Tier II report to emergency planning and response groups.

When requested, NREL provides additional emergency response and reporting information to the Jefferson County LEPC, the CERC, the West Metro Fire Protection District, the Denver Fire Department (DFD) and the Rocky Mountain Fire Protection District. The Jefferson County LEPC uses hazard categories and threshold reporting quantities as defined by the Uniform Fire Code rather than those specified in SARA Title III. This results in a larger number of individual hazard categories and lower reporting thresholds. NREL has been represented in the LEPC since its inception and is actively involved in the emergency planning concepts of SARA Title III with two active members on the Jefferson County LEPC.

The laboratory is also subject to reporting requirements in the event of a release of an RQ of any hazardous substance listed by EPCRA. EPCRA Section 313 requires that a toxic chemical release inventory report (Form R) be filed with the EPA for any chemical that is manufactured, processed, or otherwise used in quantities exceeding TPQs. Although NREL is not a manufacturing facility and does not fall within any of the standard industrial classification (SIC) codes for which Section 313 reporting is required, EO 12856, *Federal Compliance With Right-To-Know Laws and Pollution Prevention Requirements*, requires all federal facilities to file a report, if applicable, regardless of SIC code. NREL has never manufactured, processed, or otherwise used chemicals on the 313 list in quanti-

ties exceeding TPQs, so has never had to report under Section 313.

NREL is also subject to permitting requirements through local jurisdictions. NREL obtains annual hazardous material permits from West Metro Fire Rescue for the STM and DWOP sites as required by West Metro Fire Rescue. NREL obtains permits for a total of six buildings where hazardous materials are stored, used, or both. Prior to issuing the permits, a representative from West Metro Fire Rescue conducts a walk-through inspection of the entire STM site and DWOP.

The ReFUEL facility is within the jurisdiction of the City and County of Denver and is subject to the DFD Hazardous Materials Information System (HMIS) requirements. The ReFUEL facility's inventory of listed materials, including various fuels such as biodiesel, must be reported to the DFD annually. The DFD inspects the facility and issues a hazardous materials permit.

### 2011 COMPLIANCE SUMMARY AND ACTIVITIES

In early 2011, NREL submitted a Tier II report to CDPHE for reporting year 2010, identifying diesel fuel, petroleum oil and sulfuric acid in lead-acid batteries. See table on EPCRA Reporting for details.

- West Metro Fire Rescue conducted an annual hazardous material inspection and issued permits for all major research facilities on the STM campus.

2011 EPCRA REPORTING		
EPCRA Section	Description of Reporting	Status
EPCRA Section 302-303	Planning Notification	Not required
EPCRA Section 304	Extremely Hazardous Substance Release Notification	Not required
EPCRA Section 311-312	Material Safety Data Sheet/ Chemical Inventory	Yes
EPCRA Section 313	TRI Reporting	Not required
<p>"Yes" indicates that the laboratory reported under the provision.</p> <p>"Not required" indicates that the laboratory was not required to report under the provision (e.g., did not meet the threshold or did not have an extremely hazardous substance release).</p>		

- The inventory of materials at the ReFUEL facility was provided to the Denver Fire Department.
- There were no releases of hazardous materials requiring reporting.

- All program activities were in compliance with requirements.

## 9.2 REGULATED WASTE MANAGEMENT

NREL is committed to the appropriate management of regulated waste generated through its daily operations. Research and development activities and general facility operations at the laboratory can create several types of wastes including those containing toxic chemicals or metals. These wastes must be handled, stored, and disposed of responsibly to minimize the potential for health and environmental impacts due to a release or improper disposal.

Research in such areas as PV, bioenergy, wind energy, transportation technologies, and energy storage use a vast range of chemical products that, in turn, generate hazardous and non-hazardous waste in form of solids, liquids, and gases. Proper planning ensures that the resulting waste streams are reduced in volume and managed in an environmentally friendly manner.

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 prior to commencement of an activity all the way through to how byproducts and waste materials will be managed for disposal. Hazardous materials proposed for use are assessed for the potential substitution of less hazardous prod-

ucts, resulting in less hazardous waste streams.

All waste items are handled in a manner that incorporates a high level of safety and environmental stewardship for NREL and its surrounding neighbors. Waste management activities on-site are conducted in a manner that will minimize potential effects on human health and the environment.

### PROGRAM MANAGEMENT

Regulated wastes are handled and disposed of according to RCRA in Title 40 of the Code of Federal Regulations and implemented in the state of Colorado by CDPHE's Hazardous Materials and Waste Management Division (HMWMD) through the Colorado Hazardous Waste Act under 6 CCR 1007-3. Additional applicable regulatory requirements fall under the realm of Title 49 of the Code of Federal Regulations, Transportation.

NREL implementation of regulatory requirements with regard to waste management is multi-faceted including but not limited to:

- Documented waste management and minimization program
- Annual training for all staff who generate waste
- Regular inspection and tracking of all waste containers
- Storage, packaging, shipment, and tracking until final disposition via a fully-permitted waste disposal or recycling facility
- Active monitoring of waste volumes to determine generator status
- Maintaining records that are generated through "cradle to grave" waste management activities per applicable federal and DOE records management protocols.

NREL typically disposes of the following categories of waste:

- Hazardous waste (as defined by environmental regulations)
- Non-hazardous waste (not within the definition of hazardous waste and could include such items as propylene glycol from building chillers or select pretreatment liquors from biomass processing, etc.; does not include municipal solid waste)
- Universal waste (less stringent environmental regulations governing the management of such items as mercury-containing light bulbs, lead-acid batteries, aerosol cans, and electron-

### COMPARISON OF FOUR WASTE CATEGORIES GENERATED AT NREL FACILITIES IN 2010 AND 2011 (LBS. NET WEIGHT)

	Hazardous Waste	Non-Hazardous Waste	Electronic Waste	Other Universal Waste
2010	18,322	12,129	11,676	5791
2011	20,557	6156	29,549	3539
% change	12.20	-49.24	153.07	-38.89

## 2011 Accomplishments and Highlights

The laboratory strives to divert waste from municipal solid waste landfills whenever possible. As a best management practice, staff began collecting toxicity-compliant light bulbs in conjunction with its universal waste lamps for subsequent off-site shipment and recycling.

A comparison of waste volumes generated in CY 2010 and CY 2011 is summarized in the table: Comparison of Four Waste Categories Generated at NREL Facilities in 2010 and 2011.



Hazardous wastes are handled and disposed of according to RCRA. Photo by Eric Schmitz, NREL PIX 20960

ics waste such as circuitry, solder, display monitors, etc.)

- Low-level radioactive waste is generated in small quantities in one designated laboratory and normally consists of personal protective equipment, disposable labware, scintillation fluids, and water-based liquids containing small amounts of low-level isotopes. Radioactive waste is shipped off-site for disposal as needed (see section 9.6 Radiological Materials and Waste Management for more information).

NREL maintains unique EPA identification numbers for each of its five facilities: STM, DWOP, NWTC, JSF, and ReFUEL. Pursuant with state and federal regulations, annual generator notifications are made and applicable fees are paid to the HMWMD based on monthly volumes of hazardous waste that are generated at each facility. The three waste generator classifications are:

- Large Quantity Generator (LQG): generates  $\geq 1000$  kg of hazardous waste in a calendar month (or  $> 1$  kg of acutely toxic hazardous waste)
- Small Quantity Generator (SQG): generates  $> 100$  kg but  $< 1000$  kg of hazardous waste in a calendar month (and  $< 1$  kg of acutely hazardous waste)
- Conditionally Exempt Small Quantity Generator (CESQG): generates  $< 100$  kg of hazardous waste in a calendar month (and  $< 1$  kg of acutely hazardous waste)

The table—2011 Generator Status for NREL Facilities—provides data for each NREL facility. Four out of five NREL facilities fall under the waste generator category of CESQG, generating minimal amounts of hazardous waste per calendar month. STM typically produces quantities of hazardous waste well within the category of SQG; however, due to pilot scale research experiments, STM can episodically elevate to that of LQG in one or more months during the year.

NREL has a conservative waste management policy where select materials that are not regulated by RCRA, yet pose a potential hazard, are collected and disposed of as non-hazardous materials at EPA-permitted disposal facilities. For example, non-hazardous,

nanomaterial-bearing wastes are not RCRA-regulated, but due to the potential for health risk, these wastes are managed and disposed of via the same management methods used for hazardous waste. In a general order of preference, waste items are shipped off site for final disposition through recycling, reclamation, incineration, treatment, and landfill.

### 2011 COMPLIANCE SUMMARY AND ACTIVITIES

- All program activities were in compliance with requirements.
- All regulatory notifications were updated and applicable waste generator fees were paid for five NREL facilities in calendar year 2011.
- Due to three calendar months of episodic hazardous waste generation at volumes totaling more than 1000 kg per month and in anticipation of additional pilot plant research experiments, the STM facility waste generator status was changed to LQG in October 2011. Since making notification of this change to the HMWMD, STM monthly waste generation volumes remained within the SQG classification for the remainder of 2011.
- The implementation of one opportunity for improvement identified in a 2010 external assessment of NREL's hazardous waste program commenced in CY 2011. In accordance with 6 CCR 1007-3, toxicity-compliant fluorescent light bulbs may be disposed of as municipal solid waste. However, as a best management practice these items are now collected, packaged and shipped for recycling and capture of the trace amounts of metals contained within.

### 9.3 ABOVEGROUND STORAGE TANK (AST) MANAGEMENT

Poor management can lead to spills or leaks of fuels or oils, resulting in the contamination of soils, surface water, groundwater, and drinking water. In addition, spill cleanup is costly and time consuming. Proper management of storage tanks is an important part of minimizing the number and size of potential spill events and is critical to our commitment to maintain a clean and healthy environment for both neighbors and employees.

The AST Management program applies to petroleum fuel tanks and is intended to:

- Minimize releases from tanks
- Confirm that safety features are present and functional
- Confirm that compliance requirements are met.

NREL seeks to minimize the risk of underground soil and water contamination from storage tanks by utilizing only aboveground tanks where storage is required. Unlike underground tanks, aboveground installations provide access for regular visual leak inspections and allow for less costly repair and cleanup should that be necessary.

NREL maintains eight ASTs at the STM facility with a total of 10,357 gallons capacity, one AST at DWOP with a capacity of 500 gallons, and seven ASTs at the NWTC facility with a total of 1,565 gallons

2011 GENERATOR STATUS FOR NREL FACILITIES.	
Facility Name	2011 Generator Status
STM	SQG/LQG
DWOP—Bldg. 16	CESQG
NWTC	CESQG
JSF	CESQG
ReFUEL	CESQG

## 2011 Accomplishments and Highlights

- Governing procedures for AST management were updated to reflect revised regulations.
- AST and spill prevention and response training was provided by the EHS Office to all NREL personnel identified as having responsibility for operating and fueling ASTs and those providing initial spill response. Over 30 NREL personnel attended these trainings.
- The NREL AST inventory was revised to reflect new, moved, and removed ASTs at all NREL facilities.
- All tanks were reviewed to confirm adherence to recently revised regulations.

capacity.

### PROGRAM MANAGEMENT

ASTs are regulated in Colorado by the CDLE's Oil Inspection Section under the Colorado AST regulation 7 C.C.R. 1101-14. Colorado requires that ASTs 660 gallons or larger be permitted prior to installation, be inspected by the CDLE following installation, and be registered within 30 days following commencement of use. EPA regulations require that ASTs are constructed and installed according to specific standards, are regularly inspected, those inspections are documented, and that facilities meeting certain oil storage limits employ the use of an SPCC plan to facilitate management of oil sources 55 gallons or larger. Those plans must include specific information, training requirements and response and cleanup guidance designed to minimize the number and size of spills and speed the control and cleanup of spilled materials.

NREL facilities store diesel fuel for emergency generators and ethanol from research activities in ASTs. The AST management program focuses on proper tank design, operation, training, and inspection to protect against spills and leaks. The program is designed to meet, at a minimum, EPA and Colorado regulatory requirements.

Several important mechanical and procedural safeguards have been incorporated into the AST management program to prevent an accidental release of diesel fuel from the storage tanks. Mechanical safeguards include overfill and spill protection, double-wall tanks for diesel fuel equipped with sensors that result in an alarm if the inner tank wall is leaking, and exterior concrete containment structures for an ethanol storage tank and one single-wall diesel fuel tank. Procedural safeguards include written operating and tank filling procedures, monthly inspections, and record keeping of inspection results. ASTs larger than 110 gallons are visually inspected once per month.

Staff across departments participate in project planning, project

safety evaluations, readiness verifications and training activities. This participation promotes:

- Awareness of planned ASTs and their contents
- Timely achievement of necessary regulatory approval for ASTs
- Maintenance of a current and accurate AST inventory
- Procurement and placement of spill cleanup supplies to assist timely response to a spill event, whether large or small.

Training is performed annually of personnel who operate and manage ASTs. AST training occurs for individuals who are responsible for AST operation and maintenance. This training is combined with SPCC training for individuals who are responsible for AST operation and maintenance, fuel or other liquid transfer activities, and emergency response to AST spills. The intent of this combined training is to inform NREL staff of the inventory of oil-containing equipment at each site, discuss inspection and response requirements, review the oil spill history of each site and discuss lessons learned, and review and discuss recent changes in rules and regulations.

### 2011 COMPLIANCE SUMMARY AND ACTIVITIES

NREL maintained two ASTs at the STM facility during 2011 which were required to be registered, including a 6000g ethanol tank at the IBRF and an 800g diesel tank for an emergency generator at the SERF. Both of these ASTs have been in use at NREL for a number of years and comply with Colorado and EPA requirements. There are no ASTs at the NWTC which are required to be permitted or registered. It is anticipated that one or more additional ASTs requiring permitting and registration will be installed in 2012.

- All program activities were in compliance with requirements.
- No spills or releases from NREL's ASTs or related fueling activities occurred during 2011.
- Annual AST registrations were submitted to the CDLE DOPS for two NREL registered ASTs.
- The IBRF PDU 6,000-gallon stainless steel ethanol storage tank, which was temporarily removed from service in 2010, was placed back into service in June 2011, following the replacement of piping.
- In early 2011, DOE GO issued a report of its AST program surveillance, completed in late 2010. The surveillance identified 15 findings, five opportunities for improvement, and three noteworthy practices. Some areas identified as findings included venting and leak detection, internal audit, emergency power-off switch requirements, fire extinguisher requirements, training, SPCC plans, and hazard warning signage. All corrective actions were completed by August 2011.

### 9.4 SPILL PREVENTION AND RESPONSE

Spills of chemicals, fuels, and oils can result in contamination to soil, surface water, and groundwater, potentially causing damage to ecosystems, wildlife habitat, and human health. Comprehensive planning processes can reduce spills and limit impacts when spills do occur.

The laboratory seeks to prepare for and continually improve spill response. Formal SPCC plans have been developed for three facilities. The plans are designed to minimize the number and size of spills and speed the control and cleanup of spilled materials. Formal emergency notification and hazardous materials procedures are in place to provide additional support for spill response. Proper preventive planning and aggressive spill response enhance

## 2011 Accomplishments and Highlights

- SPCC plans for the STM, NWTC, and ReFUEL facilities, including oil spill response procedures, were updated to reflect revised regulations and incorporate additional best management practices.
- Emergency notification and hazardous materials event notification procedures were updated to facilitate the proper notifications and documentation in the event of a reportable spill event.

es the protection of our local water and ecological resources.

### PROGRAM MANAGEMENT

SPCC plans are required by EPA and Colorado regulations for facilities that meet certain oil storage criteria. Federal regulations 40 CFR 110, regarding Discharge of Oil, and 40 CFR 112, regarding Oil Pollution Prevention, are implemented by the EPA. The CDLE implements the DOPS Storage Tank Regulations 7 C.C.R. 1101-14. In general, facilities that store more than 1,320 gallons of oil and have the potential for a spill to enter a Water of the United States must have an SPCC plan. SPCC regulations require that any equipment or containers with the capacity to store 55 gallons or more of oil be included in the plan. The plan must address such items as:

- Topography and location of waterways
- Location and quantity of oil sources
- Possible transport mechanisms
- Spill scenarios and potential spill volumes
- Spill prevention and response training
- Spill notification procedures and contact information
- Emergency response plans.

Due to the quantity of fuels stored on the STM, NWTC, and ReFUEL sites, an SPCC plan is required for each of these locations. NREL's SPCC plans are updated every three years or whenever there is a significant change in regulations, operations, or equipment that renders the plan incomplete or inaccurate.

NREL maintains an effective notification and spill reporting program and follows the procedures in the respective SPCC plans for spills that might occur at any facility. Spill response carts and

caches are maintained at multiple locations allowing response and cleanup activities to occur quickly. Given the potential for spills of hydraulic fluids and fuels at construction sites, construction contractors are also required to implement controls through SWPPPs for each major construction site on campus (see section 8.3 Surface Water).

SPCC training occurs annually for individuals who are responsible for AST operation and maintenance, fuel, or other liquid transfer activities, and emergency response to AST spills. This training is combined with training for AST operation and maintenance. The intent of this combined training is to inform staff of the inventory of oil-containing equipment at each site, discuss inspection and response requirements, review the oil spill history of each site and discuss lessons learned, and review and discuss recent changes in rules and regulations.

While in a given year, the laboratory typically does not experience spills that require notification to the state, incidental spills do occur on occasion. Typically, these are small hydraulic system leaks and fuel transfer spills which occur during normal construction and maintenance activities. In order to assess the frequency of spill occurrences, a log of spills and clean-up responses is maintained. This record demonstrates that spills are generally small and infrequent, and the responses are adequate to prevent the spread of contamination. Lessons learned from clean-up activities help improve future contingency planning.

### 2011 COMPLIANCE SUMMARY AND ACTIVITIES

- All program activities were in compliance with requirements.
- Three SPCC plans, for the STM, NWTC, and ReFUEL facilities, were revised to address changes to EPA SPCC regulations and the Colorado AST regulations.
- No spills requiring reporting occurred in 2011.
- Thirty-one minor spills of diesel or hydraulic fluids at STM and two at the NWTC were responded to. The size of spills ranged from less than 0.1 gallon to 15 gallons. About half of the spills



Thorough cleanup of a small hydraulic fluid leak from a boom lift. *Photo by Matt Ogle, NREL/PIX 21215*

were on impervious surfaces and half were to soil. In all, a total of roughly 61 gallons of oil or diesel were spilled at STM, primarily from construction related activities, and about five gallons at the NWTC. Each spill was cleaned up promptly and did not result in any significant impact to the environment.

## 9.5 POLLUTION PREVENTION

NREL actively seeks opportunities to prevent pollution, going above and beyond compliance requirements to reduce potential impacts to our environment. Pollution prevention can come in many forms and can reduce impacts from activities such as: using and storing fuel, petroleum products, and chemicals; laboratory chemical use; purchasing, recycling and composting; employee commuting and travel; energy and water use; and building design and construction.

The positive impact of reducing pollution from NREL's activities comes in many forms:

- Replacing toxic chemicals with safer alternatives where possible reduces potential exposure to employees, the public, and local ecosystems.
- Choosing bio-based and recycled-content products reduces upstream impacts on natural systems.
- Encouraging employees to telecommute, take alternative transportation, and supporting web-based meetings reduces air pollution and traffic and health effects on surrounding communities.
- Using sustainable, low energy and low water use designs for buildings reduces GHG emissions and use of Colorado's limited water supplies.

NREL has made a formal commitment to pollution prevention through its laboratory-wide environmental protection policy (see section 3 Environmental Management System). NREL fulfills this commitment by implementing a variety of controls to reduce the potential environmental impacts in various areas of laboratory operations.

While the majority of NREL's environmental management programs were established to meet compliance requirements, many of these programs also strive to go beyond compliance requirements to continually improve environmental performance. In addition, staff regularly identify opportunities to prevent pollution through the implementation of NREL's hazard identification and control process.

NREL dedicates resources for sustainable operations through the Sustainable NREL program.

Formal pollution prevention assessments are conducted to identify opportunities to reduce pollution and improve program effectiveness.

Staff are available to provide guidance and assistance in the reduction of environmental impacts and prevention of spills.

## 2011 Accomplishments and Highlights

In FY 2011, three pollution prevention assessments were successfully completed:

- **Printer Reduction.** This assessment estimated the environmental benefits and cost savings of removing desktop printers to encourage greater use of multi-function devices (all-in-one printer, copier, scanner, and fax device). The assessment was conducted in one major building on the STM campus and verified existing printer inventories and the functionality of existing multi-function devices for color printing, copying, scanning, and faxing. The assessment determined that 50 to 60 devices could be removed with little or no impact to users. As a result, a printer consolidation project is currently under consideration for this building.
- **Sulfur Hexafluoride (SF<sub>6</sub>) Reduction.** This assessment determined the current uses of SF<sub>6</sub>, the feasibility to capture or reduce emissions, and estimated the potential environmental benefits of a capture or reduction program. SF<sub>6</sub> is a compound that, when released to the atmosphere, contributes to global warming. SF<sub>6</sub> has the highest known global warming potential (GWP) at roughly 23,000 times that of CO<sub>2</sub>. One use of SF<sub>6</sub> on campus is as a tracer gas for American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 110 fume hood testing. Based on this assessment, SF<sub>6</sub> alternatives will be considered for future NREL fume hood commissioning.
- **Aerosol Can Recycling.** This assessment evaluated the number of aerosol cans NREL uses to understand the environmental impacts of this waste stream. The study estimated that roughly 400 empty aerosol cans per year are being disposed of. Any cans that still contain hazardous materials are disposed of via a qualified waste contractor. Establishing a recycling program for aerosol cans is being considered based on this assessment to reduce generation of solid waste and conserve resources.

Sustainable NREL initiated a pilot Pollution Prevention Initiative, which provided staff with the opportunity to identify and implement new pollution prevention practices at the laboratory. Project proposals were submitted by staff to help the laboratory achieve reductions in waste, materials, water, air emissions, and energy use. Three projects were funded in 2011 including:

- **Idling Reduction.** This project created new guidance based on best practices and developed a site-wide education program for idling reduction. Estimated reductions include 1,700 gallons/yr and \$6,400/yr in diesel fuel use for NREL shuttles.
- **Pump Replacement.** This project replaced an existing oil-based wet pump with an energy-efficient sealed pump in a research laboratory. This replacement will reduce oil waste and energy usage associated with the pump.
- **NREL Library Reduce and Recycle.** This project replaced 85 linear feet of print journals with electronic journals to reduce paper use and the footprint required for the scientific reference library. This project reduced collection shelving requirements by 30%, saving both material and energy costs.



## PROGRAM MANAGEMENT

DOE O 436.1, *Departmental Sustainability* became effective in May 2011 and cancels DOE O 450.1A, *Environmental Protection Program* and DOE O 430.2B, *Departmental Energy, Renewable Energy and Transportation Management*. The order implements the objectives of EOs 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, and 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, which direct federal agencies to conserve natural resources, reduce energy use, develop renewable energy, reduce GHG emissions, and manage buildings and transportation in a sustainable manner. DOE O 436.1 also requires that DOE facilities comply with the Pollution Prevention Act of 1990 at DOE facilities and support pollution prevention.

Through the implementation of NREL's hazard identification and control process, staff regularly identify opportunities to prevent pollution. In addition, resources are dedicated for sustainable operations and pollution prevention through the Sustainable NREL program. Formal pollution prevention assessments are conducted to identify opportunities to reduce pollution and improve program effectiveness. The PPI provides staff with an opportunity to identify and implement new pollution prevention practices at the laboratory.

## 2011 COMPLIANCE SUMMARY AND ACTIVITIES

While there is no requirement to conduct pollution prevention assessments, such assessments are conducted periodically and are used to identify opportunities to reduce pollution, reduce costs, and improve internal processes.

## 9.6 RADIOLOGICAL MATERIALS AND WASTE MANAGEMENT

NREL is involved in a wide range of research activities, some of which, from time to time, include investigations using radioactive materials. NREL uses several x-ray diffraction analytical techniques and occasionally uses small quantities of radioisotopes for biological labeling in research. All of the materials used at NREL have very low activity levels and are used in extremely small amounts. Unlike many DOE facilities, NREL does not conduct work activities involving nuclear materials and does not have legacy radiological contamination issues associated with past nuclear weapons production and research activities.

NREL has established strict protocols for equipment containing sources or for the use of radioisotopes in laboratory experiments through its Radiation Safety program. Some of these controls include:

- Confining work with radioisotopes to a single laboratory
- Monitoring of equipment and facilities for removable contamination is performed in the laboratory where radioisotopes are used
- Inspecting x-ray equipment regularly
- Assuring that future users are not at risk for receiving contaminated materials—no equipment used on-site will be surplus until background levels of radiation present are achieved.

## 2011 Accomplishments and Highlights

- In 2011, there were no activities at the laboratory involving radioactive materials except for the use of sealed sources in tritium exit signs, gauging devices, and monitoring equipment check sources.

## PROGRAM MANAGEMENT

Radiation emissions are regulated under Section 112 of the Clean Air Act as implemented by 40 CFR 61, Subpart H, promulgated by the EPA. 40 CFR 61 established NESHAPs, and, more specifically, Subpart H, sets such standards for radiological materials, known as Rad NESHAPs.

DOE O 458.1, *Radiation Protection of the Public and the Environment* cancelled DOE O 5400.5. This order establishes radiation emission limits for DOE facilities. DOE facilities, including NREL, must annually demonstrate compliance with the Rad NESHAP, which limits emissions to amounts that would prevent any member of the public from receiving an effective dose equivalent of 10 millirem (mrem) per year or greater.

No radioactive air emission monitoring is conducted at NREL because of the extremely low usage of radioactive material. Therefore, NREL demonstrates compliance with the Rad NESHAPs in 40 CFR 61, Subpart H, by using the EPA's COMPLY computer model (version 1.6) to determine the effective dose equivalent to the public.

All radioactive waste generated during NREL activities is classified as low-level waste. Waste from the STM site is temporarily stored at the Waste Handling Facility (WHF) until disposal is arranged at an off-site facility permitted to accept low-level radioactive waste. Internal procedures prohibit the clearance of property unless it has been decontaminated to background levels.

## 2011 COMPLIANCE SUMMARY AND ACTIVITIES

- NREL began the development of an Environmental Radiation Protection Plan to provide information about the laboratory's management of radioactive materials and efforts to prevent exposures of these materials to the public and the environment.
- All program activities were in compliance with requirements.
- The effective dose equivalent to the public from NREL activities was 0.0054 mrem per year, far below the 10 mrem per year limit.
- No low-level radioactive waste was generated. Small quantities of low-level radioactive waste are currently in storage awaiting off-site disposal.
- No planned or unplanned radiological releases occurred.

## 10 National Environmental Policy Act (NEPA)

NREL's National Environmental Policy Act (NEPA) program provides a mechanism to consider environmental factors in the decision-making process and promotes sustainable and environmentally responsible operations. Staff conduct reviews under the NEPA process (described below) of a wide range of activities prior to work commencing.

Examples of activities receiving a NEPA review include new or revised laboratory research, construction activities, CRADAs and other partnering arrangements, and feasibility studies or data analyses performed for other government agencies.

### PROGRAM MANAGEMENT

NEPA is a federal law that requires potential environmental impacts to be considered for activities with a federal connection, such as those using federal funds, property, facilities, equipment, and staff paid using federal funds. The Act requires that federal agencies integrate the NEPA process into their activities at the earliest possible time. Soon after NEPA was passed, the president's Council on Environmental Quality (CEQ) promulgated regulations [40 CFR Parts 1500-15081] implementing NEPA which are binding on all federal agencies. Subsequently, DOE established NEPA

### EXAMPLES OF ACTIVITIES THAT COULD HAVE ENVIRONMENTAL IMPACTS

Activities	Potential Impacts
Chemical handling, storage, and disposal	Impacts to surface water resources if chemicals mishandled or disposed of improperly
Excavation and dirt moving during construction and maintenance	Fugitive dust Damage to historic or cultural resources Increased traffic or noise Impacts to wetlands
Mowing, maintenance, or off-road activities	Migratory birds impacts such as nest abandonment or bird deaths
Disturbance of asbestos-containing materials during indoor modifications or renovations	Employee health impacts due to inhalation of asbestos

## 2011 Accomplishments and Highlights

- In 2011, NEPA reviews were a top priority given the extensive on-site construction activities, as well as numerous off-site projects, many in response to American Recovery and Reinvestment Act (ARRA) funding opportunities.
- Provided project-specific NEPA training for several NREL programs, including Wind for Schools, Solar Incubator, and Work for Others wind assessment programs. With a better understanding of NEPA requirements for specific types of recurring projects, project managers can more effectively consider the potential for environmental impacts during their project planning activities.
- Worked collaboratively with NREL's ISMS and EMS teams to strengthen NEPA procedures and daily activities.
- Provided extensive NEPA support in the preparation of proposals for DOE Funding Opportunity Announcements (FOAs) that support DOE's mission and the nation's energy objectives.
- Participated in outreach activities by discussing NEPA requirements and potential environmental impacts during a webinar related to the Wind for Schools program. The webinar was attended by representatives from several colleges and universities across the country who will in turn communicate environmental requirements and potential impacts to participating schools.

Implementing Procedures (10 CFR 1021) which DOE (and NREL) use to comply with section 102(2) of the National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4332(2)) and CEQ regulations for implementing the procedural provisions of NEPA (40 CFR parts 1500-1508). The DOE procedures supplement, and are to be used in conjunction with, CEQ regulations.

NREL has developed a NEPA procedure to provide a mechanism to consider environmental factors in the decision-making process at NREL and to promote environmentally responsible decisions during project planning activities. The NREL NEPA Handbook has been prepared to provide NREL project managers and procurement specialists with guidance on implementing the NEPA procedures, and training is provided to staff, as appropriate.

The laboratory initiates NEPA reviews and supports the DOE GO in making NEPA determinations before work can begin. In accordance with DOE NEPA Implementing Procedures (10 CFR 1021), all NREL activities, other than routine, office, laboratory, or research activities, must undergo a NEPA environmental review. The outcome of this review is considered the NEPA determination. A NEPA determination is required before federal funds are expended, before a contract award can be made, and before project activities begin.

In most cases, proposed activities have either been evaluated in an existing site-wide EA or supplement or fall under a Categorical Exclusion (CX). A CX applies to activities that, based on agency experience, will normally have no significant individual or cumulative effect on the quality of the human environment. Examples of DOE CXs include information gathering, data analysis, feasibility studies, bench-scale research and development, and minor interior modifications. The NEPA review is initiated by preparing either a NEPA worksheet or checklist.

### Worksheets

For activities where the potential for environmental impact does not exist or for types of activities that have been previously analyzed in existing NREL site-wide NEPA documents, a NEPA worksheet is completed. The NEPA worksheet is a simple one page form that lists the proposed project and documents the appropriate CX or NREL site-wide NEPA document related to the proposed work. Allowable types of projects include office work, such as computer modeling or programming, data analysis, or preparation of educational materials, routine maintenance activities, minor interior modification of existing facilities, and bench-scale research and testing in an existing facility. For projects recorded on NEPA worksheets, the work can go forward upon receipt and review of the project information by EHS.

### Checklists

For proposed projects where there is a potential for environmental impact a NEPA checklist is completed. The information included on the checklist helps the NEPA reviewer to evaluate the potential environmental impacts of the project (e.g., utilization of hazardous materials, generation of hazardous waste or air emissions, ground disturbing activities, presence of floodplains, wetlands, endangered species, or critical habitats, potential for noise and visual impacts, etc.). Projects such as onsite construction, pilot-scale research and testing, installation of meteorological towers for wind resource assessments, and prototype deployment of renewable energy technologies are examples of projects that are typically reviewed using the NEPA checklist.

For a project recorded on a NEPA checklist, work may not commence until GO has reviewed the submittal and provided a signed NEPA determination by a DOE NEPA Compliance Officer. GO may include provisional language in the NEPA determination, which may limit the type of work that can be done until additional information is received, or which may specify the kind of mitigation actions that must be taken to avoid impacts.

### Environmental Assessment

If the proposed action is not included in the description provided in the CXs established by DOE, or there are extraordinary circumstances (such as impacts to historic resources, endangered species, floodplains or wetlands, etc.), or the proposed action fits within a category of actions that DOE has determined to typically require an EA, then NREL and DOE GO prepare an EA. The purpose of an EA is to determine the significance of the environmental effects and to look at alternative means to achieve the agency's objectives. An EA is prepared for classes of activities such as siting, construction, and operation of energy system demonstration actions including wind resource, hydropower, geothermal, biomass, and solar energy projects and operations. An EA provides sufficient evidence and analysis for determining whether to prepare an environmental impact statement (EIS). The EA provides an opportunity for public review and comment and demonstrates compliance with NEPA when no EIS is necessary, i.e., it helps to identify better alternatives and mitigation measures. The EA also facilitates preparation of an EIS when one is necessary.

An EA provides a brief discussion of the need for the proposal, alternatives to the proposal, the environmental impacts of the proposed action and alternatives, and a list of agencies and persons consulted. The EA process concludes with either a Finding of No Significant Impact (FONSI) or a determination to proceed to preparation of an EIS. The FONSI documents the reasons why it has been concluded that there are no significant environmental impacts that would occur if the project or activities were implemented. The EA and FONSI can include mitigation measures or alternatives that would be desirable to consider and adopt even though the impacts of the proposal will not be "significant." NREL has completed site-wide EAs for both the NWTC and STM facilities.

### Environmental Impact Statement

An EIS provides a detailed analysis of projects that the proposing agency views as having significant prospective environmental impacts. The EIS provides a discussion of significant environmental impacts and reasonable alternatives (including a No Action alternative) which would avoid or minimize adverse impacts or enhance the quality of the human environment. An EIS is also made available for public review and comment. As a final step, a Record of Decision (ROD) is prepared which states the decision, the alternatives considered, including the environmentally preferred alternative, and discusses mitigation plans, including any enforcement and monitoring commitments. It should be noted that no NREL activities have required an EIS to date.

### 2011 COMPLIANCE SUMMARY AND ACTIVITIES

- Five hundred and fifteen NEPA reviews were conducted for project activities on and off site during 2011. Of these, 30 NEPA "checklists" were completed given their potential to cause an environmental impact. For each of these, work commences only after DOE reviews the submittal and provides a signed NEPA determination which specifies any needed mitigation actions that must be taken to avoid impacts. Two projects were determined to require an EA.

- A Supplemental EA was initiated to address a proposed action for enhancements to the RFHP.
- A site-wide EA was initiated for proposed continued and enhanced operations at the NWTC.
- This program was in compliance with the DOE NEPA Implementing Regulations.

## 11 Natural and Cultural Resources Protection

NREL is committed to responsible stewardship of our natural ecosystems, native wildlife and vegetation, and important cultural resources. Natural resources at the STM and NWTC facilities are managed appropriately to ensure our research needs are met while protecting native wildlife and vegetation. Responsible management not only benefits our environment, but also NREL employees and the surrounding community, and demonstrates the laboratory's leadership in the DOE and federal government as a whole. Management focuses on these key areas:

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

### 11.1 WILDLIFE MANAGEMENT

The Wildlife Management program is intended to promote responsible wildlife and habitat management and gather information to better consider impacts to wildlife when implementing projects on-site. NREL is committed to responsible land stewardship and the proper management of wildlife populations into the future. Many surrounding landowners, including residential neighborhoods and the Jefferson County Open Space value the benefits of maintaining wildlife habitat and opportunities to observe wildlife. Proper wildlife management provides an important benefit to our community.

NREL biologists work with project managers and decision makers as part of an integrated project team on construction projects to minimize impacts to wildlife and maintain habitat by avoiding sensitive areas and reclaiming lands once disturbance is complete.

At STM, a long term objective is to maintain wildlife movement through campus by retaining linkages between the open space areas north of campus and Pleasant View Community Park and Lena Gulch to the south. At the NWTC, ecologically sensitive areas are preserved within the site and linkages with surrounding open

space areas are maintained. At both sites, periodic monitoring using wildlife surveys informs responsible management.

When control of pest wildlife species is necessary, a graded approach is used to humanely eradicate 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. Pests are relocated whenever possible. When pests must be destroyed, mechanical methods are preferred over poisoning. When necessary, pesticides are selected to minimize secondary impacts.



Bee swarm outside the RSF. Photo by Brenda Beatty, PIX 21212

### 2011 Accomplishments and Highlights

- STM and NWTC site-wide wildlife and vegetation surveys were completed. These surveys enable staff to compare current conditions to those found in previous studies, establish environmental conditions for future NEPA EAs (see section 10 National Environmental Policy Act ), and make informed wildlife management decisions.
- Avian use, and avian and bat mortality surveys, were conducted at the NWTC to gauge potential impacts associated with the installation of three next-generation, multi-megawatt wind turbines (see 2011 Compliance Summary and Activities below).
- Several bee swarms were found on campus. Two swarms naturally moved off-site, but a third, which settled into a building cavity to construct a new hive, was safely relocated by a professional beekeeper.
- Numerous rattlesnakes that posed a hazard to workers were relocated to nearby habitat on NREL sites.

## PROGRAM MANAGEMENT

Several federal laws, an executive order, and a Colorado statute comprise the regulatory framework for this program.

The MBTA of 1918 (16 U.S.C. 703-712; Ch. 128; July 13, 1918; 40 Stat. 755) is the main driver for protection of migratory birds in the United States. In the biological sense, a migratory bird is a bird that has a seasonal and somewhat predictable pattern of movement. Generally, this includes all native birds in the U.S., except those non-migratory species such as quail and turkey that are managed by individual states as game species.

Under the MBTA, it is unlawful “by any means or manner to pursue, hunt, take, capture [or] kill” any migratory birds except as permitted by regulations issued by the U. S. Fish and Wildlife Service (USFWS). The term “take” is not defined in the MBTA, but the USFWS has defined it by regulation to mean to “pursue, hunt, shoot, wound, kill, trap, capture or collect” any migratory bird or any part, nest or egg of any migratory bird covered by the conventions, or to attempt those activities.

The USFWS has developed a system of permits for activities that involve the take of migratory birds, including those governing scientific collection and bird banding, and lethal and non-lethal measures taken to prevent depredation of agricultural crops and to protect public health and safety. Existing migratory bird permit regulations authorize take for specific types of activities, such as collecting birds for scientific or educational purposes, or lethal control of birds damaging agricultural crops or other personal property. The USFWS does not authorize take resulting from activities such as forestry or agricultural operations, construction or operation of power lines, and other activities where an otherwise legal action might reasonably be expected to take migratory birds, but is not the intended purpose of the action. Therefore, NREL property managers do not have a permitting option for their activities unless for scientific, educational or property damage. Construction activities do not have permitting options.

In response to EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds* the USFWS issued guidance identifying goals for federal program activities. The USFWS highlighted the need to identify means and measures to avoid and/or minimize potential for take of migratory birds, eggs, and active nests, including but not limited to (1) project modification, (2) time-of-year restrictions on vegetation clearing, (3) avoidance of cavity trees, colonial bird nests, and other active nests, and (4) avoidance of nests of species of concern. The USFWS also seeks to ensure that environmental analyses of federal activities under the NEPA or other established environmental review processes evaluate the effects of actions and agency plans on migratory birds, particularly on species of concern.

Wildlife is considered a state resource under Colorado law. Under Colorado Revised Statute 33-6-128: Damage or Destruction of Dens or Nests—Harassment of Wildlife, no wildlife dens or nests, young, or eggs may be damaged or destroyed unless permitted

by the Colorado Division of Parks and Wildlife. It is unlawful for any person to willfully harass wildlife. This statute gives district wildlife managers the power to ticket offenders and enforce a similar provision to the MBTA and to protect mammalian wildlife species.

On August 1, 2006, a MOU was finalized between the USFWS and the DOE regarding the protection of migratory birds. Under the MOU, DOE agrees to integrate migratory bird conservation principles, measures, and practices into agency activities, and avoid or minimize, to the extent practicable, adverse impacts on migratory bird resources and their habitats.

NREL’s Wildlife Management Program was developed to implement measures to allow NREL to meet or exceed the regulatory requirements discussed and to minimize or avoid impacts to wildlife species and their habitats while achieving the mission of NREL. Several activities occur periodically to achieve the program’s intent:

- Monitoring
  - Prior to ground or vegetation disturbing activities conducted between March 15 and September 15, NREL biologists conduct a nesting bird survey. If nests are found, the area is closed with a proper buffer area until nestlings fledge.
  - Periodic surveys are conducted on a site-wide basis to document biological conditions at NREL facilities.
- Research Studies
  - Periodically, research studies are conducted to better understand the potential impacts of projects or site management.
- Vegetation management
  - Areas that may be impacted by outdoor activities are surveyed then mowed to reduce vegetative cover, discouraging bird nesting in that area.
- Project Reviews
  - Biologists conduct project reviews to assess potential impacts to avian species including consideration of window glazings to reduce bird collisions and timing construction activities to start before or after the nesting season.
- Coordination
  - Biologists coordinate with local, state and federal agencies to improve wildlife management where possible.

These activities are conducted in concert with surveys for threatened and endangered species and habitats (see section 11.2 Endangered Species and Species of Concern). Because habitat is as much of a concern as the wildlife species themselves, program activities often overlap with vegetation management.

## 2011 COMPLIANCE SUMMARY AND ACTIVITIES

- All program activities were in compliance with requirements.
- Developed a Migratory Bird Conservation Plan for NREL sites. This plan is used as guidance for specific types of projects that

have the potential to impact migratory birds and provides BMPs that are recommended to eliminate or minimize impacts for identified risk areas including:

- Disturbance of vegetation
- Building maintenance
- Collisions with buildings, windows, meteorological towers, and wind turbines.

The plan also outlines strategies for monitoring of avian species of special concern, such as eagles and other raptors. The plan is intended to be a guidance document that meets NREL's obligations under the MOU described above.

- Bird-friendly glass windows were installed on the laboratory's new STM parking garage set to open in 2012. The glass in this structure is patterned with a 50% frit that appears etched but still allows for visibility. This special glass was installed on all glass breeze-ways and critical areas of glass stairwells. This design should reduce the potential for bird collisions, lessening impacts on migratory birds.

In 2011, wildlife surveys were completed at STM and the NWTC. Surveys were conducted during 2010 and 2011 to include all four seasons of the year. Survey methods were those typically used in baseline surveys: point count for birds, live small mammal trapping, scent posts for carnivores, recorded call surveys for amphibians and owls, and bat acoustic surveys. Results include:

#### STM

- One-hundred and two wildlife species were detected: five herptiles, 86 birds, and 11 mammals. In comparison, previous survey efforts observed a total of 31 species in 1987, and 69 species in 2005.
- The seasonal average for wildlife species richness, diversity (dominance) and total number of detections all approximately doubled since reported for 2005. This is explained by an increased survey effort.
- One special status species was observed, the peregrine falcon (*Falco peregrinus*), a State Species of Special Concern.
- Small mammal trapping resulted in a low species richness with only three species captured on-site over two survey periods including Mexican woodrat (*Neotoma Mexicana*), deer mouse (*Peromyscus maniculatus*), and western harvest mouse (*Reithrodontomys megalotis*).
- Mammalian predator surveys detected red fox (*Vulpes vulpes*), coyote (*Canis latrans*), and striped (*Mephitis mephitis*) and spotted skunk (*Spilogale gracilis*). Only coyotes had been detected previously.
- Amphibian call surveys detected one species, Woodhouse's toad (*Bufo woodhousii*).
- Playback surveys failed to detect any owls.
- No bat species were detected.

#### NWTC

- Seventy three wildlife species were detected including: three herptiles, 45 birds, 17 mammals, and eight insect species. In comparison, previous survey efforts observed a total of 31 species in 1987, and 69 species in 2005. Thirty five species were observed in off-site reference areas.
- High species richness for small mammals indicates that the site has high biodiversity value, especially for small mammals and their predators.
- Six species were added to the list of species previously documented on-site: Boreal Chorus Frog, Woodhouse's Toad, Masked Shrew, Western Harvest Mouse, Meadow Vole, and American Elk.
- Bat acoustic monitoring documented that bat activity was highest from mid-July to mid-September.

#### Avian use and avian and bat mortality surveys at NWTC

Installation of three newer generation multi-MW wind turbines at the NWTC has raised concerns regarding the potential for mortality impacts to avian and bat species at the NWTC. To identify species or species groups that may be at risk from NWTC operations and development, NREL conducted a year-long survey completed in 2011 to document avian use and to document bird and bat mortalities. Avian use surveys included breeding bird surveys during the spring and summer, raptor migration surveys during the spring, and weekly avian site use (including raptors and non-raptors) surveys over the entire year. Avian and bat mortality surveys were also conducted weekly over the entire year. In addition, wildlife surveys, including bat surveys were conducted during 2010 and 2011. All surveys were conducted using standard methodologies used at other wind facilities.

The data collected from these surveys will be used to make informed decisions regarding wildlife impacts under continued site use and future development scenarios. These data will be used to evaluate methods that could be used to avoid, minimize, or mitigate wildlife impacts in the future, including the potential use of bird diverters to make meteorological tower guy wires more visible, and changing turbine cut-in speeds during times when bats are most at risk of collision (i.e., during spring and fall migration). Results of these surveys are discussed below.

#### BREEDING BIRD SURVEYS

Spatial distribution of grassland songbirds was evaluated in relation to vertical structures, including wind turbines and meteorological towers. Grassland bird species observed during the breeding season included western meadowlark (*Sturnella neglecta*), vesper sparrow (*Pooecetes gramineus*), grasshopper sparrow (*Ammodramus savannarum*), savannah sparrow (*Passerculus sandwichensis*), and horned lark (*Eremophila alpestris*). Based on survey results, grassland breeding bird (other than vesper sparrow) distribution does not appear to be affected by the current distribution of turbines at the site. For the vesper sparrow, there were

fewer detections east of Row 3 road, than to the west, likely due to increased human presence and activity where the medium and large turbines are located.

### RAPTOR MIGRATION SURVEYS

The eastern front of the Southern Rocky Mountains in central Colorado (i.e., the Front Range) is used annually by raptors residing in the intermountain west, particularly for spring migration north from lower latitudes. Since wind turbines, antennae, and meteorological towers have been shown to cause bird collisions and fatalities, a survey of migrating raptors was conducted for 20 days during April 2010. Migratory and resident raptors were observed. A total of 378 raptor species were observed. The most abundant species observed were the turkey vulture (*Cathartes aura*) (114 observations), American kestrel (85), and red-tailed hawk (65). Of the total number of observations, 126, or 33%, were migratory. Only five migrant raptors were detected within the NWTC airspace. However, it should be noted that the year-to-year variation in April migrant routes is large. For example, in 2010, most migrating raptors were observed flying to the west of the NWTC, over the foothills. In previous years, the flight path was much to the east of the site. As a result, depending on each year's migration route, there could be a greater or lesser presence of raptors flying over the NWTC, in the vicinity of large-scale turbines, which would result in a greater or lesser risk of collision with aerial structures.

Of the five migratory raptors that passed within NWTC airspace, flight height ranged from zero to 820ft (250m) and averaged 338ft (103m). In contrast to the low migrant presence over the site, resident raptors engaged in semi-constant use of the landscape during April 2010, particularly tall towers and guywires. Flight height for resident raptors ranged from zero to 1050ft (320m) above the ground for the three resident species (American kestrel, red-tailed hawk, and turkey vulture). The majority of resident raptor flights occur at heights similar to the majority of towers, structures and associated guywires. Turbine heights onsite range from 29ft (9m) to 295ft (90 m), meteorological towers range in height from 29ft (9m) to 443ft (135m), and rotor swept areas range from 23ft (7m) to 36ft (11m) above the ground (for the smallest turbine onsite) to an area covering 131ft (40m) to 459ft (140m) above the ground (for the largest turbine onsite). No collisions or dead raptors resulting from structure collisions were observed during the April 2010 migrating raptor survey. However, since resident raptors tend to spend more time hunting onsite than migrating raptors, they may be at higher risk of collision.

### AVIAN SITE USE

Six fixed point surveys were conducted over the course of a year onsite at the NWTC, as well as at two offsite reference locations (three fixed points on Boulder County Open Space, and three fixed points on the Rocky Flats National Wildlife Refuge). Surveys were conducted weekly during the spring, summer, and fall, and every other week during the winter. Both raptors and non-raptors were counted during the surveys to characterize the bird community using the site throughout the year.

Non-raptor mean use was highest during the summer among all surveyed seasons (12.85 birds/20 minutes). Western meadowlark, red-winged blackbird (*Agelaius phoeniceus*), horned lark, and grasshopper sparrow were among the most numerous non-raptors observed. Of these species, only horned larks and grasshopper sparrows were observed flying at rotor swept area (RSA) height (0.08 and 0.03 birds flying at RSA height/20 min, respectively). Horned larks are susceptible to collision during the breeding season because male horned larks fly to heights of 262ft (80m) to 820ft (250m) for breeding displays. While other species, such as the barn swallow (*Hirundo rustica*), song sparrow (*Melospiza melodia*), common raven (*Corvus corax*), black-billed magpie (*Pica hudsonia*), and mourning dove (*Zenaida macroura*) were also observed flying at RSA height, their low site use and frequency of encounter indicate that mortalities are likely to be few.



Killdeer. Photo by Brenda Beatty, NREL/PIX 21232

Raptor mean use was highest during the spring and early summer among all surveyed seasons (0.25 birds/30 minutes and 0.29 birds/30 minutes, respectively). Raptor species with the highest mean use included red-tailed hawk, turkey vulture, and American kestrel. Of raptor species observed during point count surveys, only turkey vultures, American kestrels, red-tailed hawks and ferruginous hawks (*Buteo regalis*) were observed flying at RSA height during all point count surveys and all other raptors were observed flying below the RSA height of the three large turbines.

The scientific literature indicates that raptor mortality appears to be low (less than 0.15 raptors/MW/yr) when raptor use is low (i.e., less than 1.0 birds/20 min), which is the case for raptor use at the NWTC during all seasons.

### BAT SITE USE

Of the 18 species of bats known to occur within Colorado, 11 have been documented in Jefferson County or neighboring counties. Bat species that were documented at the NWTC during 2010 wildlife surveys include big brown bat (*Eptesicus fuscus*), hoary bat (*Lasiurus cinereus*), silver-haired bat (*Lasionycteris noctivagans*), eastern red bat (*Lasiurus borealis*), fringed myotis (*Myotis thysanodes*), and other unidentified myotis species. None of the bat species observed onsite are threatened or endangered at the federal or state level.

## MORTALITY SURVEYS

Surveys were conducted over the course of a year to document whether avian and bat fatalities were occurring as a result of interactions with wind turbines and other vertical structures (including guy wires). Results of mortality surveys are discussed below.

Thirteen bat fatalities were found during standardized carcass searches from August 2010 through September 2011. Species found include hoary bat, silver-haired bat, big brown bat and two unidentified bat species. Bat fatalities were found only during summer and fall seasons. All bat carcasses were found beneath turbines. In general, bat fatalities documented at wind farms are highest during mid to late summer and early fall and tend to involve migratory tree roosting species (e.g., hoary bat and silver-haired bat). Peaks in fatality rates appear to coincide with increasing bat activity levels associated with southward migration. Although NWTC is not a wind farm, peaks in bat activity and subsequent mortalities were similar to those found at wind farms.

A total of five avian carcasses representing three species and two unidentifiable carcasses were found. Avian fatalities were found in every season except winter and included a black-billed magpie, mourning dove, red-winged blackbird, an unknown sparrow, and an unknown songbird. Except for the unknown songbird, all other species were discovered underneath meteorological towers, indicating guy wire strikes.

The above values indicate the number of bird and bat carcasses observed during the survey. The actual number of fatalities is dependent upon how efficient the searcher is at locating carcasses and how long the carcass persists on the ground before being removed by scavengers (or by other means such as grass/brush mowing). To account for these variances, searcher efficiency trials and carcass persistence trials were conducted, using standard methodologies used at other wind facilities. Results indicated that overall searcher efficiency was estimated at 49%.

For the carcass persistence trials (where a carcass is placed randomly onsite and monitored for 30 days to ascertain the length of time fatalities would remain before being removed [i.e., before it could be observed and counted]), the estimate for average mean persistence across seasons was 16.3 days (the fewer days the carcass persists on the ground, the less likely it would be observed during the survey).

Under current operating conditions, and based upon 2010–2011 fatalities, searcher efficiency trials, and carcass persistence trials, three avian fatalities and 16 bat fatalities are estimated to occur on the NWTC site during fall/winter seasons. During spring/summer seasons, 10 avian fatalities and 17 bat fatalities are estimated to occur on the NWTC site.

## 11.2 ENDANGERED SPECIES AND SPECIES OF CONCERN

NREL manages its research and facility-related activities to preserve and protect environmental quality and strives to practice good land stewardship at its facilities. The laboratory is committed

to the protection of imperiled wildlife species and monitors for these species at its two main research sites: STM and the NWTC.

Periodically, surveys are conducted for declining wildlife species and rare plants including species that are federally or state protected or otherwise considered imperiled or declining. Biologists also survey for potential habitat for these species. Should potential habitat be found, more targeted surveys may be conducted. These surveys identify the presence or absence of rare species or their habitats and aid in siting and planning new projects. While no protected or declining species have been detected at an NREL facility, appropriate steps would be taken should such a species be found.



Ute ladies' tresses orchid at Prospect Park, Lakewood, CO. Photo by Bob Fiehweg, NREL/PIX 20956

## 2011 Accomplishments and Highlights

- Completed site-wide rare plant and animal surveys at the STM and NWTC. NREL conducted surveys for federally threatened species including Ute ladies' tresses orchid (*Spiranthes diluvialis*), Colorado butterfly plant (*Gaura neomexicana* Woot. ssp. *Coloradensis*) at STM, and Colorado butterfly plant and Preble's meadow jumping mouse (*Zapus hudsonius preblei*) at the NWTC.
  - All surveys completed resulted in clearance at STM; therefore, no NREL projects need to address listed species.
  - Surveys at the NWTC resulted in clearance for rare plants and potential habitat for the Preble's mouse (including critical habitat).
  - Survey results were shared with the USFWS to provide continued assurance that NREL activities do not impact rare species.



## PROGRAM MANAGEMENT

The Endangered Species Act (ESA; 16 USC §1531-1544 as amended) provides for the designation and protection of wildlife, fish, and plant species that are in danger of extinction, and preserves the habitats on which these species depend. Federal agencies are required to abide by the ESA and ensure that their actions do not adversely affect species that are federally listed under the ESA as threatened, endangered, or candidate species.

Additional federal and state laws and regulations protect wildlife, such as the Bald and Golden Eagle Protection Act. The Colorado Division of Parks and Wildlife identifies a list of endangered, threatened, and wildlife species of concern for Colorado. Furthermore, the Colorado Natural Heritage Program (CNHP) has a list of rare species that, while not regulatory in nature, is useful as it is the only designation besides the ESA that considers rare plants. The list of threatened, endangered, candidate species and species of concern (i.e., bald and golden eagles, state listed species, CNHP species) are all considered imperiled species and can be referred to as a group known as “Threatened, Endangered or Species of Concern (TESC)” species.

The USFWS lists seven species in accordance with the ESA as threatened, endangered, or a candidate for listing that could potentially occur in Jefferson County. Of these seven species, three have potential to occur on the STM or the NWTC sites. These are the Preble’s meadow jumping mouse, the Ute ladies’ tresses orchid, and the Colorado butterfly plant. Periodic surveys are conducted for these three species to document their presence or absence on the STM or NWTC sites.

NREL also considers other plant and animal species that may be state listed or generally in decline. Current information is obtained from both the Colorado Division of Parks and Wildlife and the CNHP. These two entities work together to track declining species and habitats throughout Colorado. Although not required by federal regulation, periodic surveys are conducted for species that may occur at NREL sites, typically, every five years when baseline vegetation and wildlife studies are conducted. These baseline surveys are a vital part of NREL’s NEPA program where impacts to natural resources from mission activities are assessed.

## 2011 COMPLIANCE SUMMARY AND ACTIVITIES

- All program activities were in compliance with requirements.
- The USFWS has designated critical habitat for the Preble’s meadow jumping mouse on the adjacent Rocky Flats National Wildlife Refuge, and a small portion of this designated habitat extends onto the NWTC. NREL and DOE reviewed the area with a representative from the Colorado Field Office of USFWS. Although the habitat extending onto the NWTC site is of marginal habitat quality, USFWS has no mechanism to declassify critical habitat once it is designated. The area will be managed in accordance with its ecological importance.

## 11.3 VEGETATION MANAGEMENT

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

For these reasons, the focus of NREL’s approach to vegetation management is as follows:

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



Sulphur flower (*Eriogonum umbellatum*). Photo by Brenda Beatty, NREL/PIX20957

Approximately 60 acres of land within the NWTC site boundaries are managed as a conservation area. This includes on-site seeps and ephemeral drainages and ponds, native grassland habitat, and remnant tallgrass prairie. The purpose of conserving these areas is to avoid development to protect the site’s natural resources.

Where removal of native vegetation cannot be avoided, reseeding is done using grass and forb seed mixes native to the local area. A

palette of native flowering plants, shrubs, and trees has been identified for use on both the STM and NWTC campuses to enhance ecosystem diversity and integrity. NREL staff continually evaluate and modify revegetation techniques as needed to promote healthy plant establishment.

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

- Minimize water use
- Reduce the need for pesticides and fertilizers
- Reduce maintenance costs
- Maximize ground cover to reduce soil erosion
- Establish a variety of habitats to support diverse wildlife
- Create an aesthetically pleasing landscape environment.

During construction of the RSF, NREL participated in the SITES two year pilot program, a partnership of the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center at the University of Texas at Austin, and the United States Botanic Garden, along with a diverse group of other stakeholders. The purpose of this program is to develop the first national rating system for sustainable landscapes. While there currently exists a green building rating system (LEED certification) for new and existing buildings, there is no similar rating system for landscaped environments.

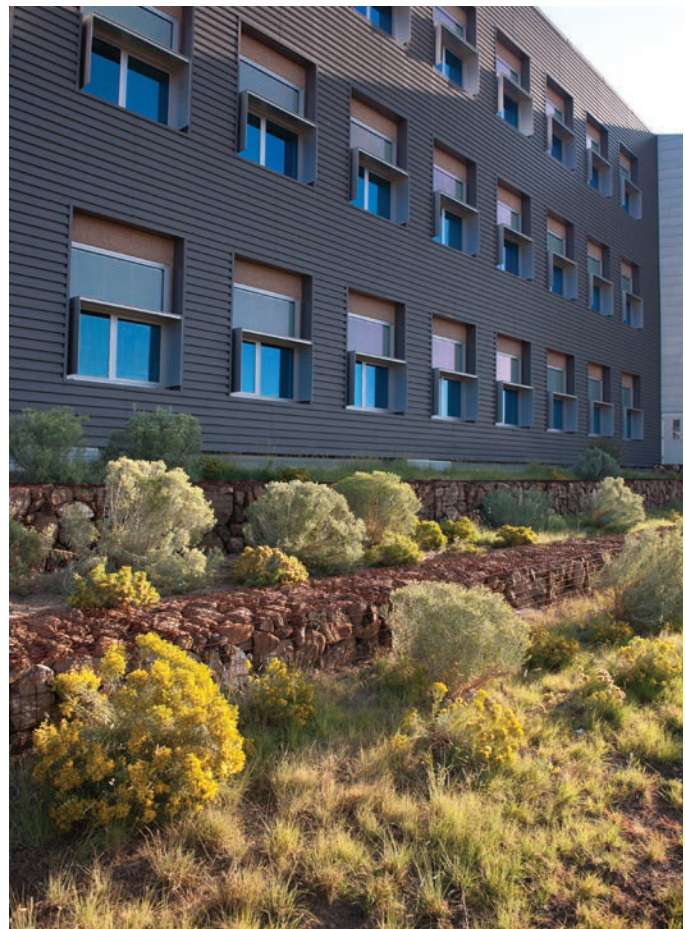
RSF landscaping was designed and installed with sustainability in mind, and includes features such as native plantings, Xeriscape principles appropriate for arid climates, and infiltration of stormwater to provide water and nutrients. The landscaping was designed so that the RSF would give the impression of “rising out of the prairie” instead of being a structure on the landscape.

NREL uses an integrated weed management approach that incorporates various types of weed control methods including mechanical practices (e.g., mowing), cultural (e.g., reclamation of disturbed areas), prevention (e.g., limiting or eliminating driving of vehicles off established roadways), and herbicide treatment. The effectiveness of control methods is periodically assessed. The use of multiple strategies for control has been successful in significantly reducing populations of diffuse knapweed and Canada thistle. 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 assists in targeting weed control efforts.

NREL continues to refine and optimize this program with interdisciplinary participation, bringing together the expertise of biologists, landscape architects, water quality specialists, and maintenance staff.

### PROGRAM MANAGEMENT

The vegetation management program meets the requirements of EO 13112, Invasive Species and the Colorado Noxious Weed Act, which require the control of invasive weeds.



Native, water efficient landscaping at the RSF. *Photo by Robb Williamson, NREL/PIX 20958*

In Colorado, the Department of Agriculture Commissioner, in consultation with the state noxious weed advisory committee, local governments, and other interested parties, develops and implements noxious weed management plans for three categories of weed species. Class A species are targeted for eradication. Class B species are subject to management plans designed to stop the continued spread of these species. Local governments can manage Class C-listed species at their discretion. If they do choose to manage them, the state provides funding for certain programs.

The laboratory continues to address the control of these species using the integrated weed management approach described above. The weed maps below show the results of recent weed surveys at STM and the NWTC. These surveys are used to inform management and control of weeds at the sites. The table below lists noxious weed species at the STM and NWTC.

### STM

No rare or imperiled plant species have been found at STM in recent surveys. Areas of mixed foothills shrublands (also called tall upland shrubland) have been identified at STM on top of the mesa within NREL's conservation easement area. This natural community is listed as rare and imperiled by the CNHP. No development will occur in the conservation easement area.



Lark sparrow on mullein stalk. Photo by Brenda Beatty, NREL/PIX 20959

## 2011 Accomplishments and Highlights

- Surveyed and mapped vegetation at STM and the NWTC. These surveys were done in anticipation of their use in the upcoming NEPA EAs in 2012, and to evaluate any changes that may have occurred since previous surveys. Maps were developed showing vegetation communities, wetlands and drainages, conservation areas, disturbed areas, and concentrations of noxious weeds.
- Based on lessons learned from previous revegetation efforts, landscaping plans for current construction projects were adjusted to optimize plant establishment, withstand difficult shading and snow conditions, and deter animal browsing while providing wildlife habitat (i.e., spaces for nesting birds, plants for pollinators such as hummingbirds, and protective cover for other species).
- Developed landscaping plans for a stormwater detention basin using a significantly larger palette of grasses and other native vegetation to accommodate the variety of moisture conditions anticipated. This plant selection will stabilize soils and create habitat for wildlife anticipated to utilize the basin.
- Conservation of existing ecosystems is accomplished to the maximum extent possible during design review of proposed construction projects, at an early stage when modifications to site layout are still possible. This approach was used successfully at the NWTC when a megawatt-scale turbine base was resituated to avoid a unique community of native plants along the site's eastern border.

## NWTC

No rare or imperiled plant species were found on the site. However, the survey identified a small area of remnant tallgrass prairie (defined as mesic mixed grassland in this study) located in the southwest corner of the NWTC. This natural community is listed as rare and imperiled by the CNHP. This listing implies no legal designation or regulatory enforcement. It is so designated primarily for management purposes. This area of the NWTC is not impacted by research or construction activities on the site, and was specifically protected during construction activities associated with the installation of an eight-acre PV array.

For information on rare and imperiled plant species, see section 11.2 Endangered Species and Species of Concern section for more information.

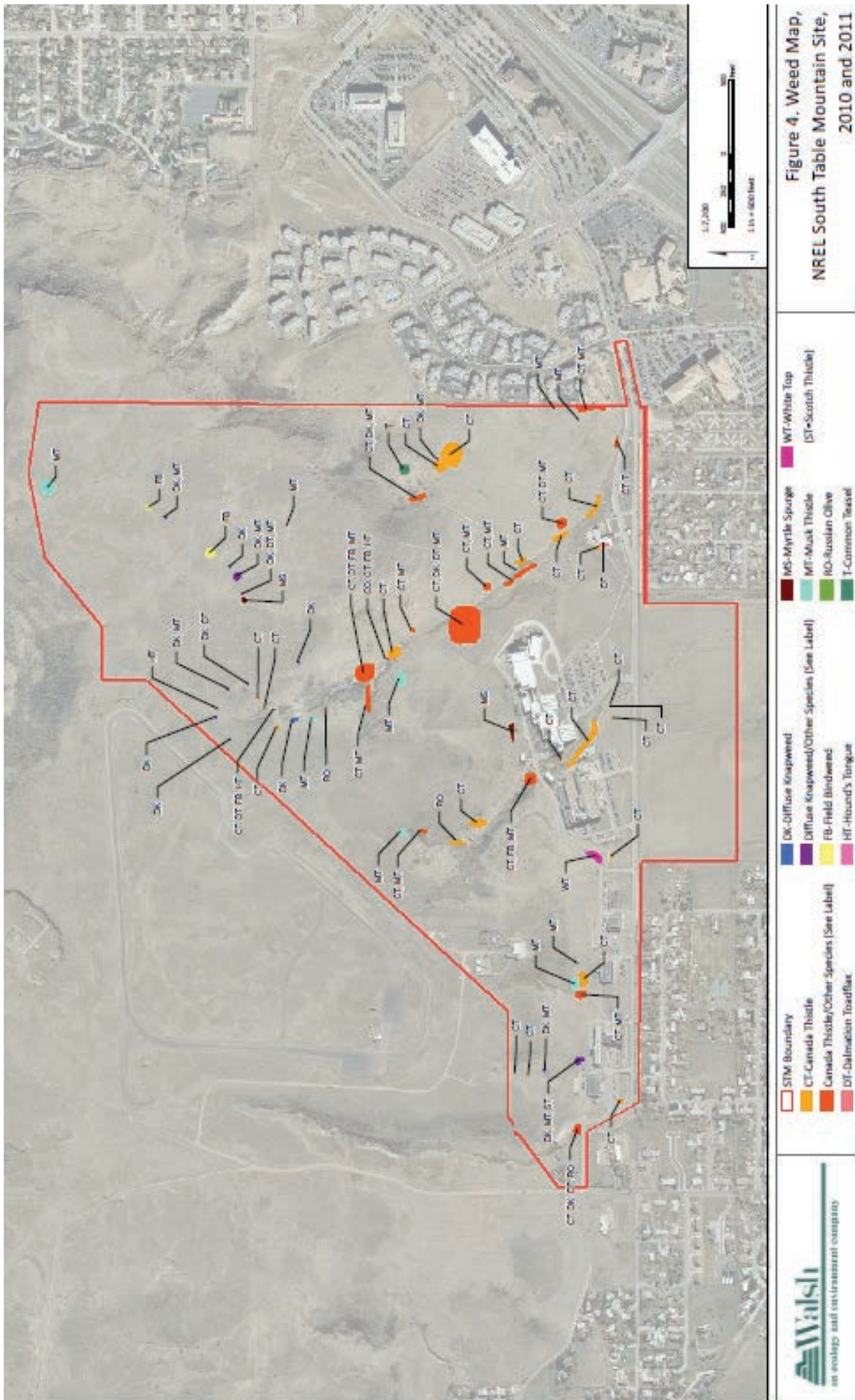
The FIFRA regulates the use, storage, and disposal of herbicides and pesticides. For application of certain types of herbicides designated as "restricted-use" by the EPA, a certified applicator must be used. Application of restricted-use herbicides is conducted in accordance with the regulation. NREL currently uses contractors for this type of application.

## 2011 COMPLIANCE SUMMARY AND ACTIVITIES

- All program activities were in compliance with requirements.
- The application of restricted-use herbicides was conducted using certified applicators. This included treatment of approximately 200 acres at the NWTC and two acres at STM.
- Requested that contractors and NREL workers doing landscape maintenance compost landscaping waste, including weeds, to reduce the waste stream and to reduce the propagation of listed weeds.

## NOXIOUS WEED SPECIES IDENTIFIED AT THE STM AND THE NWTC

Noxious Weed Class	Species Present at STM	Species Present at NWTC
Class A:	Myrtle spurge	None
Class B:	Canada thistle Common teasel Dalmation toadflax Diffuse knapweed Hoary cress (whitetop) Hound's tongue Musk thistle Russian olive Scotch thistle	Canada thistle Chicory Dalmation toadflax Diffuse knapweed Hoary cress (whitetop) Leafy spurge Musk thistle Sulfur cinquefoil
Class C:	Field bindweed Cheatgrass	Field bindweed Cheatgrass



Weed survey results at the STM. Illustration from Walsh



## 11.4 WETLANDS AND FLOODPLAINS

Floodplains are land areas adjacent to rivers and streams that are subject to recurring inundation. Wetlands are lands that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support distinct soil types and plant communities. Wetland areas typically take the form of swamps, marshes, bogs and groundwater seeps and are frequently located within or adjacent to a floodplain.

Both wetlands and floodplains play a key role in providing flood-water storage, reducing flood flow rate, and filtering floodwater. The resulting enriched floodplain soils promote the growth of wetland and riparian vegetation that provide habitat for a rich



Ephemeral pond, NWTC conservation management area. *Photo by Brenda Beatty, NREL/PIX 21687*

### 2011 Accomplishments and Highlights

- Vegetation surveys were performed at the NWTC and STM. This information will be used to guide campus development and weed management activities to protect wetland plant communities.
- A preliminary wetland assessment of the NWTC drainages was jointly conducted with the U.S. Army Corp of Engineers (USACE). In addition to serving as the basis for conducting wetland delineations and accurate mapping, this effort helps protect and potentially improve valuable wetland areas.
- As part of recent construction, improvements were made to STM's Middle Drainage, including widening the channel bottom, sloping the channel banks, and realigning the channel to more efficiently convey and store flood waters and prevent erosion.

diversity of terrestrial and aquatic plants and animals. NREL seeks to preserve the important natural functions of its wetlands and floodplains, thereby protecting the physical, biological and chemical integrity of receiving waters and riparian areas on and adjacent to STM and the NWTC.

NREL protects its wetlands and floodplains through several means including:

- Periodic vegetation surveys and wetland delineations
- Mapping of wetland areas potentially affected by proposed construction
- Identification of potential impacts
- Coordination with other jurisdictions on the control of floodwaters leaving NREL sites.

### PROGRAM MANAGEMENT

Wetlands became regulated in 1972 when, under the CWA, the definition of Waters of the United States was expanded from only those waters capable of supporting interstate or foreign commerce as defined under the Rivers and Harbors Act of 1899, to waters that also include tributaries to navigable waters, interstate wetlands, wetlands which could affect interstate or foreign commerce, and wetlands adjacent to other waters of the United States. Wetlands that meet certain soils, vegetation, and hydrologic criteria, are protected under the CWA Section 404, which is administered by the USACE, with program oversight provided by the EPA. Areas that do not meet the criteria above and do not fall within the jurisdiction of the Corps are not protected or regulated under Section 404. However, such areas may still perform wetland functions as described above and act as valuable ecologic components.

In 2009, the USACE visited the STM campus, after which they issued a jurisdictional determination stating that all drainages examined were considered upland swales and consequently are not regulated by the USACE. The jurisdictional determination, which is valid for a period of five years (through April 27, 2014), enables NREL to perform work in the upland swales without a USACE permit. As stated above, a preliminary wetland assessment and delineation was jointly conducted with the USACE on the NWTC site. A formal delineation will be submitted to the USACE in 2012 to obtain a jurisdictional determination for the NWTC.

Counties typically map the 100-year floodplain boundaries within their jurisdiction and then develop regulations that control the type and amount of development within those areas. Jefferson County has no 100-year floodplain boundaries that affect the NWTC or STM. However, the new south entrance to the STM campus, which is being constructed on county and private property adjacent to STM, is located in the Lena Gulch 100-year floodplain. Lena Gulch is a small tributary of Clear Creek. To do work in the floodplain, a Floodplain Development permit is required from Jefferson County and Urban Drainage and Flood Control District. In order to obtain the permit, one must determine how their project alters the floodplain and then develop a Conditional Letter

of Map Revision (CLOMR). Once approval is given the project can proceed. Once the project is completed, a final Letter of Map Revision (LOMR) is recorded.

Federal regulation 10 CFR 1022, Compliance with Floodplain and Wetlands Environmental Review Requirements, establishes policy and procedures for discharging DOE's responsibilities under E.O. 11988, Floodplain Management, and E.O. 11990. For projects that occur in floodplains or have the potential to affect wetlands, DOE must determine the potential impacts to the floodplain or wetlands, document this in a floodplain and wetland assessment, and complete notices of availability to appropriate government agencies (e.g., federal emergency management organizations and state and local governments) and to persons or groups known to be interested in or potentially affected by the proposed floodplain or wetland action. For such actions, DOE must also distribute the notification in the area where the proposed action is to be located (e.g., by publication in local newspapers). After the consideration of public and agency comments, the process concludes with the preparation of a Floodplain and Wetland Statement of Findings.

### 2011 COMPLIANCE SUMMARY AND ACTIVITIES

- Delineated regulatory wetlands adjacent to Lena Gulch that were impacted by the construction of a new south entrance to the STM campus. Bridge construction activities associated with the project resulted in the permanent loss of 0.25 acres along Lena Gulch. A USACE Nationwide Permit No. 14 for Linear Transportation Projects was obtained and this loss was mitigated through acquisition of wetland banking credits through the South Platte Wetlands Bank in Brighton, Colorado.
- A CLOMR was filed with Jefferson County with Urban Drainage and Flood Control District concurrence for bridge construction associated with the new south entrance road since a number of bridge elements such as abutments and headwalls would be in the floodplain. A letter of concurrence regarding the CLOMR was received on February 25, 2011. With Urban Drainage and Flood Control District approval, a Jefferson County Floodplain Development permit was obtained for the new south entrance bridge.
- A floodplain and wetland assessment was prepared to describe the potential floodplain and wetland impacts associated with the construction of the new south access road to the STM campus. Because the project would cross the 100-year floodplain of Lena Gulch and have the potential to affect wetlands in this same area, in accordance with 10 CFR 1022, a floodplain and wetland assessment was prepared and the public and federal and state agencies were notified of the availability of the assessment in May, 2011 via letter and newspaper advertisement. DOE determined that this project would not result in adverse impacts to the 100 year floodplain and impacts to wetlands were properly mitigated, as discussed above. Temporary disturbance within the floodplain will cease following completion of construction activities. Proper erosion and sediment control measures are being utilized and site

restoration will be done following completion of construction activity in 2012. DOE determined that the action would not result in any increase in the base flood elevations from the project conditions to post-project conditions or other long-term impacts to the floodplain and its functionality. No effects to lives and property associated with floodplain disturbance are anticipated. No substantive comments were received from the public or agencies, and a Floodplain and Wetland Statement of Findings was issued in June 2011.

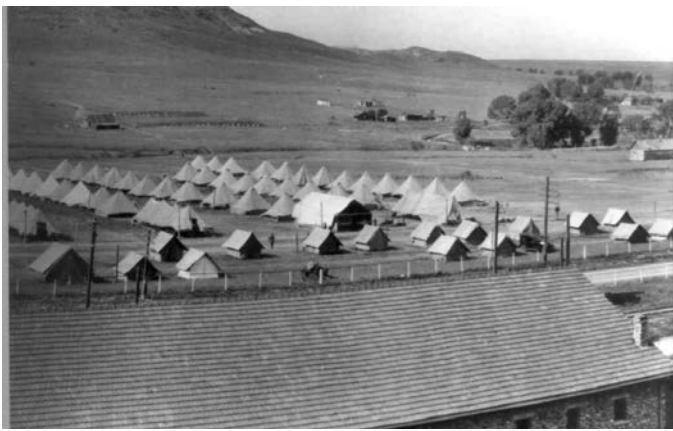
- This program was in compliance with all local and federal requirements.

### 11.5 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. NREL identifies and protects cultural resources in several ways:

- An established cultural resources program oversees preservation of artifacts that may be found at any of the NREL facilities.
- Surveys are periodically conducted to document presence or absence of cultural or historic resources, while considering project impacts to the human environment. When surveys reveal artifacts, staff work with the SHPO to determine if the artifacts are eligible for consideration as cultural or historic resources.
- Construction contractor site orientation training informs workers that in the event they discover any evidence of cultural resources during ground-disturbing activities at STM or the NWTC, workers are to stop all work in the vicinity until a qualified archaeologist evaluates the significance of the find.

The STM site has had a long history as a location with a variety of human uses over the decades. In 1903, the Colorado National Guard established the State Rifle Range at a location three miles east of Golden, Colorado. The site was designated as "Camp George West" in 1934 honoring civil war veteran and Golden business man, George West. George West was Adjutant General from 1887-1889 and editor and publisher of the Transcript newspaper in Golden, Colorado. He was credited as the first person to recommend this land parcel be used by the Colorado National Guard. This site became an integral part of Colorado National Guard activities throughout the first half of the 1900s. By the 1920s, the camp totaled 750 acres and many buildings were added throughout the 1930s and 1940s. During World War II, much of Camp George West was leased to the federal government for military training purposes. From the 1930s to the 1970s, several state entities took up residence at Camp George West, including the Colorado State Highway Courtesy Patrol, the Colorado Law Enforcement Training Academy, and the Colorado Correctional Center. In 1981, 300+ acres were transferred to the federal government for solar energy research purposes. An additional 25 acres was transferred to DOE in 2003. Today, the STM site totals 327 acres.



Encampment at Camp George West looking northeast toward STM. Used with permission from the Jefferson County Historical Society.

### PROGRAM MANAGEMENT

Cultural resources are protected under Section 106 of the NHPA of 1966, as amended. Significant cultural resources are either eligible for, or listed in, the National Register of Historic Places.

Cultural resources can be divided into three major categories:

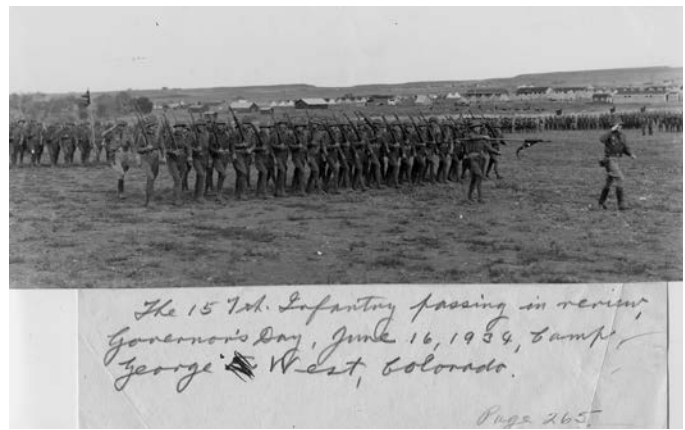
- Prehistoric and historic archaeological resources
- Architectural resources
- Traditional cultural resources.

Prehistoric and historic archaeological resources are locations where human activity measurably altered the earth or left deposits of physical remains (e.g., arrowheads, pottery, tools). Prehistoric resources that predate the advent of written records in a region range from a scatter composed of a few artifacts to village sites and rock art. Historic resources may include campsites, roads, fences, trails, dumps, battlegrounds, mines, and a variety of other features.

Architectural resources include standing buildings, dams, canals, bridges, and other structures of historic or aesthetic significance. Architectural resources generally must be more than 50 years old to be considered for protection under existing cultural resource laws. However, more recent structures, such as Cold War facilities, may warrant protection if they manifest the potential to gain significance in the future.

A traditional cultural resource can be defined as a property that is eligible for inclusion in the National Register of Historic Places because of its association with cultural practices or beliefs of a living community that are rooted in the community's history, and are important in maintaining the continuing cultural identity of the community. Traditional resources may include archaeological resources, buildings, neighborhoods, prominent topographic features, habitats, plants, animals, and traditional culture.

Three formal surveys of historic and cultural resources have been performed on the STM site. These surveys were completed in 1980, 1987, and 2003. Two additional limited surveys of the Camp George West District involving the STM site have also been conducted.



"Review" of the 157th infantry, 1934. Used with permission from the Denver Public Library.

Three historical sites were recognized as significant cultural resources that should be preserved. These resources include:

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

The three structures were constructed during the Works Progress Administration era in the 1930s. Through NREL's efforts, these structures have been added to the National Register, with the amphitheater and stone footbridge listed together as a single resource.

The Camp George West Historic District, also listed on the National Register of Historic Places, includes the 25-acre parcel of the STM site south of Denver West Parkway. Two types of contributing historic archaeological resources have been identified on this parcel: firing range lines and a low rock wall. Contributing resources are those features within a historic district that contribute to the district's overall eligibility for the National Register.

### 2011 COMPLIANCE SUMMARY AND ACTIVITIES

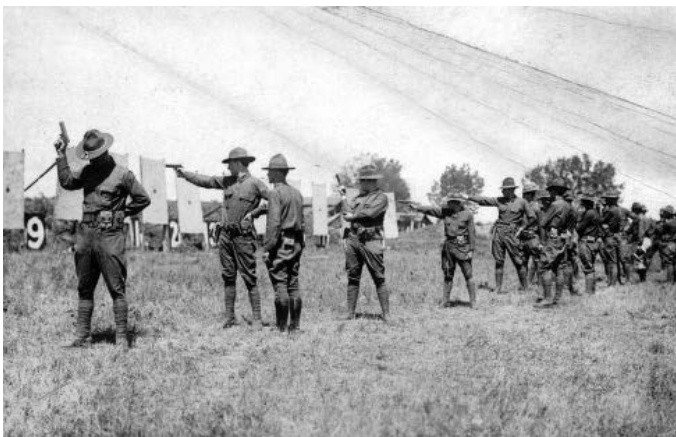
- All program activities were in compliance with requirements.
- Construction activities were completed on the new addition to the RSF. During preliminary excavations, a few items were unearthed that were reviewed for cultural significance, though none were found to be of unique value.
- In 2010, a Class III Cultural Resource Inventory was completed on the final configuration of the new south entrance to STM, which lies within the Camp George West Historic District. SHPO concurred that construction would impact a 500-yard firing line and a 600-yard firing line, both of which are contributing features of the Camp George West Historic District, and that impacts should be mitigated. In 2011, DOE signed a memorandum of agreement with the SHPO to mitigate impacts to these features and an interpretive sign will be placed in Pleasant View Community Park.





Open-air amphitheater on the STM Site. Photo by Warren Gretz, NREL/PIX 12596

- In 2009, DOE signed a memorandum of agreement with the SHPO for the removal of a 200-yard firing line, a 300-yard firing line, and a target area as part of the construction of a new surface parking lot. As mitigation, DOE was required to prepare a Historic American Buildings Survey Historic American Engineering Record (HABS/HAER) report prior to the removal of the firing lines and target area. In addition to these required actions, the 300-yard firing line was salvaged and moved in 2011 to the new stormwater detention feature at the STM campus. Now the firing line is a prominent feature of an interpretive trail surrounding the stormwater detention area. In addition, an interpretive sign will provide a brief description of the firing line.



Pistol range at Camp George West. Used with permission from the Denver Public Library.

## 12 Conservation Easement Lands

In 1999, DOE granted a conservation easement for 177 acres of the STM site to Jefferson County. The purpose of the easement is to preserve the natural character of the property, including its visual, biological, and recreational resources, especially in relation to the changing land uses adjacent to the NREL site and within the region.

The goals of the easement are to:

- Retain, preserve, and protect natural, scenic, ecological, and historical aspects of the conservation easement property
- Protect the ecosystem of the STM area and the sustainable habitat for diverse vegetation, birds, and terrestrial animals
- Ensure the scenic and biological integration with adjoining open-space land
- Prevent further industrial, commercial, or residential development of the conservation easement property
- Preserve the conservation easement property as natural open space.

A baseline inventory of the property was prepared in June 1999 to document the current condition of the easement property and to assess the conservation value of the property<sup>5</sup>. The baseline inventory includes a description of the geographical setting and adjacent property owners, access and use of the property by the public, and a description of the existing environmental conditions of the property (including geology, hydrology, vegetation, wildlife, and cultural resources).

Jefferson County Open Space maintains formal trails on the conservation easement property. Two trails cross the easement, connecting Denver West Parkway (near the NREL site entrance) to the trails on the mesa top. NREL staff and the public use these trails daily.

### 2011 PROPERTY ASSESSMENT

During 2011, there was no NREL activity on the conservation easement property having the potential to degrade the environmental condition of the property. Jefferson County Open Space conducted a site inspection and no degraded conditions or other environmental issues were found.

<sup>5</sup>U.S. Department of Energy, Golden Field Office (1999). *National Renewable Energy Laboratory (NREL) Site Conservation Easement Baseline Inventory*. Golden, Colorado.

## 13 Traffic Management

The STM campus draws hundreds of commuter vehicles daily, as well as visitor and delivery traffic coming to and leaving the site. NREL continued to bring staff on-site, moving them into offices in the RSF building throughout 2011. However, many of those staff were parking in off-site parking locations while on-site parking was being constructed. Traffic management for the site is important for minimizing negative impacts to traffic flow on Denver West Parkway and in nearby neighborhoods and business areas. Reducing traffic also reduces noise and light pollution, vehicle emissions, fuel use, parking requirements, and road maintenance costs.

The laboratory seeks to reduce traffic by encouraging:

- Alternative modes of commuting, such as mass transit, ride-sharing (carpool and vanpool), and bicycling
- Telecommuting one or more days per week
- Flexible shifts and alternate work schedules
- Teleconferencing, videoconferencing, and web-based tools for conducting meetings and trainings remotely.

### 2011 Accomplishments and Highlights

- Conducted a commuting survey of employees to identify commuting methods and measure the effectiveness of previous traffic reduction efforts. Key results include:
  - Twenty-five percent of staff currently work AWSs.
  - Nineteen percent of staff telecommute one time per week and 5% telecommute at least two times per week.
  - Twenty-five percent of staff daily commute trips were made with alternative transportation, up 8% from 2007. The table, Commuter Habits Comparison, shows the results of the commuter survey.
- NREL's telecommuting program was implemented laboratory-wide in 2011.

Periodic traffic monitoring at the STM site provides information regarding total traffic volumes and peak vehicle trips. Baseline traffic levels were established prior to moving increased numbers of staff to STM and traffic has been monitored during 2011 to measure changes in traffic volumes to better inform traffic management.

Traffic analysis is periodically performed to measure NREL-generated traffic volumes, as well as volumes at the Denver West Parkway/Marriott Boulevard (DWP/DWMB) intersection and the Quaker St./South Golden Road intersection. Monitoring is conducted to confirm that traffic flow has not degraded to an unacceptable level. Monitoring will continue to be conducted as additional staff are relocated to STM.

Capacity improvements and the addition of a right-turn lane at the DWP/DWMB intersection are planned for the near future. The planned capacity improvements will increase acceptable peak hour thresholds. An additional entrance to the STM site is anticipated to be completed in May 2012, at which point it is expected that traffic volumes using the east entrance will substantially decrease, shifting a portion of volume to the new south entrance.

### PROGRAM MANAGEMENT

A mitigation action plan (MAP), finalized in May 2008, was developed to address potential environmental impacts from changes in traffic at STM and to support an EA FONSI for several projects at the laboratory. The MAP specifies the methods for implementing mitigation measures to ensure that the impacts of continued and expanded laboratory operations are not significant. The MAP requires that:

- The DWP/DWMB intersection operates at a LOS of D or better.

### COMMUTER HABITS COMPARISON, 2007 TO 2011

Mode	2007 Survey	2011 Survey	Change
Drove Alone	81 %	75%	-8%
Bicycle	3%	4%	+1%
Transit (bus)	6%	7%	+1%
Carpool/Vanpool	6%	8%	+2%
Walk	2%	1%	-1%
Telecommute	1%	5%	+4%
Other	1%	1%	0%

- The Quaker St./South Golden Road intersection operates at a LOS of D or better.
- Traffic flow to and from the STM east entrance will be monitored semi-annually.
- A report on the implementation and effectiveness of the STM traffic mitigation measures will be published in the NREL Annual Site Environmental Report.

The MAP also identified specific mitigation strategies to be implemented as needed to ensure that the traffic thresholds are not exceeded. These actions include TDM strategies such as AWSs, expanded shuttle services, expanded carpools, encouraging walking and bicycling, increased use of the Quaker St. entrance, infrastructure improvements, and traffic flow control measures. The TDM measures implemented are described below.:

### Alternative Modes of Commuting

- Eco Passes provided to employees encourage use of the RTD public transportation system. This includes unlimited RTD regional, express, local, light rail, and Call-n-Ride services.
- Shuttle routes provide connections between NREL facilities in Golden and three regional RTD transit stations in Lakewood, Wheat Ridge, and Boulder.
- Incentive parking is provided for vanpools and carpools at STM, Golden Hill and Denver West sites.
- Vanpool subsidies are available for participants who commute in formal organized vanpools.
- Bike racks and bicycle maintenance stations are in key locations on the STM site. Bike racks on shuttle vehicles permit staff to take their bikes with them when they commute or move between buildings.
- RideShare Connections intranet site allows staff to post and search listings for potential carpool and vanpool partners within NREL.
- Literature kiosks in key building locations provide shuttle and RTD schedules, bicycle maps, and telecommuting information.
- Information sharing events promote safe bicycling, rideshare (carpool and vanpool) and RTD services.

### Flexible Workplace Practices

Conferencing by video, telephone, and the internet as well as Alternative Work Schedules (AWS) provide flexibility in how people work, saving staff time, energy, and money. An AWS policy allows employees to work varying schedules (with management approval), including four-day workweeks, reduces the miles driven by employees to and from the laboratory.

### Telecommuting

A pilot telecommuting program initiated in the fall of 2009 was opened laboratory-wide in the first quarter of 2011. Laboratory-wide employee surveys have confirmed that adoption of this program has been very strong.

### Teleconferencing

The laboratory promotes and encourages use of teleconferencing and videoconferencing for meetings to decrease local vehicle trips and air travel.

### 2011 COMPLIANCE SUMMARY AND ACTIVITIES

- All program activities were in compliance with requirements.
- Transportation on Demand (TDM) management measures required by the MAP were continued in 2011.
- PM Peak Hour traffic averages at the DWP/DWMB intersection were 260 vehicle trips. The monitoring period was October 2010 through April 2011. The MAP threshold of LOS D or better is equivalent to a maximum of 387 vehicle trips per hour entering or leaving the site at the east entrance at the afternoon rush hour.
- PM peak hour LOS at the DWP/DWMB intersection was at LOS B, which does not exceed the MAP threshold of LOS D or better.
- PM peak hour LOS at the Quaker St./South Golden Road intersection was at LOS B, which does not exceed the MAP threshold of LOS D or better.

### Detailed Traffic Metrics and Results

Previously conducted traffic studies indicated that the greatest impact to traffic in the local area from NREL activities occurs between 4:30 p.m. and 5:30 p.m. This hour has been designated the PM Peak Hour. Solar powered radar traffic counters were installed at the east (main) entrance to the STM site in June 2010. The counters continually recorded traffic volumes coming to and leaving the sites to monitor traffic as it relates to the MAP threshold. Traffic counts for the PM peak hour were extracted from the complete dataset for the recording period and compared against the MAP threshold. The MAP threshold indicates the amount of traffic that would cause degradation to the LOS at the DWP/DWMB intersection.

The figure on page 74 shows the median hourly distribution of traffic counts at the east entrance to STM by hour during a six week monitoring period in February and March 2011. The allowable threshold and the median traffic flow volumes are indicated on the figure.

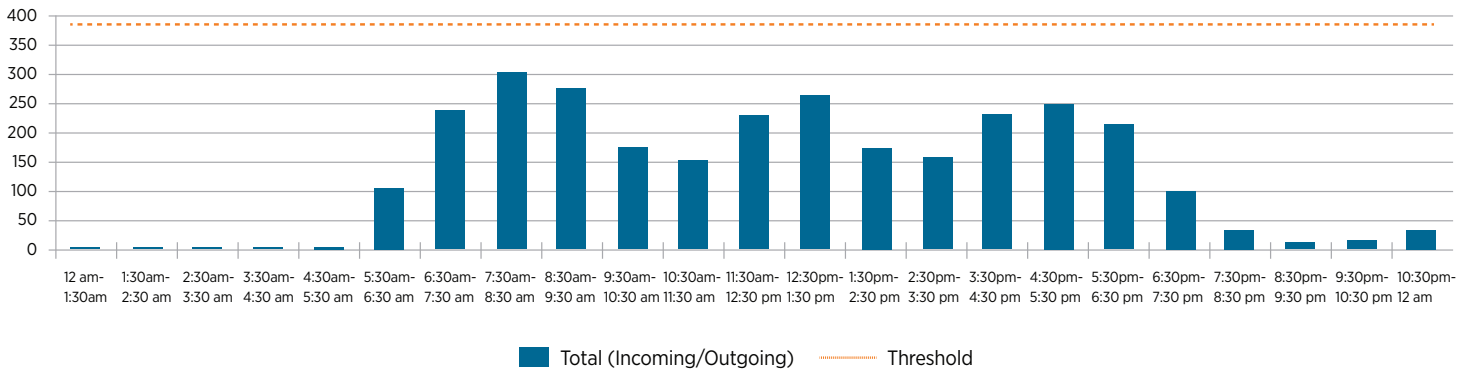
The applicable traffic volume threshold identified in the MAP is 387 vehicle trips in the PM Peak Hour (from 4:30 p.m. to 5:30 p.m.) at the DWP/DWMB intersection. This threshold identifies the acceptable number of vehicle trips NREL can contribute to the intersection without causing significant degradation to flow. In 2011, PM Peak Hour traffic volume averages remained below the MAP threshold.

- PM Peak Hour Average (average for six months from October 2010 to April 2011) = 260 vehicle trips

A summary of the PM peak hour volumes for each weekday is presented in the table on page 74.

## Median Hourly Distribution

During 6 Week Monitoring Period in February 2011 to March 2011



Traffic Counts by Time of Day at the East Entrance to STM.

In April 2011, the radar traffic counters were relocated to accommodate new signage at the east site entrance. As a result of the relocation, traffic data was inaccurate and unusable for the period May 2011 through December 2011.

In December 2011, in order to confirm that traffic counts had not increased to the point of degrading the LOS at the key

intersections identified in the MAP, traffic analyses were conducted at the DWP/DWMB and Quaker St./South Golden Road intersections. The results indicate:

- The LOS at the DWP/DWMB intersection is at LOS B during the PM peak hour. LOS B is within the MAP allowed service levels.
- The LOS at the intersection of Quaker St. and South Golden Road is at LOS B during the PM peak hour. LOS B is within the MAP allowed service levels.

The analysis indicates that while NREL traffic volumes have increased, LOS remains at acceptable levels. The analysis also shows that background traffic has not substantially increased. This suggests that the NREL generated PM peak hour traffic volume thresholds identified in the MAP could be adjusted to better reflect current conditions. PM peak hour traffic thresholds could be increased from 387 vehicle trips per hour to 747 trips per hour while still maintaining an acceptable LOS.

### SUMMARY OF PM PEAK TRAFFIC FLOWS, VEHICLE TRIPS IN PM PEAK HOUR

Statistics for Total PM Peak Hour (4:30 p.m. to 5:30 p.m.) October 2010 through April 2011

	Mon.	Tue.	Wed.	Thu.	Fri.	Weekday
Average	263.0	278.1	275.5	261.7	220.8	259.8

## Appendix A: Plant Communities at STM and the NWTC

In 2011, vegetation surveys were completed for STM and the NWTC. Plant communities and species were identified for each of the sites. Changes in results from similar surveys completed in 2000 are noted.

### STM PLANT COMMUNITIES

The majority of vegetation at STM belongs to the grassland community type. Within that association, there are two distinct community types: short-grass grassland on the mesa top and mixed-grass grassland located on the slopes and toe area. Other mapped vegetation communities at STM include ravine shrubland, tall shrubland, short shrubland, and wetlands. The plant communities are described below and mapped as illustrated in the figure below.

### SHORT-GRASS GRASSLAND

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

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

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

### MIXED-GRASS GRASSLAND

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

A few patches of anomalous vegetation occur within the mixed-grassland where subsurface water appears to be close to the surface. These areas support wide swaths of mat muhly (*Muhlenbergia richardsonis*). One is located on a southern-facing slope, near the eastern property boundary. The other is located on a southwestern-facing slope of the ravine north of the Visitor Center. This area is notable for a large population of poison ivy (*Toxicodendron rydbergii*), which grows in thickets of tall (*one meter and larger*) plants that have a woody, shrub-like growth form. A small number of plains cottonwood (*Populus deltoides*) saplings, skunkbrush, chokecherry, and snowberry occur in this patch as well.

The mixed-grass areas grade into both the upland and ravine shrublands and contribute the majority 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 have been planted and have subsequently spread into the mixed-grass community.

### UPLAND SHRUBLANDS

Shrubland habitat occurs along the upper sides of ravines, and on the steeper mesa slopes, becoming 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 very similar in overall composition but distinguished by the dominant species.

### TALL SHRUBLAND

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

### SHORT SHRUBLAND

The short shrublands occur on elevated flat areas amidst the surrounding grasslands, some of which appear to have experienced surficial disturbance in the past. These areas are distinctive because of their dominance by rubber rabbitbrush. The other common location for short shrublands is on the outer slopes of the ravines. Skunkbrush defines these and other short shrublands along the upper portions of the steepest slopes of the mesa. These communities usually grade into the ravine shrublands along the

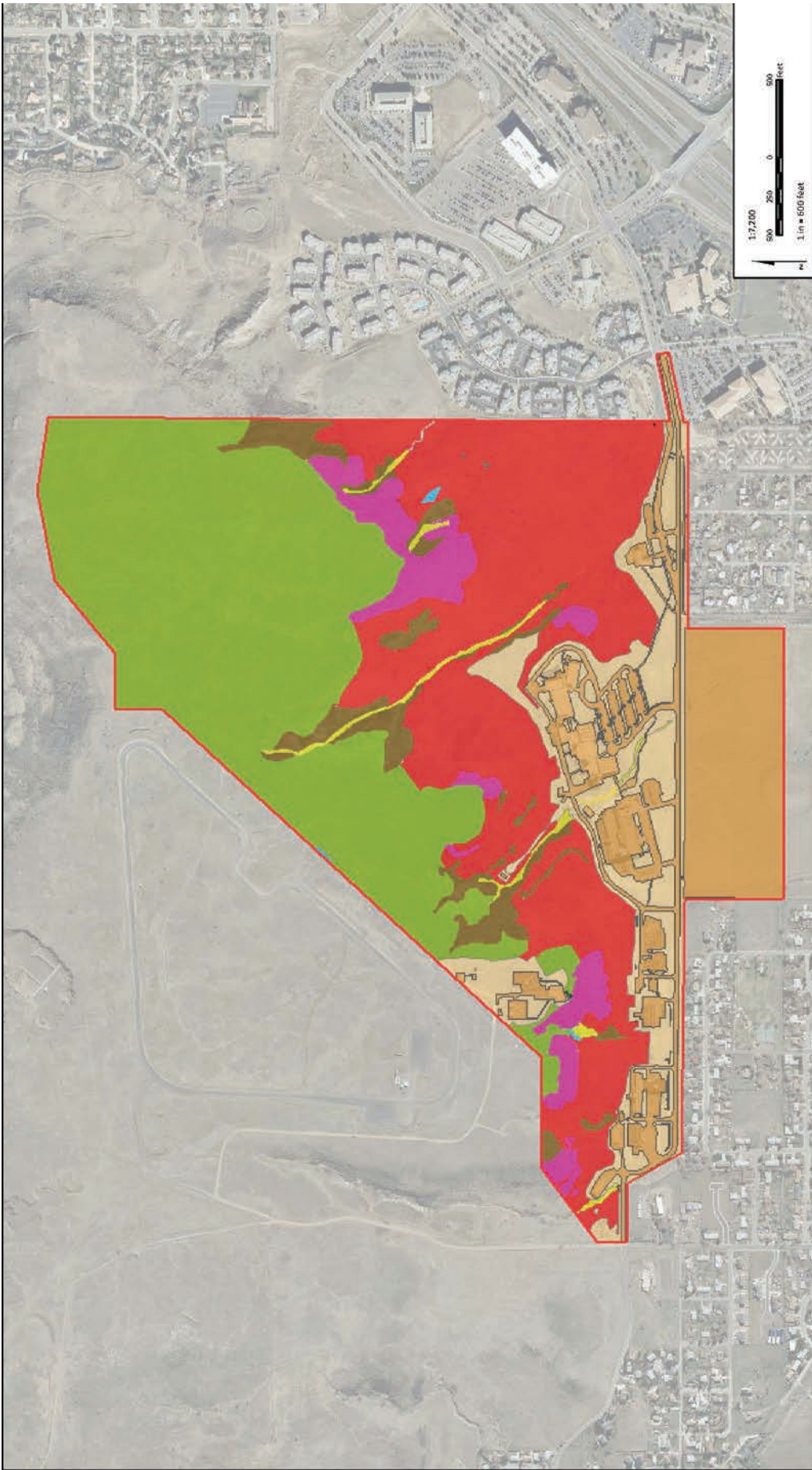


Figure 3. Vegetation Map,  
NREL South Table Mountain Site,  
2010 and 2011

- STM Boundary
- Buildings/Roads/Structures
- Disturbed Areas
- Plant Communities
  - Mixed-Grass Grassland
  - Ravine Shrublands
- Short-Grass Grassland
- Short Shrubland
- Tall Shrubland
- Wetlands



Vegetation survey results at STM. Illustration from Walsh

drainage bottoms and the tall shrublands near the top of the mesa slopes. The short shrubland community also has a sparse understory of the same grasses and forbs as the tall shrub community.

### **RAVINE SHRUBLANDS**

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

### **WETLANDS**

Five very small communities on the STM site were found to support wetland vegetation. These communities were not examined for the soils and hydrology that would classify them as functioning wetlands; rather they are noted only for their domination by wetland vegetation. These are limited to very small areas (less than half an acre in total). One is in a shallow swale at the mouth of the ravine at the southwestern corner of the project boundary where surface water and/or subsurface drainage have created a pocket of saturated soil. Species here include sedges (*Carex spp.*), rushes (*Juncus spp.*), bulrush (*Schoenoplectus sp.*), and peach-leaf willow. The second wetland could have 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 solar facility. Perhaps where equipment was once staged, this area appears to hold seasonal water for enough consecutive growing seasons to support some wetland vegetation including arctic rush (*Juncus arcticus*), American speedwell (*Veronica americana*), and broadleaf cattail (*Typha latifolia*).

The wetland at the mouth of the ravine may no longer experience the hydrology that originally allowed these plants to establish there. In 2002, this plant community supported populations of cattails that were not observed in 2010.

Three small seeps are located on the hill slope between the Visitor Center and the public trail on the far eastern boundary of the site. These seeps are dominated with sedges, rushes, and Canada thistle (*Cirsium arvensis*).

A seventh wetland community that was observed by Plantae in 2000<sup>7</sup>, no longer appears to support wetland vegetation. In 2002, cattail species near an old stock tank in the eastern-most drainage appeared to have been supported by a pipe coming out of the hillside. Although the stock tank was observed in 2010, it appears the cattails have not persisted in the intervening years.

### **DISTURBED/RECLAIMED**

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

### **NWTC PLANT COMMUNITIES**

The majority of the vegetation at the NWTC site 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 tall-grass or true prairie such as big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and prairie dropseed (*Sporobolus heterolepis*), with species more typical of the short-grass prairie such as blue grama (*Chondrosium gracile*) and buffalo grass (*Buchlōe dactyloides*). Intermediate grasses (mid-grasses) such as the needle grasses (*Hesperostipa* and *Nassella spp.*), wheat grasses (*Pascopyron*, *Agropyron*, *Elytrigia*, *Elymus*, and *Thinopyrum spp.*), and blue grasses (*Poa spp.*) are also important constituents of mixed-grass prairie.

The grasslands at the NWTC fall into the xeric mixed grassland community type identified and classified primarily on available soils and soil moisture, reflected in xeric mixed grassland plant species assemblages.

A number of changes in vegetation patterns noted since the NWTC site was previously mapped (DOE 1998<sup>6</sup>, Plantae 2000<sup>7</sup>) are discussed by specific plant community below.

The plant communities are described below and mapped as illustrated in the figure below.

### **XERIC MIXED GRASSLAND**

Xeric mixed grassland is by far the largest and most widespread community type at the NWTC site. These areas do not have access to regular soil moisture (xeric conditions) and are dominated by typical short- and mixed-grass prairie species. This plant community includes a large variety of native grass species as well as a diverse forb component, typical of mixed grasslands. Dominant species noted include big bluestem, little bluestem, and prairie dropseed, blue grama, and buffalo grass. Intermediate grasses (mid-grasses) such as the needle grasses, wheat grasses, and blue grasses are also important constituents of mixed-grass prairie. Species flowering in late spring include little bluestem, cheatgrass, sand lily (*Leucocrinum montanum*), wild iris (*Iris missouriensis*), Lambert locoweed (*Oxytropis lambertii*), mouse-ear (*Cerastium strictum*), western wallflower (*Erysimum capitatum*), and prairie golden pea (*Thermopsis rhombifolia*).

### **MESIC MIXED GRASSLAND**

A distinctive single area dominated by big bluestem was mapped as mesic mixed grassland in the southwestern portion of the

<sup>6</sup> U.S. Department of Energy (1998). *Environmental Assessment, Right-of-Way Easement for Public Service Company of Colorado at the South Table Mountain Site, Golden, Colorado*. DOE/EA-1254.

<sup>7</sup> Plantae Consulting Services (2000). *Vegetation Survey, NREL National Wind Technology Center*. Boulder, Colorado.



**Figure 1. Vegetation Mapping at the National Renewable Energy Laboratory, National Wind Technology Center, 2010 and 2011**

- NWTC boundary
- Ephemeral Drainage
- Prairie Dog Relocation Area
- Building/Road/Structure
- Conservation Management Areas
- Plant Communities
- Palustrine Emergent Wetland
- Disturbed
- Riparian Fringe Wetland
- Groundwater Seep Wetland
- Mesic Mixed Grassland
- Ornamental Trees and Shrubs
- Ponderosa Pine Woodland
- Seasonal Pond
- Upland Shrubland
- Xeric Mixed Grassland



Vegetation mapping at the NWTC. Illustration from Walsh



NWTC site by Plantae in 2000. The relative size of the area, as well as the complete dominance of big bluestem, was distinctive enough to designate this community in the current survey as well. Dominant species noted include big bluestem, smooth brome, Canada thistle (*Cirsium arvense*), and Canada bluegrass (*Poa compressa*). Species flowering in late spring include lambert locoweed.

### **PONDEROSA PINE WOODLAND**

One woodland habitat, defined by a single community, the ponderosa pine (*Pinus ponderosa*) woodland, occurs in the northwestern corner of the site along a granite outcrop. This small area supports a very diverse native plant community including common grassland and foothills species, as well as a number of introduced and noxious weeds. Dominant species noted include ponderosa pine (*Pinus ponderosa*), smooth brome, crested wheatgrass, and green needlegrass (*Nassella viridula*). Species flowering in late spring include sand lily, western snowberry (*Symphoricarpos occidentalis*), groundsel (*Senecio sp.*), and wax current (*Ribes cereum*).

### **UPLAND SHRUBLAND**

A small upland shrub community is located to the southeast of the ponderosa pine woodland, where the same ridge arises to a lesser degree from the surrounding grassland community. This rocky ridge supports shrub species interspersed with grasses and forbs representative of the surrounding grasslands. Dominant species noted include western snowberry, Canada wild rye (*Elymus canadensis*), Canada bluegrass, Kentucky bluegrass (*Poa pratense*), and little bluestem. Species flowering in late spring include prairie goldenpea.

An isolated group of hawthorn (*Crataegus erthyropoda*) shrubs occurs along the western site boundary, within the NWTC site boundary. These trees are at the top of the slope and occur directly east of an active area of construction disturbance, which is outside the NWTC site boundary.

### **PALUSTRINE EMERGENT WETLAND**

Two wetlands on the site fall into the palustrine emergent category. The first is a linear depression on the southern side of the south road. This area appears to have developed as the result of soil excavation intercepting sufficient surface water run-off from the adjacent road to support sedge species (*Carex spp.*). A second wetland is located on the southern boundary in an area previously disturbed from the neighboring industrial activities. This wetland comprises a center of cattails (*Typha angustifolia*) surrounded by a stand of coyote willow (*Salix exigua*).

Two palustrine emergent wetlands were mapped in the mesic mixed grassland in the 2000 growing season. These areas appear to have dried considerably in the intervening ten years. The small wetland pockets of cattails (*Typha spp.*) that occurred in the southern portions of this area are no longer present, apparently replaced, by large stands of Canada thistle. Dead remnants of

Baltic rush (*Juncus balticus*) can be found in the area litter (prior years' herbaceous vegetation). The dominant species noted was smooth brome.

### **HEADWATER WETLAND**

Areas of headwater wetland occur along the two ephemeral drainages on the NWTC site. Both drainages occur in the northeastern portion of the site, one flowing east and one flowing north. Both show evidence of intermittent surface flow. The northern-most drainage is a tributary of Coal Creek and the second drainage is a tributary to Rock Creek.

Surface flow in the drainage to the northeast appears to be augmented by outflow from the groundwater seep wetland on the western bank. The second and larger drainage conducts surface flows through the center of the site off to the eastern fence line. The upper reaches of this drainage are a shallow grassland swale (also shown in the NWTC weed map). This channel deepens as it flows east across the site. At its eastern reaches, this drainage clearly intercepts subsurface water, although not in sufficient quantities to produce consistent surface flow. At the point where this drainage leaves the NWTC site, there is a human-constructed rock wall. Dominant species noted include Canada thistle, Baltic rush, curly dock (*Rumex crispus*), common evening-primrose (*Oenothera villosa*), smooth brome, and western wheatgrass (*Pascopyrum smithii*).

### **GROUNDWATER SEEP WETLAND**

Two areas of groundwater seep wetland are located on the NWTC site. The first occurs west of the ponderosa pine woodland, in the northwestern portion of the site along the northern fenceline. The species in and surrounding this draw comprise more upland species than noted in 2000.

The second occurs over a very small area on the banks of the northern drainage. This community is a clearly demarcated area of primarily wetland plants amidst the surrounding grassland. Fifty plant species were identified in this community in 2000, many of which also occur in the headwater wetland to the south. Dominant species noted include sedges (*Carex sp.*) and rushes (*Juncus sp.*). Common teasel (*Dipsacus fullonum*) has invaded the northern drainage area. Species flowering in late spring include common teasel, showy milkweed (*Asclepias speciosa*), wild iris, fieldmint (*Mentha arvensis*) and Canada thistle.

### **SEASONAL POND**

A seasonal pond and pond margin occur at the northwestern corner of the site, west of the southern terminus of the ponderosa pine woodland. This area appears to depend on an elevated spring and early summer water table for the hydric soil moisture conditions that support this community. Observers have noted that the pond depression often contains standing water in the spring and early summer in some years<sup>8</sup>. However, no standing water was observed in this area during the most recent survey. These drier soil conditions are reflected in a shift of dominant plant species in

<sup>8</sup> Plantae Consulting Services (2000). Vegetation Survey, NREL National Wind Technology Center. Boulder, Colorado.

this community between the 2000 and 2011 surveys. Dominant species noted include curly dock, Canada bluegrass, smooth brome grass, and Canada thistle.

### Disturbed

These plant associations reflect surface disturbance due to human activities on the site. These areas include roadsides, pad sites, parking lot perimeters, construction sites, and storage areas. Some of these areas have been revegetated and now include a combination of species from surrounding natural plant communities, reclamation species, and adventive (non-native) or ruderal (native or adventive, disturbance colonizer) species. Dominant species noted include smooth brome grass and cheat grass.

### Ornamental Trees/Shrubs

Disturbed areas around buildings have been planted with a combination of native and ornamental trees and shrubs. The 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.

The following are lists of common and scientific names of wildlife species observed at STM and the NWTC. The species for the NWTC were identified during surveys completed in 2011. The species listed for STM were observed by staff and/or observed in surveys completed in 1987, 2005, and 2011.

## Appendix B: Wildlife Species Observed at STM and the NWTC

### WILDLIFE SPECIES AT THE STM

SPECIES COMMON NAME	SCIENTIFIC NAME	Seen in 1987 Survey	Seen in 2005 Survey	Seen in 2011 Survey	Observed at other times
<b>BIRDS</b>					
American crow	<i>Corvus brachyrhynchos</i>		X	X	
American goldfinch	<i>Carduelis tristis</i>			X	
American kestrel	<i>Falco sparverius</i>	X	X	X	
American pipit	<i>Anthus rubescens</i>			X	
American redstart	<i>Setophaga ruticilla</i>			X	
American robin	<i>Turdus migratorius</i>	X	X	X	
American tree sparrow	<i>Spizella arborea</i>		X	X	
American white pelican	<i>Pelecanus erythrorhynchos</i>			X	
Bald eagle	<i>Haliaeetus leucocephalus</i>				X
Barn swallow	<i>Hirundo rustica</i>			X	
Black-billed magpie	<i>Pica hudsonia</i>	X	X	X	
Black-capped chickadee	<i>Poecile atricapilla</i>		X		
Black-crowned night heron	<i>Nycticorax nycticorax</i>		X		

## WILDLIFE SPECIES AT THE STM

SPECIES COMMON NAME	SCIENTIFIC NAME	Seen in 1987 Survey	Seen in 2005 Survey	Seen in 2011 Survey	Observed at other times
Black-headed grosbeak	<i>Pheucticus melanocephalus</i>			X	
Blue-gray gnatcatcher	<i>Polioptila caerulea</i>			X	
Blue jay	<i>Cyanocitta cristata</i>		X	X	
Brewer's blackbird	<i>Euphagus cyanocephalus</i>	X		X	
Brewer's sparrow	<i>Spizella breweri</i>			X	
Broad-tailed hummingbird	<i>Selasphorus platycercus</i>			X	
Broad-winged hawk	<i>Buteo platypterus</i>			X	
Brown-headed cowbird	<i>Molothrus ater</i>	X	X	X	
Bullock's oriole	<i>Icterus bullockii</i>		X	X	
Bushtit	<i>Psaltriparus minimus</i>			X	
California gull	<i>Larus californicus</i>		X		
Canada goose	<i>Branta canadensis</i>		X	X	
Cedar waxwing	<i>Bombycilla cedrorum</i>			X	
Cassin's kingbird	<i>Tyrannus vociferans</i>			X	
Chestnut-collared longspur	<i>Calcarius ornatus</i>			X	
Chipping sparrow	<i>Spizella passerina</i>			X	
Cliff swallow	<i>Petrochelidon pyrrhonota</i>			X	
Common grackle	<i>Quiscalus quiscula</i>			X	
Common nighthawk	<i>Chordeiles minor</i>	X	X	X	
Common raven	<i>Corvus corax</i>		X	X	
Common snipe	<i>Gallinago delicata</i>		X		

## WILDLIFE SPECIES AT THE STM

SPECIES COMMON NAME	SCIENTIFIC NAME	Seen in 1987 Survey	Seen in 2005 Survey	Seen in 2011 Survey	Observed at other times
Cooper's hawk	<i>Accipiter cooperii</i>		X	X	
Dark-eyed junco	<i>Junco hyemalis</i>		X	X	
Double-crested cormorant	<i>Phalacrocorax auritus</i>			X	
Downy woodpecker	<i>Picoides pubescens</i>				
Eastern kingbird	<i>Tyrannus tyrannus</i>			X	
Eurasian collared dove	<i>Streptopelia decaocto</i>				X
European starling	<i>Sturnus vulgaris</i>	X	X	X	
Golden eagle	<i>Aquila chrysaetos</i>		X		
Grasshopper sparrow	<i>Ammodramus savannarum</i>			X	
Great blue heron	<i>Ardea herodias</i>		X	X	
Green-tailed towhee	<i>Pipilo chlorurus</i>			X	
Hepatic tanager	<i>Piranga flava</i>			X	
Hermit thrush	<i>Catharus guttatus</i>			X	
Horned lark	<i>Eremophila alpestris</i>	X		X	
House finch	<i>Carpodacus mexicanus</i>		X	X	
House sparrow	<i>Passer domesticus</i>		X	X	
House wren	<i>Troglodytes aedon</i>			X	
Killdeer	<i>Charadrius vociferous</i>	X	X	X	
Lark bunting	<i>Calamospiza melanocorys</i>	X	X		
Lark sparrow	<i>Chondestes grammacus</i>			X	
Lazuli bunting	<i>Passerina amoena</i>			X	
Lesser goldfinch	<i>Carduelis psaltria</i>			X	

## WILDLIFE SPECIES AT THE STM

SPECIES COMMON NAME	SCIENTIFIC NAME	Seen in 1987 Survey	Seen in 2005 Survey	Seen in 2011 Survey	Observed at other times
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		
Osprey	Pandion haliaetus		X		
Peregrine falcon	Falco mexicanus			X	
Pine siskin	Carduelis pinus			X	
Prairie falcon	Falco mexicanus		X		
Red-breasted nuthatch	Sitta canadensis		X		
Red-tailed hawk	Buteo jamaicensis	X	X		
Red-winged blackbird	Agelaius phoeniceus	X			
Rock dove	Columba livia		X		
Rock wren	Salpinctes obsoletus		X		
Ruby-crowned kinglet	Regulus calendula			X	
Sage thrasher	Oreoscoptes montanus			X	
Say's phoebe	Sayornis saya		X		
Sharp-shinned hawk	Accipiter striatus			X	

## WILDLIFE SPECIES AT THE STM

SPECIES COMMON NAME	SCIENTIFIC NAME	Seen in 1987 Survey	Seen in 2005 Survey	Seen in 2011 Survey	Observed at other times
Spotted towhee	<i>Pipilo maculatus</i>		X		
Swainson's hawk	<i>Buteo swainsoni</i>		X		
Tree swallow	<i>Tachycineta bicolor</i>		X	X	
Turkey vulture	<i>Cathartes aura</i>		X		
Vesper sparrow	<i>Poocetes gramineus</i>		X		
Virginia's warbler	<i>Oreothlypis virginiae</i>				
Violet-green swallow	<i>Tachycineta thalassina</i>			X	
Western kingbird	<i>Tyrannus verticalis</i>	X	X		
Western meadowlark	<i>Sturnella neglecta</i>	X	X		
Western scrub-jay	<i>Aphelocoma californica</i>		X		
White-crowned sparrow	<i>Zonotrichia leucophrys</i>		X		
White-faced ibis	<i>Plegadis chihi</i>			X	
White-throated swift	<i>Aeronautes saxatalis</i>			X	
Yellow-breasted chat	<i>Icteria virens</i>			X	
Yellow-rumped warbler	<i>Dendroica coronata</i>			X	

## MAMMALS

Black-tailed jackrabbit	<i>Lepus californicus</i>	X		X	
Bushy-tailed woodrat	<i>Neotoma cinerea</i>	X			
Coyote	<i>Canis latrans</i>	X	X	X	
Deer mouse	<i>Peromyscus maniculatus</i>	X		X	
Fox squirrel	<i>Sciurus niger</i>		X		
Long-tailed weasel	<i>Mustela frenata</i>		X		

## WILDLIFE SPECIES AT THE STM

SPECIES COMMON NAME	SCIENTIFIC NAME	Seen in 1987 Survey	Seen in 2005 Survey	Seen in 2011 Survey	Observed at other times
Mexican woodrat	<i>Neotoma mexicana</i>		X	X	
Mountain cottontail	<i>Sylvilagus nuttalli</i>	X	X	X	
Mule deer	<i>Odocoileus hemionus</i>	X	X	X	
Prairie vole	<i>Microtus ochrogaster</i>	X	X		
Raccoon	<i>Procyon lotor</i>	X	X	X	
Red fox	<i>Vulpes vulpes</i>	X		X	
Striped skunk	<i>Mephitis</i>			X	
Western harvest mouse	<i>Reithrodontomys megalotis</i>	X	X	X	
Western spotted skunk	<i>Spilogale gracilis</i>			X	
White-tailed jackrabbit	<i>Lepus townsendii</i>		X		
Yellow-bellied marmot	<i>Marmota flaviventris</i>	X			

## REPTILES AND AMPHIBIANS

Bull snake	<i>Pituophis catenifer</i>	X			
Plains garter snake	<i>Thamnophis radix</i>	X	X		
Prairie lizard	<i>Sceloporus undulatus</i>			X	
Racer	<i>Coluber constrictor</i>			X	
Six-lined racerunner	<i>Cnemidophorus sexlineatus</i>		X		
Tiger salamander	<i>Ambystoma tigrinum</i>		X	X	
Western rattlesnake	<i>Crotalus viridis</i>	X	X	X	
Woodhouse's toad	<i>Bufo woodhousii</i>			X	

Note: No terrestrial arthropod genera of specific concern were detected during surveys in 2010.

## WILDLIFE SPECIES AT THE NWTC

SPECIES COMMON NAME	SCIENTIFIC NAME
<b>BIRDS</b>	
American crow	<i>Corvus brachyrhynchos</i>
American goldfinch	<i>Spinus tristis</i>
American kestrel	<i>Falco sparverius</i>
American pipit	<i>Anthus rubescens</i>
American robin	<i>Turdus migratorius</i>
American tree sparrow	<i>Spizella arborea</i>
Bald eagle	<i>Haliaeetus leucocephalus</i>
Barn swallow	<i>Hirundo rustica</i>
Black-billed magpie	<i>Pica hudsonia</i>
Black-capped chickadee	<i>Poecile atricapillus</i>
Blue jay	<i>Cyanocitta cristata</i>
Brewer's blackbird	<i>Euphagus cyanocephalus</i>
Brewer's sparrow	<i>Spizella breweri</i>
Broad-tailed hummingbird	<i>Selasphorus platycercus</i>
Brown-headed cowbird	<i>Molothrus ater</i>
Bullock's oriole	<i>Icterus bullockii</i>
Canada goose	<i>Branta canadensis</i>
Cedar waxwing	<i>Bombycilla cedrorum</i>
Chipping sparrow	<i>Spizella passerina</i>
Common grackle	<i>Quiscalus quiscula</i>
Common raven	<i>Corvus corax</i>

## WILDLIFE SPECIES AT THE NWTC

SPECIES COMMON NAME	SCIENTIFIC NAME
<b>BIRDS</b>	
Common snipe	<i>Gallinago delicata</i>
Dark-eyed junco	<i>Junco hyemalis</i>
Downy woodpecker	<i>Picoides pubescens</i>
Eurasian collared-dove	<i>Streptopelia decaocto</i>
European starling	<i>Sturnus vulgaris</i>
Ferruginous hawk	<i>Buteo regalis</i>
Franklin's gull	<i>Larus pipixcan</i>
Golden eagle	<i>Aquila chrysaetos</i>
Grasshopper sparrow	<i>Ammodramus savannarum</i>
Gray catbird	<i>Dumetella carolinensis</i>
Great blue heron	<i>Ardea herodias</i>
Great horned owl	<i>Bubo virginianus</i>
Hairy woodpecker	<i>Picoides villosus</i>
Horned lark	<i>Eremophila alpestris</i>
House finch	<i>Carpodacus mexicanus</i>
Killdeer	<i>Charadrius vociferus</i>
Lark bunting	<i>Calamospiza melanocorys</i>
Loggerhead shrike	<i>Lanius ludovicianus</i>
Long-billed curlew	<i>Numenius americanus</i>
Mallard	<i>Anas platyrhynchos</i>
Mountain bluebird	<i>Sialia currucoides</i>



## WILDLIFE SPECIES AT THE NWT

SPECIES COMMON NAME	SCIENTIFIC NAME
<b>BIRDS</b>	
Mountain chickadee	Poecile gambeli
Mourning dove	Zenaida macroura
Northern flicker	Colaptes auratus
Northern harrier	Circus cyaneus
Red-headed woodpecker	Melanerpes erythrocephalus
Red-tailed hawk	Buteo jamaicensis
Red-winged blackbird	Agelaius phoeniceus
Rough-legged hawk	Buteo lagopus
Ruby-crowned kinglet	Regulus calendula
Sandhill crane	Grus canadensis
Savannah sparrow	Passerculus sandwichensis
Say's phoebe	Sayornis saya
Song sparrow	Melospiza melodia
Spotted towhee	Pipilo maculatus
Swainson's hawk	Buteo swainsoni
Tree swallow	Tachycineta bicolor
Turkey vulture	Cathartes aura
Vesper sparrow	Pooecetes gramineus
Western kingbird	Tyrannus verticalis
Western meadowlark	Sturnella neglecta

## WILDLIFE SPECIES AT THE NWT

SPECIES COMMON NAME	SCIENTIFIC NAME
<b>MAMMALS</b>	
American elk	Cervus canadensis
Big brown bat	Eptesicus fuscus
Coyote	Canis latrans
Deer mouse	Peromyscus maniculatus
Desert cottontail	Sylvilagus audubonii
Eastern red bat	Lasiurus borealis
Fringed myotis	Myotis thysanodes
Hoary bat	Lasiurus cinereus
Masked shrew	Sorex cinereus
Meadow vole	Microtus pennsylvanicus
Mexican woodrat	Neotoma mexicana
Mule deer	Odocoileus hemionus
Myotis bats	Myotis sp.
Prairie vole	Microtus ochrogaster
Silver-haired bat	Lasionycteris noctivagans
Thirteen-lined ground squirrel	Spermophilus tridecemlineatus
Western harvest mouse	Reithrodontomys megalotis

## WILDLIFE SPECIES AT THE NWTC

SPECIES COMMON NAME	SCIENTIFIC NAME
<b>REPTILES AND AMPHIBIANS</b>	
Boreal chorus frog	<i>Pseudacris maculata</i>
Bull snake	<i>Pituophis catenifer</i>
Woodhouse's toad	<i>Bufo woodhousii</i>
<b>TERRESTRIAL ARTHROPODS</b>	
Aphrodite fritillary	<i>Speyeria aphrodite</i>
Cabbage white	<i>Pieris rapae</i>
Checkered white	<i>Pontia protodice</i>
Common wood nymph	<i>Cercyonis pegala</i>
Dainty sulphur	<i>Nathalis iole</i>
Gray hairstreak	<i>Strymon melinus</i>
Orange sulphur	<i>Colias eurytheme</i>
Western white	<i>Pontia occidentalis</i>





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