2014 ASHRAE TECHNOLOGY AWARD CASE STUDIES

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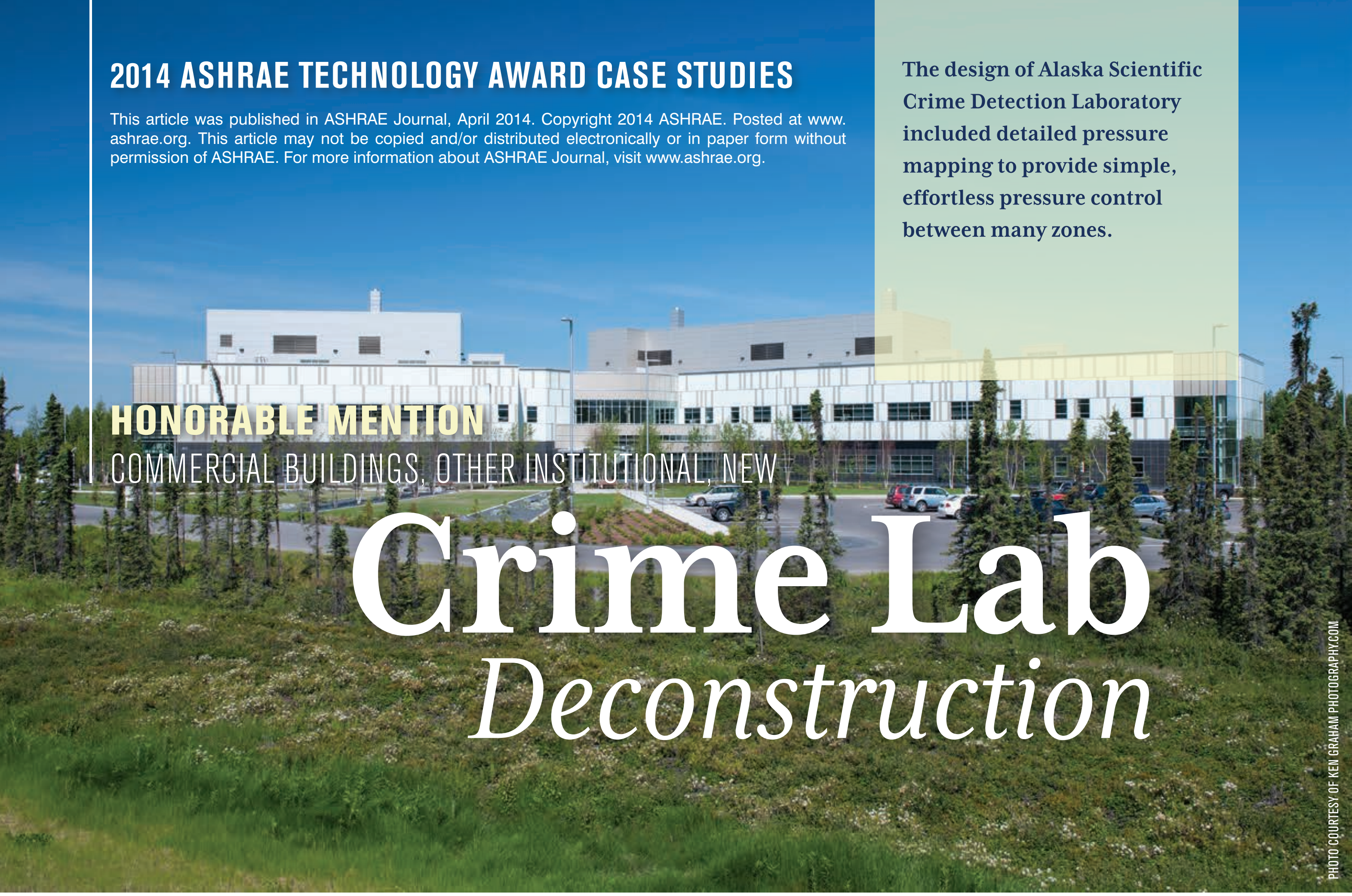
The design of Alaska Scientific Crime Detection Laboratory included detailed pressure mapping to provide simple, effortless pressure control between many zones.



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HONORABLE MENTION

COMMERCIAL BUILDINGS, OTHER INSTITUTIONAL, NEW

Crime Lab *Deconstruction*

BY DAVID SHUMWAY, P.E., MEMBER ASHRAE

BUILDING AT A GLANCE

Alaska Scientific Crime Detection Laboratory

Location: Anchorage, Alaska

Owner: State of Alaska Department of Public Safety

Principal Use: Criminal Forensics Laboratory

Includes: Specialized forensic lab suites, ballistics suite with dedicated indoor range, crime scene sally port, secure evidence storage areas, training classrooms/labs & admin. support offices.

Employees/Occupants: 50

Gross Square Footage: 84,410 (7482 m^2)

Substantial Completion/Occupancy: June 1, 2012

Occupancy: 44%

National Distinctions/Awards: 2013 Illuminating Engineering Society National Award of Merit Lighting design featured in January 2014 issue of LD+A, Lighting Design & Application, the magazine of the Illuminating Engineering Society of North America

The new Alaska Scientific Crime Detection Laboratory is a modern two-story 84,410 ft^2 (7482 m^2) state-of-the-art crime lab in Anchorage, Alaska. The facility is arranged in two wings with a large central two-story main entry, lobby and faculty dining area serving as its architectural focal point. The facility includes many specialized forensic laboratory suites, a ballistics suite with dedicated indoor firing range, secure evidence storage areas, training classrooms/labs and administrative support offices. Project design began in 2006 with the facility officially opening for business in 2012. User satisfaction is very high and operations and maintenance personnel are pleased with the HVAC systems, their arrangement and performance. The design conforms to the requirements of the 2004 versions of ASHRAE Standards 55, 62.1, 90.1 and the *ASHRAE Laboratory Design Guide*.

David Shumway, P.E., is the mechanical engineer of record and commissioning authority for the new Alaska Scientific Crime Detection Laboratory in Anchorage, Alaska.

COURTESY WSP USA

ABOVE Laboratory exhaust air valve arrangement emphasizes accessibility.

LEFT Central boiler room designed for intuitive systems operation and hassle-free maintenance.

Energy Efficiency

Laboratories have a well-deserved reputation for consuming large amounts of energy, especially in cold climates. The *ASHRAE Laboratory Design Guide* was implemented extensively to help reduce energy use while maintaining a safe work environment for its occupants. Both supply and exhaust ventilation systems use variable air volume control. Exhaust airflow rate is controlled to maintain the desired ventilation rate in air changes per hour (ach). Supply airflow rate is offset from exhaust airflow rate to provide precise room pressure control.

The facility uses three separate manifolded laboratory exhaust systems. Types and concentrations of chemicals used, lower first cost, fewer stacks, simple connection to exhaust air heat recovery and excellent exhaust air dilution made this the logical system choice for this laboratory application.

Runaround loop heat recovery coils were implemented for each of the three separate 100% outdoor air laboratory ventilation systems. This heat recovery method was selected to eliminate any concerns with cross-contamination. Each exhaust air heat recovery coil is preceded by a MERV 8/MERV 13 filter bank. Filter air pressure drop is monitored through the central building automation system (BAS) to ensure the coils are maintained clean for maximum energy savings.

Toilet rooms, janitor closets and other spaces requiring 100% general exhaust ventilation were tied into the laboratory exhaust fan systems using exhaust air control valves; eliminating many small exhaust fans and allowing the runaround loop heat recovery systems to recover as much general exhaust air energy as possible before leaving the building.

Six modular, high efficiency, fully modulating, gas-fired boilers provide precise hydronic heating control with a minimum turndown to 8% of the building's design heating day load. Variable-speed drive hydronic heating pumps precisely match system flow with heating demand.

Energy analysis software package eQUEST v3.61 was used to model the facility's annual energy consumption. The HVAC system was zoned and modeled based on the actual architectural building envelope to the maximum extent practical. Composite U-values were calculated from the many detailed architectural roof, wall and floor cross sections. Heating and cooling system input was very representative of the actual mechanical design. Lighting levels and control features were modeled for each room based on building wide averages. Estimated plug and task lighting loads were combined and applied equally throughout the building.

Utility energy consumption data for 2012–13 was collected for comparison to energy model predictions. Results show an over prediction of electrical energy and demand and an under prediction of fuel gas usage. Overall agreement is good.

The Laboratories for the 21st Century (Labs21) benchmarking database tool was used to gauge overall success of the energy reduction design goals compared with peer facilities. In 2008, this facility was predicted to use approximately 242 kBtu/ft^2·yr (763 kWh/m^2·yr) of site energy, well below the 277 kBtu/ft^2·yr (874 kWh/m^2·yr) average for peer Labs 21 database facilities. During the 12 months of operation from June 2012 through May 2013, actual energy usage was 152 kBtu/ft^2·yr (480 kWh/m^2·yr), 37% less than anticipated. Energy costs were predicted at $346,000 per year. Actual energy cost was $284,000, 18% less than predicted.

Indoor Air Quality

The HVAC design follows the recommended practices of ASHRAE Standard 55-2004 for thermal comfort. Room temperature and ventilation system airflow are managed based on user activity and clothing. Building occupants are typically standing or seated with an activity level near 1.0 met. In the summer, clothing insulation (clo) is 0.65, allowing a higher comfortable indoor operating temperature of 75°F (24°C). During the winter, clo increases to 1.3, suggesting an optimum indoor operating temperature of 68°F (20°C).

A combination of thermally controlled ventilation and radiant floor heating (in main lobby, staff dining and laboratory areas) is used to maintain indoor temperature between 68°F and 72°F (20°C to 22°C) and a nearly linear vertical temperature profile. Zone ventilation supply air temperature is reset to within 20°F (11°C) of room temperature setpoint to maximize mixing and minimize drafts. Supply air entering radiant floor heated zones is supplied at close to room temperature setpoint, effectively removing the ventilation heat load component, allowing the radiant floor system to control zone temperature. Air outlets are sized, located and balanced to limit air velocities to less than or equal to 50 fpm (429 L/s) at the occupants' shoulders.

Standard 55 recommends an indoor relative humidity range of 35% to 60% for an operating temperature of 68°F (20°C). Occupant comfort in Anchorage is balanced against the ever-present problem of ice buildup at the building envelope. Mechanical humidification control is universally problematic in arctic regions, and is seldom provided except where absolutely required. For these reasons, the owner opted to omit humidity control. During the summer, an outdoor design temperature of 72°F (22°C) and 30% relative humidity falls into the optimum humidity range for comfort when cooled to room temperature setpoint. The 15-minute peak-to-peak temperature change within each zone, as trended by the BAS, was demonstrated to be 1°F (0.55°C) or less.

The building ventilation systems were designed to comply with Standard 62.1-2004 for indoor air quality. A formal exhaust re-entrainment assessment (numerical dispersion computer modeling) was conducted by a third-party consulting firm to confirm air intake, laboratory stack, boiler stack, and diesel generator exhaust locations.

General ventilation systems (recirculating air systems) serving administration, classroom and other general use areas were designed using the Standard 62.1 Ventilation Rate Procedure. Supply and return air grilles were located

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to maximize ventilation effectiveness ($E_v = 0.8$). Minimum OSA intake volume for these systems is controlled by the BAS by monitoring both mixed air temperature and system airflow rates (using duct-mounted airflow stations).

Ventilation rates for laboratory ventilation systems (100% outdoor air systems), serving the forensic laboratory suites, are controlled using an electronic indoor environmental quality (IEQ) control system connected directly to the BAS. The IEQ system obtains continuous laboratory air samples through small diameter tubing using a vacuum pump; transports the sample to an analyzer where it is analyzed for volatile organic compounds (VOCs) and particulate concentration.

The IEQ system determines the required ach based on measured airborne contaminant concentrations and adjusts zone ventilation rates through the BAS from less than 4 ach to a maximum of 12 ach. Each laboratory suite is sequentially sampled several times per hour on an automatic rotating basis through a "router" within the IEQ system. Many laboratory suites often run safely at their minimum ventilation rates (less than 4 ach) providing huge operational energy savings. Users have observed that burning small strips of magnesium (to dull bullet casings) or spray painting small objects quickly causes the IEQ system to maximize the ventilation rate, demonstrating that it works properly.

Laboratory Source Capture. Each laboratory suite includes a number of chemical fume hoods, point-source snorkel exhausts and specialized containment cabinets (i.e., vaporized super glue cabinet) to effectively contain and remove airborne contaminants at their source.

Each suite uses a BAS room controller that automatically controls individual exhaust airflow rate from each source capture device, as well as, general laboratory exhaust rates. Room controllers maintain minimum acceptable suite ventilation rate, as determined by the IEQ system while maintaining zone differential pressure relationships.

Indoor Shooting Range. The indoor shooting range uses a dedicated, stand-alone, 100% outdoor air ventilation system. The system safeguards the shooter's breathing zone in both standing and sitting positions while maintaining downrange target visibility. The American

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Conference of Government Industrial Hygienist recommends a minimum capture rate of 50 fpm (0.25 m/s) at the firing line. Practical application requires 50 fpm (0.25 m/s) across the entire down range cross-sectional area to transport smoke. From a ventilation perspective, an indoor pistol range is essentially a "walk-in" industrial fume hood with the firing line being the "sash" area. Horizontal laminar flow supply air is provided from behind the shooting line and is drawn downrange past the firing line (shooter's breathing zone) by the range exhaust fan. The smoke plume from the gun's discharge is removed by the up range exhaust grille, while the airborne debris from the bullet's impact is removed from the downrange exhaust grille to maintain range visibility.

Innovation

Detailed Pressure Mapping. The ventilation system was designed from initial project concept using detailed building wide pressure mapping in accordance with the *ASHRAE Laboratory Design Guide*. Pressure relationships, partition wall locations, door locations, door swing direction (to seat door on its jamb gasket in the direction of pressure drop), door undercut cross sectional area and door sealing methods (i.e., astragals, jamb gaskets) were thoroughly considered and included as part of the facilities programming. Differential pressures are maintained throughout the building using two positive and two negative 0.05 in. w.c. (12.5 Pa) pressure increments relative to ambient outdoor air pressure (datum = 0). Only one increment of pressure drop is allowed at any door separation. Each doorway is assumed to have a constant leakage rate of 200 cfm (94 L/s), the vector sum of which sets the exhaust air to supply air control offset for each zone. Each zone's ventilation rates were evaluated for heating, cooling, maximum air change rate (12 ach) and minimum controllable ventilation rate. The required ventilation rate ranges for variable air volume supply terminals and exhaust air valves, as well as pressure control offsets, are documented on dedicated pressure map drawings. This level of pressure mapping detail upfront allows the building design to include simple, effortless pressure control between many zones.

Maintenance & Operation

The BAS senses and automatically adjusts the central HVAC and plumbing systems to control building comfort and maintain differential pressure relationships

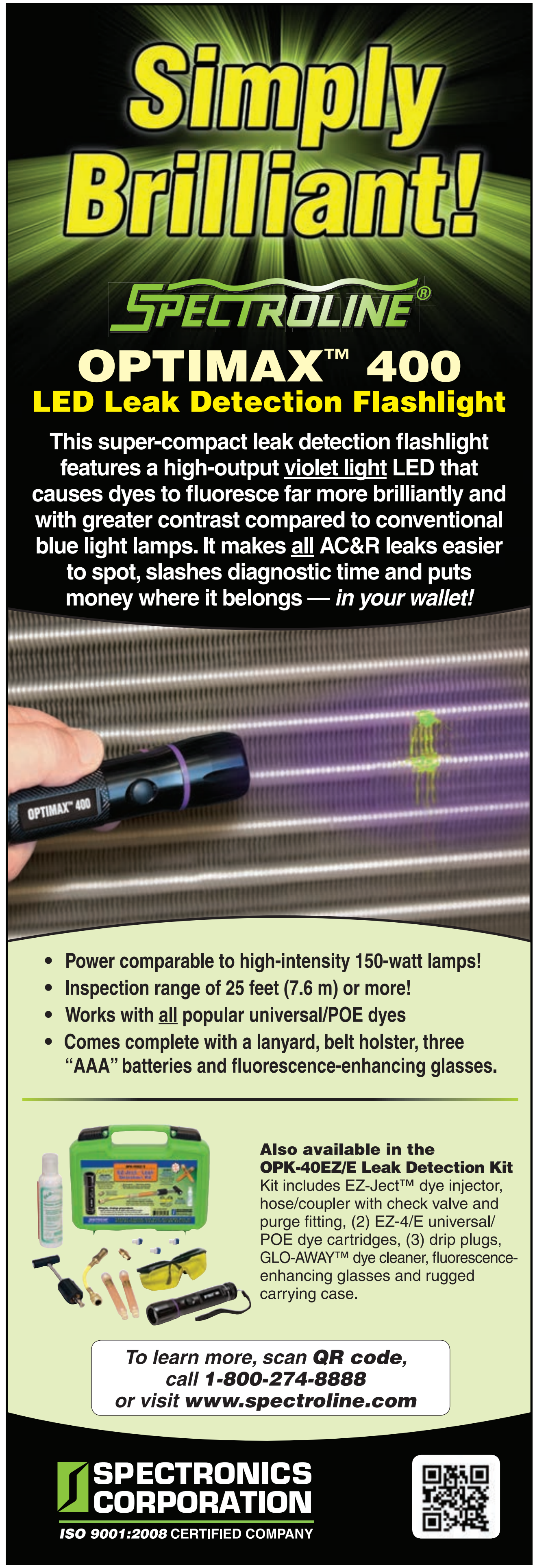

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FIGURE 1 Electrical use, estimated and measured.

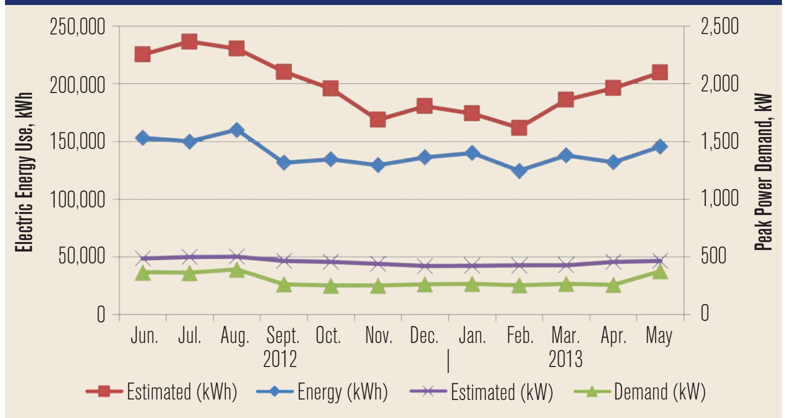
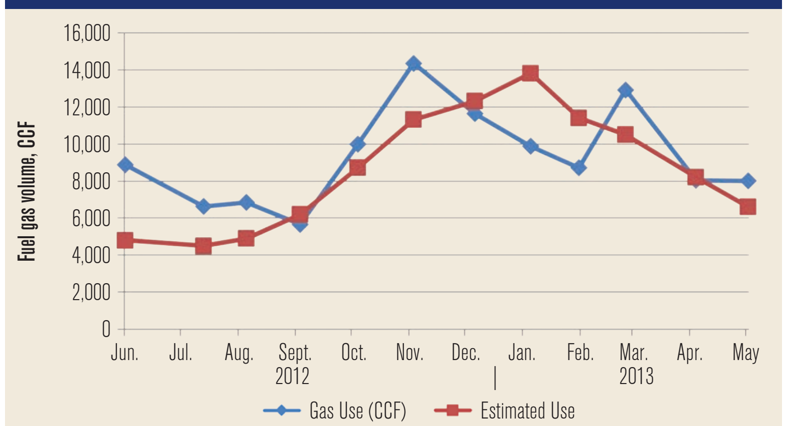


FIGURE 2 Fuel gas use, estimated and measured.



while optimizing energy use. Mechanical and electrical systems can be fully monitored and controlled remotely. System alarms are instantly forwarded to the maintenance staff for immediate action.

The facility maintains precise differential pressure control between the various laboratories and general use areas, using an "airflow tracking" control strategy, minimizing airborne cross contamination of evidence and providing a safe and comfortable working environment.

All major mechanical equipment (with the exception of the direct expansion air conditioning refrigeration condensers and dry coolers) is located indoors for convenient maintenance during the harsh winter.

Replacement fan motors were purchased as part of the original project and are stored on-site for quick replacement in the event of a fan motor failure.

In a few laboratory suites, a high concentration of heat-producing equipment (analyzers and low temperature refrigerators) makes it a rush to perform regularly scheduled maintenance (i.e., air filter replacement) with the associated central ventilation systems temporarily shut down as room temperatures can easily exceed 90°F (32°C) within an hour. Due to work flow requirements, the close proximity of this equipment could not be avoided.

Few occupant complaints have occurred regarding thermal comfort. At one exterior corner office, ceiling air supply diffusers were relocated to improve personal comfort.

Outdoor air intake louvers were sized for free area airflow velocities less than or equal to 600 fpm (3 m/s). During one extreme cold event, very fine "dry" snow particles accumulated within the AHU intake plenums requiring manual removal by maintenance personnel.

Cost Effectiveness

The initial $200,000 expense of adding the IEQ monitoring system to the project (including a five-year service/calibration agreement) was evaluated as part of the energy modeling process. Safely operating the 100% outdoor air laboratory systems at reduced ventilation rates (less than 4 to roughly 6 ach) using active monitoring of airborne contaminants, rather than at higher recommended ventilation rates (typically up to 12 ach for labs) was estimated to save between $150,000 to $200,000 per year in operating costs, indicating a possible one- to two-year payback. As seen in the operating cost data shown in *Figures 1* and *2,* initial utility costs are actually lower than predicted, accelerating this payback period.

Environmental Impact

Due to the dilution of laboratory chemicals facilitated by the manifolded laboratory exhaust systems (500:1 dilution for a worst case 30 mL spill of dichloromethane) and the dispersion effect of the exhaust stack exit cones, there is no detectable impact on the local environment from this facility's laboratory exhaust.

Using the EPA Target Finder tool, this project is estimated to emit approximately 600 metric tons (CO_2e) less total greenhouse gases per year when compared to typical labs. This is a 28% reduction. In addition, the facility's cooling systems use R-407C refrigerant. ■