AIR COMBAT COMMAND

INSTALLATION SUSTAINABILITY ASSESSMENT REPORT

A Historic Building in the HTA District

Revised/Updated
Final
May 2012

Langley Air Force Base
Virginia

Sustainability assessment summary of Langley Air Force Base to establish baseline metrics, to identify actionable opportunities and investment strategies, and year-over-year comparisons.

TABLE OF CONTENTS

"So we have a choice to make. We can remain one of the world's leading importers of foreign oil, or we can make the investments that would allow us to become the world's leading exporter of renewable energy. We can let climate change continue to go unchecked, or we can help stop it. We can let the jobs of tomorrow be created abroad, or we can create those jobs right here in America and lay the foundation for lasting prosperity."–President Obama, March 19, 2009

EXECUTIVE SUMMARY

Due to expanding requirements and diminishing resources as well as lacking holistic/integrated design approaches, HQ ACC/A7PS has formulated a process for measuring sustainability at Air Combat Command (ACC) installations. This process will establish baseline metrics to identify actionable opportunities and investment strategies, and facilitate year-to-year comparisons. There are many individual efforts already in place at HQ ACC/A7PS and at the installation level. It is within this context that the ACC Installation Sustainability Assessment (ISA) process and report was developed. This report summarizes the current and recommended sustainability efforts at Langley Air Force Base (Langley AFB) and provides a basis for comparison and benchmarking.

Numbers have been calculated for the five sustainability indicators at Langley AFB for their mission support functions. Additionally, flying mission numbers have been established for the total carbon footprint and energy intensity to show their additional effect on the installation's overall impact on sustainability. The circle indicators, as shown in the chart below, represent how Langley AFB compares to industry-recognized benchmarks[1]. Green indicates a metric is on target or better than target. Yellow indicates a metric is slightly off target. Red indicates a metric is off target.

MISSION SUPPORT			
Carbon Footprint[1]:	27,843	mTons	
Energy Usage:	848,868	MMBTU	
Water Conservation:	177	Mg	
Waste Production[2]:	851	tons	
Land Utilization:	2,412	SF/acre	

FLYING MISSION			
Carbon Footprint:	169,830	mTons	
Energy Usage:	2,392,588	MMBTU	

[1]Does not include commuting.

[2]Inlcude solid and hazardous waste

SF = square feet, mTons = metric tons, Mg = million gallons, and MMBTU = million British thermal units

ACC has a solid history of successes with sustainability initiatives; however, progressive action must continue. This report outlines a concise, measurable, and repeatable process that can be utilized year to year. Upon this installation's yearly assessment and data analysis, recommendations and actionable items will be established and monitored. ACC HQ/A7PS's role includes identifying synergies between installations to implement new and bridge existing sustainability initiatives. The ACC HQ/A7PS ISA will deliver a positive return on investment and promote leadership in sustainable initiatives.

[1]Industry recognized benchmarks are noted where referenced within the report.

I. INTRODUCTION

A. Installation Sustainability Assessment (ISA) Definition

The Installation Sustainability Assessment (ISA) is a process by which an installation's relative level of sustainability can be measured, identifies and recommends installation-specific improvement strategies, and it is expressed in five key indicators: (1) Carbon Footprint, (2) Energy Usage, (3) Water Conservation, (4) Waste Reduction, and (5) Land Utilization. Identified improvement strategies will allow for the bridging of diverse sustainable initiatives (i.e., energy, heat island effect, water conservation, habitat/watershed protection and restoration and new construction practices) and a more efficient implementation of these initiatives as it will account for installation-wide conditions. Additionally, overall review of completed ISAs will provide valuable trend analysis across installations. Direct comparison of installations is not the focus due to differing missions, climate variations, and unique installation attributes.

Sustainable design is a design philosophy that seeks to maximize the quality of the community and the built environment while minimizing or eliminating the negative impact to the natural environment. The word installation is defined as the grounds and buildings that belong to a given institution, and specifically refers to the Air Force installation in this document. Sustainability initiatives include conscious efforts to protect habitats, optimize land use, produce zero waste, reduce heat islands, improve air quality, reduce light pollution, use energy efficiently, and maintain the health and well-being for a community.

Initiatives to improve on a particular established indicator typically will also have an effect on other indicators. In determining and prioritizing actionable items, it is important to take into account this interaction to determine which initiatives will result in the most positive outcome and highest return on investment.

B. ISA and the DoD Strategic Sustainability Performance Plan

The *Installation Sustainability Assessment* (ISA) process, metrics, and indicators were initially developed in 2009 by HQ ACC as a means for measuring the overall "green posture" of the installation. In late 2010, the Department of Defense (DoD) published the Strategic Sustainability Performance Plan (SSPP) which identified department wide goals.

HQ ACC reevaluated the ISA process, metrics, and indicators in light of policy established in the SSPP in order to determine if there were conflicts or if changes were needed in the ISA.

The following table provides a summary of the evaluation. The ISA anticipated and aligned favorably with the broad goals and policy in the SSPP. Few modifications in the ISA data collection were needed and those have been fully incorporated into this updated ISA. The SSPP identified some goals which are completely outside the ability of the ISA to collect and report as, to the best of our knowledge, this information is not currently being collected (recall that the ISA relies on collecting data from existing sources).

Bottom Line: The ISA will remain ACC's tool for evaluating the progress of an installation towards the goals and performance expectations of the SSPP.

The following headers are provided in the following table.

- *SSPP Goals* are the goals and sub-goals taken directly from DoD's SSPP.
- *Changes to Align ISAs with SSPP Goals* shows three categories addressing how the ISA aligned with the SSPP.
  - *Few/No ISA Changes* indicates that the original data collect and the data input format of the ISA aligned very closely with the SSPP. *Modifications* that were needed have been incorporated into the ISA.
  - *ISA Additions (data available)* means that the ISA did not originally collect or have a data input format for these goals that were eventually identified in the SSPP. For the most part the data is available *for* collection. However, some of the data may not be easily accessible. Modifications to the ISA spreadsheet have been made for inputting the new data.
  - *Goals outside the ability of the ISA to collect and report* refer to goals that are not applicable to ACC *installations*. It also includes goals for which installations do not have the ability to collect the data for measuring progress against the goal.
- *Data Status and Location* addresses the location within the electronic ISA worksheet where data can be found and inputted in order to calculate progress towards meeting the SSPP goals. It also identifies what data has been collected for each goal.

COMPARISON AND ALIGNMENT OF ISA AND SSPP

SSPP Goals		Changes to Align ISAs with SSPP Goals: Few/No ISA Changes	ISA Additions (Data Available)	Goals Outside the Ability of the ISA to Collect and Report	Data Status and Location
Goal 1	**Use of Fossil Fuels Reduced**				
Sub-Goal 1.1	Energy intensity of facilities reduced by 30% of FY03 levels by FY15 and 37.5% by FY20	●			• Data collected in the ISA is acceptable. • Data input under the Energy Tab Spreadsheets.
Sub-Goal 1.2	18.3% of energy consumed by facilities is produced or procured from renewable sources by FY20	●			• Data collected in the ISA is acceptable. • Data input under the Energy Tab Spreadsheets. • Sustainable Measures Tab worksheet shows a separate table for facilities with the energy intensity bar chart showing the renewable component.
Sub-Goal 1.3	Use of petroleum products by vehicle fleets reduced by 30% by FY20 relative to FY05	●			• Data collected in the ISA acceptable. • Data input under the Energy Tab Spreadsheets. • Sustainable Measures tab shows reduction in transportation energy use and separates petroleum and renewable sources.
Goal 2	**Water Resources Management Improved**				
Sub-Goal 2.1	Potable water consumption intensity by facilities reduced by 26% of FY07 levels by FY20 Assessment of ISA	●			• Data collected in the ISA is acceptable. • Data input under the Water Tab Spreadsheets. • Sustainable Measures Tab shows the percent improvement from baseline in the per built SF table.
Sub-Goal 2.2	Reduce industrial and irrigation water consumption 20% by FY20 from FY10 baseline			●	• Water Tab spreadsheet updated to provide data entry points for when data becomes available. • Data not currently available for input in the ISA for this metric. No separate metering for industrial uses.
Sub-Goal 2.3	All development and redevelopment projects of 5,000 square feet or greater maintaining pre-development hydrology to the maximum extent technically feasible		●		• Water Tab spreadsheet modified to add a yes/no box with a percent compliance. • Data not originally collected for sub-goal.
Goal 3	**Greenhouse Gas Emission from Scope 1 and 2 Sources Reduced 34% by FY20, Relative to FY08**	●			• Data collected in the ISA is acceptable. • Data input under the Energy Tab Spreadsheets.
Goal 4	**Greenhouse Gas Emission from Scope 3 Sources Reduced 13.5% by FY20, Relative to FY08**				
Sub-Goal 4.1	Greenhouse gas emission from employee air travel reduced 15% FY20 relative to FY11		●		• Operations Tab spreadsheet modified to a yes/no box with a percent compliance. • Data not originally collected for sub-goal.
Sub-Goal 4.2	30% of eligible employees teleworking at least once a week, on a regular, recurring basis, by FY20		●		• Operations Tab spreadsheet modified to a yes/no box with a percent compliance. • Data not originally collected for sub-goal.
Sub-Goal 4.3	50% of non-hazardous waste diverted from disposal in landfills not owned by DoD by FY15, and thereafter through FY20	●			• Data collected in the ISA is acceptable. • Waste Management Tab has a check box for verification of the waste is going to non-DoD landfill.

COMPARISON AND ALIGNMENT OF ISA AND SSPP

SSPP Goals		Changes to Align ISAs with SSPP Goals: Few/No ISA Changes	ISA Additions (Data Available)	Goals Outside the Ability of the ISA to Collect and Report	Data Status and Location
Goal 5	**Solid Waste Minimized and Optimally Managed**				
Sub-Goal 5.1	All DoD organizations implementing policies by FY14 to reduce the use of printing paper		●		• Operations Tab spreadsheet modified to a yes/no box with a percent compliance. • Data not originally collected for sub-goal.
Sub-Goal 5.2	50% of non-hazardous solid waste diverted from the waste stream by FY15, and thereafter through FY20—not including construction and demolition debris	●			• Data collected in the ISA is acceptable. • Data input under the Waste Management Tab Spreadsheets.
Sub-Goal 5.3	60% of construction and demolition debris diverted from the waste stream by FY15, and thereafter through FY20		●		• Waste Management Tab spreadsheet modified to add a header for C&D debris. • Data not originally collected for sub-goal.
Sub-Goal 5.4	Ten landfills recovering landfill gas for use by DoD by FY20			●	• Not applicable to ACC installations.
Goal 6	**The Use and Release of Chemicals of Environmental Concern Minimized**				
Sub-Goal 6.1	On-site releases and off-site transfers of toxic chemicals reduced 15% by FY20, relative to FY07		●		• Waste Management Tab spreadsheet modified for listing reportable quantities. • Data not originally collected for sub-goal.
Sub-Goal 6.2	100% of excess or surplus electronic products disposed of in environmentally sound manner		●		• Operations Tab spreadsheet modified to a yes/no box with a percent compliance. • Data not originally collected for sub-goal.
Sub-Goal 6.3	100% of DoD personnel and contractors who apply pesticides are properly certified through FY20		●		• Operations Tab spreadsheet modified to a yes/no box with a percent compliance. • Data not originally collected for sub-goal.
Goal 7	**Sustainability Practices Become the Norm**				
Sub-Goal 7.1	95% of procurement conducted sustainably				• Operations Tab spreadsheet modified to a yes/no box with a percent compliance.
Sub-Goal 7.2	15% of existing buildings conform to the guiding principles on high performance and sustainable buildings by FY15, holding through FY20			●	• ACC/A7PS is evaluating how to implement this goal.
Goal 8	**Sustainability Built into DoD Management Systems**				
Sub-Goal 8.1	All environmental management systems effectively implemented and maintained		●		• Operations Tab spreadsheet modified to a yes/no box with a percent compliance. • Data not originally collected for sub-goal. Data is available.
Sub-Goal 8.2	Sustainability of transportation and energy choices in surrounding areas optimized by coordinating with related regional and local planning		●		• Operations Tab spreadsheet modified to a yes/no box with a percent compliance. • Data not originally collected for sub-goal. Data is available.
Sub-Goal 8.3	All DoD installations have Integrated Pest Management Plans prepared, reviewed, and updated annually by pest management professionals		●		• Operations Tab spreadsheet modified to include a year and review date. • Data not originally collected for sub-goal. Data is available.

C. Goals and Objectives

The ISA has been established to formulate a process for measuring sustainability at the installation level. ISAs take a comprehensive look at ACC installations and will address, at a minimum, current use of renewable energy, green procurement practices, infrastructure systems, existing facility operations, conservation plans, environmental compliance, biological resources, habitat protection, watershed restoration, land use, and environmental stewardship.

The ISA will be used to:

- Report the findings
- Establish a baseline for year-to-year comparisons
- Define sustainable initiatives
- Identify synergistic opportunities between diverse initiatives
- Support the Mission, improve the quality of life, and conserve resources over time
- Create an awareness of impacts and a catalyst for cultural change

D. Setting the Context

Flying Mission:

Flying Mission includes anything that directly affects or has direct participation in flight. The flying mission calculations currently take into account fuel usage only.

Mission Support:

Mission Support includes all other activities on the installation. Mission support calculations include resources consumption for everything except flying mission fuel consumption. .

E. Process

1. Data Collection Categories

The ISA categories are a way of grouping data that was collected and used to calculate a set of sustainability criteria. In summary, the ISA data collection categories are:

1. **Development—**Includes land use, building utilization, transportation, noise, and light emissions.
2. **Energy—**Includes electrical, gas, oil, and liquid propane gas consumption; power purchased from utility or generated on site; and transportation and mission fuels for government vehicles and support equipment.
3. **Water—**Includes domestic, irrigation, and storm water as well as its source and its usage.
4. **Waste—**Includes solid and liquid waste production and its usage.
5. **Operations—**Includes best management practices (BMPs) such as procurement, training, maintenance, and purchasing program for energy efficient equipment.

The following defines the five data collection categories in more detail:

Development:

Expanding human requirements and economic activities are placing ever-increasing pressures on land resources, creating competition and conflicts and resulting in suboptimal use of resources. By examining all land uses in an integrated manner, it is possible to minimize conflicts, make the most

efficient tradeoffs, and link social and economic development with environmental protection and enhancement, thus helping to achieve the objectives of sustainable development.

Land use refers to the activities practiced by humans on land. Land supports uses such as residential, industrial, and commercial facilities; recreational areas; natural infrastructure areas; and transportation functions. Integrating a green infrastructure with community connectivity in land use planning is essential to achieving sustainable developments as they incorporate multiple environmental benefits including:

- Reducing storm water runoff volumes and reducing peak flows by using the natural retention and absorption capabilities of vegetation and soils.

  The capacity of the land can be generally categorized as either pervious or impervious. Pervious includes areas that allow rainwater to pass through them and soak into the ground instead of flowing into storm drains. Impervious includes areas that are mainly constructed surfaces covered by impenetrable materials such as asphalt, concrete, brick, and stone. These materials seal surfaces, repel water, and prevent precipitation and melt water from infiltrating soils. Impervious surface areas include rooftops, sidewalks, roads, and parking lots. The impacts of increased impervious surfaces to storm water runoff should be controlled to mimic natural conditions and to protect water quality. Increasing the amount of pervious ground cover increases storm water infiltration rates that reduces the volume of runoff entering our combined or separate sewer systems, and ultimately our lakes, rivers, and streams.

- Improving the rate at which groundwater aquifers are recharged or replenished.

  Groundwater provides approximately 40 percent of the water needed to maintain normal base flow rates in our rivers and streams. Enhanced groundwater recharge can also boost the supply of drinking water for private and public uses.

- Preventing pollutants from being transported to nearby surface waters.

  Once runoff is infiltrated into soils, plants and microbes can naturally filter and break down many common pollutants found in storm water.

- Limiting the frequency of sewer overflow events by using the natural retention and infiltration capabilities of plants and soils that will reduce runoff volumes and delay storm water discharges.

- Capturing and removing carbon dioxide (CO_2) from the atmosphere via photosynthesis and other natural processes of plants and soils that serve as sources of carbon sequestration.

- Mitigating the effects of urban heat islands and reducing energy demands by providing increased amounts of urban green space and vegetation.

  Urban heat islands form as communities replace natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. Heat from the sun is absorbed by impervious surface areas and is radiated back into the atmosphere, increasing temperatures in the surrounding area. Additionally, buildings and streets trap and concentrate waste heat from vehicles, factories, and air conditioners. The displacement of trees and vegetation minimizes their natural cooling effects. Trees, green roofs, and other green

infrastructure lower the demand for air conditioning energy, thereby decreasing emissions from power plants.

- Improving air quality by incorporating trees and vegetation in urban landscapes.

  Trees and vegetation absorb certain pollutants from the air through leaf uptake and contact removal. If widely planted throughout a community, trees and plants can even cool the air and slow the temperature-dependent reaction that forms ground-level ozone pollution.

- Providing increased access to recreational spaces and wildlife habitats including greenways, parks, urban forests, wetlands, and vegetated swales.

- Impacting overall human health by providing vegetation and green space.

  Research has linked the presence of trees, plants, and green space to provide a stronger sense of community, improved performance, and even reductions in physical and mental illnesses.

- Improving accessibility by reducing travel distances and improving transportation options by creating nodes such as rideshare and bus stops.

  Community connectivity, or clustering, refers to land use patterns in which related activities are located in proximity to one another. Clustering makes it easier to do things such as run several errands at the same time or socialize.

- Protecting greenfields and preserving habitat and natural resources by clustering buildings.

- Reducing greenhouse gas emissions contributing to the carbon footprint as a result of decreased vehicle use travelling to and from sites.

  Transportation fuel consumption and emissions contribute to climate change, smog, and particulate pollution, all of which have negative impacts on human health.

- Controlling noise levels below 65 decibels that is considered an acceptable level in suitable living environments.

  The Noise Control Act of 1972 (Public Law 92-574) directs federal agencies to comply with applicable federal, state, interstate, and local noise control regulations. Sound quality criteria disseminated by the U.S. Environmental Protection Agency (USEPA), the U.S. Department of Housing and Urban Development (HUD), and the Department of Defense (DOD) have identified noise levels to protect public health and welfare with an adequate margin of safety. Responses to noise vary depending on the type and characteristics of the noise, the expected level of noise, the distance between the noise source and the receptor, the receptor's sensitivity, and the time of day. These levels are considered acceptable guidelines for assessing noise conditions in an environmental setting.

- Reducing light pollution through fixture types, direction of light, lighting control, and improved airfield lighting.

Energy:

Energy is constantly consumed for the operations of every installation. Data is already being collected by installation personnel to capture all energy sources used at the installation, including transportation fuels and mission fuels. Energy sources may include petroleum, natural gas, electricity, coal, and renewable resources such as hydropower, solar, wind, geothermal, biomass, and ethanol. Using existing data, the amount and type of energy consumed is further analyzed to establish a baseline measure for year-to-year comparisons and to monitor the reduction of energy consumption.

Energy usage results in undesired emissions into the environment. Installations typically do not monitor all emissions. Collecting the installation energy data provides the opportunity to calculate a carbon footprint measure (Flying Mission and Mission Support) for the installation that can be monitored year to year.

Water:

The current water distribution systems at most installations and communities are designed to meet multiple supply needs:

- Potable requirements (e.g., drinking, cooking, cleaning, etc.)
- Firefighting
- Municipal, commercial, and industrial needs
- Non-potable applications (e.g., toilet flushing, landscape irrigation, heating, cooling, etc.)

In some areas of the United States, dual distribution systems have been implemented that provide a primary system for delivering high-quality drinking water and a secondary system for non-potable water applications. By using alternative sources for water supplies either to meet non-potable needs or to replenish existing water sources, higher-quality sources of drinking water can be preserved. Capacity and functionality of alternative infrastructure systems need to be considered in cases where separate systems are provided for potable and non-potable applications (e.g., water reuse and recovering gray water, rain water, or storm water).

Per the Energy Independence and Security Act (EISA) of 2007, any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet (SF) shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to temperature, rate, volume, and duration of flow. As mentioned under the Development category, storm water is critical to sustainable development. The combination of reducing water consumption; reusing storm, gray, and waste water as water sources; and treating runoff are sustainability goals related to water/storm water.

Waste:

Solid and liquid waste on an installation consists of paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, and hazardous wastes, each of which take their own time to degenerate. The size of the annual waste stream is determined from monthly waste-hauling reports detailing the total tons and cost of the waste that has been hauled. Waste streams include landfill, recycling, hazardous, compost, and any others that are being used on the installation.

Responsible waste management of hazardous and nonhazardous waste is essential to protecting human health and the environment. This includes conserving resources by reducing waste,

preventing future waste disposal problems by enforcing regulations, and cleaning up areas where waste may have been improperly disposed.

Wastewater is any water that has been adversely affected in quality by human influence. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources. Grey water comprises 50 to 80 percent of the wastewater produced from such activities as dish washing, laundry, and bathing. The amount of the annual wastewater produced on an installation is calculated as a percentage of the reported total monthly gallons and cost of the municipal domestic water consumption.

Treated wastewater can be used for irrigation, fire protection, toilet flushing, artificial wetlands, processing, and cooling towers. Reusing wastewater contributes to conserving water and protecting waterways.

Operations:

Operational BMPs that have been found to be an effective and practical means in protecting or enhancing the environment include such activities as green procurement of goods and services, training, maintenance, and purchasing programs for energy-efficient equipment.

Green procurement is the purchase of environmentally preferable products and services for things such as recycled paper, green cleaning supplies, office products, and printing services. In addition to being cost effective, green procurement reduces the amount of solid and hazardous waste generated and reduces consumption of energy and natural resources.

Proper training of operations and maintenance staff on the use of building systems results in energy savings with minimal upfront investment. The environment benefits from less energy being consumed and less emissions being put into the atmosphere and the building owner benefits from the cost savings associated with less energy being used.

In commercial buildings, use of equipment is the fastest-growing consumer of electricity. Purchasing and using energy-efficient equipment and appliances saves on the total energy being used and the costs associated with their use.

2. Preliminary Research and Data Collection

HQ ACC/A7PS obtained applicable data and reports for the installation from available resources. Examples of reports used as data sources include the Integrated Natural Resources Management Plan, Integrated Cultural Resources Management Plan (ICRMP), Storm Water Pollution Prevention Plan, Integrated Water Quality Management Plan, Drinking Water Management Plan, Pollution Prevention Management Plan, Hazardous Waste Management Plan, Solid and Hazardous Waste Compliance, Economic Impact Statement, Environmental Restoration Program Site Summaries Report, Department of Energy Report, Transportation Fuel Reports, Real Property Reports, and geographical information system database. Information gathered is from resources that already exist. Creation of new reports/data by installation personnel is not required.

3. On-Site Evaluation and Data Collection

A five-person A/E team consisting of two architects, a civil engineer, and two urban planner/designers met with base personnel and surveyed and documented base assets the week of 6 June 2011. While at the installation, the A/E team interviewed available environmental,

engineering, and operations flight staff, such as, but not limited to, natural and cultural resources; air, water, and solid and hazardous waste managers; civil, electrical, and mechanical engineering; community planning; energy and lighting, including high-voltage alternating current (HVAC) maintenance; engineering; procurement; and real property personnel to supplement the data collected previously from HQ ACC/A7PS as well as to collect data not previously obtained.

4. Data Analysis

The data collected was entered in the pre-established spreadsheet form. Pre-established sustainability indicators were calculated that are quantifiable, repeatable, simple, and represent installation-wide sustainability conditions. The metrics establish a baseline for year-to-year comparison, and document compliance or non-compliance with Federal guidance and other applicable agency governances (e.g., Executive Orders (EOs), Energy Policy Act (EPAct) 2005, EISA 2007, MAJCOM directives, etc.).

5. Findings Summary

This report and supporting documentation is a compilation and summary of the information collected and the sustainability indicators calculated for Langley AFB. The data was evaluated using criteria and protocol that is standard to this initiative and provides a consistent reporting structure. HQ ACC/A7PS will review these results and conclusions to identify potential projects, policy changes, incentives, and year-to-year comparisons.

The following defines the sustainability indicators and methodologies in more detail.

Carbon Footprint:

Carbon Footprint is the measure of the impact human activities have on the environment in terms of greenhouse gas emissions produced, measured in tons of CO_2.

Gases that trap heat in the atmosphere are referred to as greenhouse gases. Some greenhouse gases, such as CO_2, occur naturally and are emitted to the atmosphere through natural processes and human activities. Other greenhouse gases are created and emitted solely through human activities. Human activities typically produce the following greenhouse gases:

- **CO_2—**CO_2 is produced through the burning of fossil fuels (oil, natural gas, and coal), solid waste, and trees and wood products. CO_2 is also produced as a result of other chemical reactions.
- **Methane (CH_4)—**CH_4 is emitted during the production and transport of coal, natural gas, and oil. CH_4 emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.
- **Nitrous Oxide (N_2O)—**N_2O is emitted during agricultural and industrial activities as well as during combustion of fossil fuels and solid waste.
- **Fluorinated Gases—**Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes.

In the U.S., energy-related activities account for three-quarters of our human-generated greenhouse gas emissions, mostly in the form of CO_2 emissions from burning fossil fuels. More than half the energy-related emissions come from large stationary sources such as power plants, while approximately one-third comes from transportation. Industrial processes (such as the production of cement, steel, and aluminum), agriculture, forestry, other land use, and waste management are also important sources of greenhouse gas emissions in the U.S. (USEPA).

For reporting carbon footprint, the General Reporting Protocol v1.1 May 2008 from The Climate Registry was used. This protocol was used to calculate the carbon footprint as it is one of the most widely accepted systems in the U.S. and offers a relatively simple approach that can be adapted to installation-wide systems. Where data was available, Scope I and Scope II emissions and some of Scope III emissions have been included. Scope I emissions are all direct greenhouse gases from combustion sources to refrigerant leaks. Scope II includes indirect greenhouse gas emissions from offsite power generation. For this report, Scope III includes an estimate of employee commuting greenhouse gas emissions. Where possible, direct calculations of materials consumed or released to calculate the equivalent greenhouse gas emissions have been used. In some cases, the use of generalized lookup figures and/or averages to generate quantities of emissions has been allowed. It is important to track the greenhouse gas emissions relative to mission fuels and transportation fuels to allow comparisons to other public and corporate entities.

Energy Usage:

Energy usage is integral to every facet of our daily lives and is a critical component of a sustainable installation. The long-term reliance on non-renewable resources can be decreased and renewable resources can be developed in an environmentally and economically responsible manner. This potential for improved energy usage is important as carbon-based energy sources are the most significant contributor to greenhouse gas emissions.

For reporting energy use, actual usage data from the base was captured from reporting practices in the government. For the purposes of this project, the energy usage data was separated into building/site energy and transportation categories. Transportation data was further broken down into flying mission and mission support categories along with quantifying which energy sources are from bio-based (green) and/or renewable sources. These numbers are used to provide energy consumption relative to full-time equivalent (FTE) and installation building square footages along with allowing analysis of green/renewable sources and Flying Mission versus Mission Support consumption. It was important to separate mission energy consumption from standard transportation due to the large amount of fuels required for aircraft. This separation also provides a fair comparison to other public campuses or corporate entities.

Water Conservation:

As the demand for fresh, clean water for irrigation and industry increases, underground aquifers are being drained faster than they can be refilled. Pollution and changing climatic conditions are adding to the burden on fresh water supplies. Poor land development creates more impervious surfaces which generate higher levels of runoff, while more natural areas decrease the amount of runoff.

For reporting water conservation, the domestic water use is captured and compared to the installation population and building square footages for comparison year to year.

Storm water conservation is based on comparing the two-year post development calculation to a two-year pre-development (greenfield) calculation using the U.S. Department of Agriculture, Natural Resource Conservation Service (NRCS), Soil Conservation Service Method as outlined in Urban Hydrology for Small Watersheds Technical Release 55. Any increase in runoff has the potential for contaminated or polluted waters from parking lots, streets, and the airfield to reach water systems off site, resulting in a need for improved containment and/or treatment.

Waste Reduction:

Every economic activity produces waste. The average human uses 45 to 85 tons of materials each year. Due to diminishing resources and recent legislation, bases need to reduce the amount of waste produced and increase the amount of waste recovered. Composting has the potential to significantly alter the amount of waste thrown into local landfills.

For reporting waste reduction, data is captured regarding total waste, landfill, recycling, compost, hazardous, and the costs associate with each. The data is compared to installation population, USEPA recommended guidelines, and tracked year to year.

Land Utilization:

Community sustainability requires a transition from poorly managed sprawl to land use planning practices that create and maintain efficient infrastructure, ensure a sense of community, and preserve natural systems. Many current land use practices have converged to generate haphazard, inefficient, and unsustainable sprawl. Stratified land use policies and inadequate funding for demolition of obsolete facilities isolates employment locations, shopping and services, and housing locations from each other, thereby creating excessive transportation and creating excessive hard surfaced areas.

For reporting land use, source data was gathered on the installation that provides a baseline site area along with area breakdowns for buildable, non-buildable, and habitat areas. Combining this information with building footprints and building areas by category/use codes allows the breakdown of land use and utilization of the installation. Some of the starting basic calculations include total building area relative to the buildable land along with the total non-built or green area relative to the entire site. An attempt was made to provide a reference of built area relative to the site occupancy. Currently, the square footage per FTE being used to provide a comparison of building area against the installation's population and to depict the utilization of the building space is twice the code-recommended square footage.

6. Recommendations

The recommendations described in this report are derived from the specific information obtained at the installation and are intended for further definition and development of projects that would have a direct and viable impact for the sustainability of the installation. The recommendations are categorized within the pre-established sustainability indicators. Ultimately, this list will be used to develop a prioritized group of projects.

II. INSTALLATION INFORMATION

A. Background

Langley AFB is located in the Hampton Roads area, adjacent to the City of Hampton, Virginia. The main base is 2,900 acres and is accessed from the south by North King Street and LaSalle Avenue, and from the west by Sweeney and Langley Boulevards.

The base is located in the Coastal Plain region of Virginia (also referred to as Tidewater, Virginia) and is surrounded on three sides by tidal waters. The Southwest Branch-Back River is to the south, Tabbs Creek and Northwest Branch-Back River are to the north, and the main stem of the Back River is to the east of the installation. The Chesapeake Bay is approximately three miles east of the installation. Plum Tree Island National Wildlife Refuge and Grandview Natural Preserve are located east of the base along the bay.

B. History

Langley AFB is the oldest continuously active air installation in the United States Air Force. Established as an experimental air station in 1916, Langley's rich history parallels the history of manned flight in this country. In 1915, the National Advisory Committee for Aeronautics (NACA) was established for the purpose of continuing aeronautical research and experimentation. The decision was made in early 1916 to develop a joint research facility for NACA, the Aviation Section of the Army Signal Corps and the Navy. Most of the land that was to become Langley AFB was purchased by the government in 1916 for an Aeronautical Experimental Station and Proving Grounds. Consisting of six plantations, the land purchased for the experimental station was named Langley Field, in honor of Samuel Pierpont Langley, a pioneer in American aviation. Construction began in 1917 and operations began that same year.

The United States' entry into World War I resulted in changing Langley Field's original mission from a large experimental station to a fully operational flying field, with NACA as a tenant. Early activities at Langley included the testing of foreign aircraft, bombardment and tactical training, and aerial photography training. During the war, the 1st Fighter Wing (FW) was known as the 1st Pursuit Organization and Training Center. The wing scored its first aerial victory when Lt. Douglas Campbell of the 94th Fighter Squadron downed a German Phalz D-3 over France. By the time the war ended, the unit's name changed to the 1st Pursuit Group and it earned 202 confirmed kills.

Langley's association with lighter-than-air aviation began in 1918 with the arrival of a balloon detachment, and was followed by construction of an airship station in 1919. Several small non-rigid airships were acquired, as well as larger rigid and semi-rigid airships. Langley's association with lighter-than-air vehicles ended in 1935 with the departure of the only remaining airship.

Greater recognition of the Air Corps' basic mission led to reorganization in the 1930s. This resulted in the establishment of the General Headquarters Air Force, with headquarters at Langley Field. While this was not the separate Air Force sought by airmen, it was the first step toward the creation of an autonomous air arm within the Army. Langley rapidly became the U.S. Army's center of tactical aviation. Entry into World War II led to the rapid expansion of personnel and aircraft stationed at Langley Field. The Shellbank Plantation, consisting of 770 acres, was purchased in 1941 to alleviate crowded conditions at Langley when Langley became headquarters of the 1st Bomber Command. During World War II, the 1FW again excelled, earning three Distinguished Unit Citations for outstanding performance of duty. Redesignated as the 1st Fighter Group, the unit entered the war

flying the P-38 *Lightning*. Throughout the war, the 1st FG flew more than 20,000 sorties on 1,405 combat missions, and scored more than 400 aerial kills.

The Tactical Air Command of the Army Air Force established headquarters at Langley in 1946. In 1948, Langley Field was redesignated Langley AFB, after creation of the Department of the Air Force in 1947. In 1958 NACA became the National Aeronautics and Space Administration (NASA) and the first seven astronauts trained in part at Langley. On August 7, 1990, the 1FW, then known as the 1st Tactical Fighter Wing, deployed to Saudi Arabia in support of Operation Desert Shield, adding to the list of firsts by becoming the first U.S. unit to establish air superiority over Saudi Arabia. Through both operations Desert Shield and Desert Storm, the wing flew more than 6,200 sorties and nearly 25,000 flying hours. The wing also recorded an aerial victory when Capt. Steve Tate of the 71st FS shot down an Iraqi F-1 Mirage.

In 1991, the 1st TFW became known as it is today—the 1st Fighter Wing. For most of the 1990s, the wing practiced the lessons it learned in operations Desert Shield and Desert Storm, participating in numerous deployments and exercises throughout the world. Langley continues its role in research and development to the present. Langley AFB continues to be a leader in U.S. air power as the home of the 1st Fighter Wing and its designation as the Headquarters Air Combat Command in June 1992. This was the result of the merger of the Strategic Air Command and the Tactical Air Command. (Langley Design Compatibility Guidelines)

In 2003, the Air Force called once again on the 1FW to provide air superiority in combat. The wing deployed to Southwest Asia in support of Operation Iraqi Freedom where it flew more than 360 training and combat sorties. (http://www.af.mil/news/story.asp?id=123031184)

Joint Base Langley-Eustis was established in accordance with congressional legislation implementing the recommendations of the 2005 Base Realignment and Closure Commission. The legislation ordered the consolidation of the three facilities that were adjoining, but separate military installations, into a single joint base—one of 12 joint bases formed in the United States as a result of the law. Unlike other joint bases that share common perimeters Langley and Eustis are geographically separated by 17 miles.

C. Mission

Langley AFB is home to the Headquarters Air Combat Command (HQ ACC) and the 1st Fighter Wing, which is the Base's host unit. Langley AFB's three components to its mission include:

- Remaining a fully functioning Air Force Base capable of providing air operational support to a broad spectrum of American aircraft in both peacetime and combat environments.
- Sustaining the resources and relationships deemed appropriate to pursue National interests shared by community and governmental agencies.
- Providing for the Command/Control/Communications (C3) necessary to execute the United States Air Force (USAF), Air Combat Command (ACC), and First Fighter Wing (1FW) Vision and Missions. (Langley Design Compatibility Guidelines)

The 1FW operates and maintains the F-22 Raptor with the mission to train, organize and equip expeditionary Airmen; deploy, fight and win; and provide world-class support to Team Langley.

Other organizations at Langley AFB include the 633rd Air Base Wing (ABW), the 192nd Fighter Wing, and the 480th Intelligence, Surveillance, and Reconnaissance (ISR) Wing. The 633ABW is an Air-Force led mission support wing, serving both Air Force and Army units as a result of the joint basing

between Langley AFB and Fort Eustis. The 192D Fighter Wing is a wing of the Virginia Air National Guard that flies and maintains the F-22 Raptor to maintain the highest possible degree of combat readiness for executing directed tactical missions to destroy enemy military forces. The 480ISR Wing operates and maintains the Air Force Distributed Common Ground System (DCGS), otherwise known as the Sentinel weapon system. Associate units at Langley AFB include:

- Air Force Atlantic Area Audit Office
- Air Force Command and Control Integration Center
- Air Force Doctrine Center
- Air Force Liaison (NASA)
- Air Force Material Command Liaison Office
- Air Force Office of Special Investigations Detachment 201
- Air Force Office of Special Investigations Field Investigations Region 2
- Air Land Sea Application Center
- Area Defense Counsel
- Defense Logistics Agency, Defense Contracts Management Command
- Defense Security Service
- Document Automated Printing
- Langley Composite Squadron, Civil Air Patrol
- USAF Judiciary-Eastern Circuit, Northern Region
- U.S. Army Corps of Engineers
- 158th Fighter Wing, Vermont Air National Guard
- 372nd TRS Detachment 18 (AETC)
- 71st Aerial Port Squadron (AFRES)
- 512d Mission Support Squadron (AFRES)
- 622d Communications Flight (622 CF)
- 307th Fighter Squadron
- 710th Combat Operations Squadron
- 735th Supply Chain Management Group

D. Geography

The base has a total area of 2,900 acres.

Coordinates: 37°4'58"N, 76°21'38"W

State: Virginia

City: City of Hampton

Elevation: 3-10 feet above mean sea level

Terrain: Level

Soils: Soils at the developed areas of the base include Udorthents-Dumps, Urban Land, and Altavista-Urban Land. The Udorthents-Dumps and Urban Land soils are a mix of soils likely formed from cutting and filling required to construct the airfield and related areas. Alta-vista Urban Land soils are moderately well-drained sandy loams.

Soils at the undeveloped areas of the base include Lawnes Loam, Augusta-Urban Land, and Bohicket Muck. Lawnes Loam is a mucky loam that occupies tidal marshes. Augusta-Urban Land soils are on stream terraces and range from fine sandy loam to gravelly loamy sand. Bohicket Muck is a silty clay loam/muck that also underlies tidal marshes. (USDA NRCS Custom Soil Resource Report for Tidewater Cities Area, Virginia, 1 September 2011)

E. Climate

Langley AFB is located in a modified continental region resembling other similar regions with warm, humid summers and mild winters.

Temperature: Mean annual temperatures average 59 degrees Fahrenheit (°F). May through September are the warmest months with daytime high temperatures greater than or equal to 90°F. Daytime high temperatures during the winter are near 50°F with nighttime low temperatures in the mid to low 30's°F. The maximum annual temperature is 105°F and the minimum annual temperature is -3°F.

Precipitation: Rainfall averages 47.90 inches annually. Rainfall is generally well distributed throughout the year, but normally July and August are the months of highest rainfall with an average rainfall of 4.86 inches per month. Some snow does fall in the winter with an average annual snow precipitation of 7.5 inches.

Humidity: Relative humidity varies inversely with temperatures, with high humidity in the morning and lower humidity in the afternoon. During the warm season, average humidity is 80 percent in the morning, lowering to 60 percent in the afternoon.

Wind: The predominant wind direction is from the south and southwest. However, depending on weather conditions, occasional northerly winds are experienced. Tornados are rare, with only three significant tornado events reported in the area in the past 54 years. Hurricanes occur in the area generating strong winds and storm surges that can inundate the base and cause damage to buildings and infrastructure.

Air Quality: The base is located in the Hampton Roads Air Quality Region (HRAQR). In 2004, the HRAQR was designated as nonattainment for the eight-hour ozone standard. However, in 2007, the area was redesignated as being in attainment for ozone. The HRAQR is in attainment for the other US EPA-designated criteria pollutants: one-hour ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter (less than 10 and 2.5 microns), and lead (http://www.epa.gov/oar/oaqps/greenbk/ancl.html#VIRGINIA).

F. Demographics

According to the *Fiscal Year 2010 Economic Impact Analysis*, there are a total of over 7,900 active-duty Air Force personnel at Langley AFB, as well as 3,250 civilians. There are 10,542 active duty military personnel dependents. The total annual payroll at Langley AFB is $622.4 million in appropriated military funds. The payroll for appropriated civilians is $124.5 million.

G. Water

Surface Waters

Langley AFB is located on the Lower Peninsula of Virginia, between the Northwest Branch and Southwest Branch of the Back River (a tributary to the Chesapeake Bay). Surface waters surrounding the base are comprised of estuaries with brackish to saline waters. An unnamed tributary creek to Southwest Branch and Tabbs Creek are smaller streams in the area that are receiving water bodies from base runoff. Drainage is poor in these streams, resulting in numerous swampy areas interspersed in the stream corridors.

Groundwater

Groundwater is present in nine aquifers separated by eight confining units within the unconsolidated sediments of the Virginia portion of the Atlantic Coastal Plain. At Langley, AFB, the Water Table Aquifer, the York-Eastover Aquifer, and the Chickahominy-Piney Point Aquifer are the water bearing units.

Potable Water

Potable water for Langley AFB is obtained from the City of Newport News Water Works and complete water treatment is provided by the city's plants. The city draws approximately two million gallons per day (MGD) from the Upper and Middle Potomac aquifers and 45 MGD from surface water sources. The surface water is from a combination of five storage reservoirs and directly from the Chickahominy River. The Base Bioenvironmental Engineer monitors the drinking water quality on the base to assure that the water meets Federal and State health standards.

H. Plants and Animals

The land underlying the base was filled and graded when the base was originally constructed, so natural habitats are not common. However, there are areas of natural wetlands that are on the base fringes and in the Tabbs Creek area. The forests in the Tabbs Creek area are maritime pine-hardwoods and oak-pine forests. The majority of the base consists of managed lawns and landscaped areas with ornamental trees and shrubs. Only the west part of the base (230 acres) is forested, composed of mid-successional pines and sweet gum trees.

Currently, no federally-listed threatened or endangered species are known to occur at Langley AFB. Bald eagles (formerly a threatened and endangered species but still protected by the Bald and Golden Eagle Protection Act) have been known to nest within three miles of the base. Diamondback terrapins (a species of concern) have been known to nest on the base.

I. Cultural Resources

Langley AFB is rich in architectural history. The office of Cultural Resources in the National Park Service Southeast Regional office conducted a survey of the base architectural and historical resources in 1989. Three distinct areas were identified in this survey. These districts are the Heavier-than-Air (HTA) Area, Lighter-than-Air (LTA) Area, and the Shellbank Area. The HTA and LTA areas date back to the beginning of the base, with major construction occurring in the 1930s. Many of the structures in the HTA and LTA areas are eligible for listing on the National Register of Historic Places; there are a handful of archeological sites located within the North Base area and HTA.

Detailed information is available in the Langley Air Force Base Integrated Cultural Resources Management Plan (ICRMP).

J. Recreation

Outdoor recreation opportunities at Langley AFB include hiking, biking, walking, fishing, golfing, skating, jogging, picnicking, horseback riding, boating, and gardening. Bethel Park provides 49-acres of recreational use lands. There is an outdoor running track at the fitness center and a seven mile jogging path is available for use around the perimeter of the airfield.

The Big Bethel Recreation Area is located approximately 2.5 miles northwest of the base and is centered around the Big Bethel Reservoir. The area provides space of picnics, boating and fishing. The Langley Family Camping area (FAMCAMP) is located adjacent to the recreation area, providing 24 recreational vehicle sites with hookups.

K. Regional Priority Credits (RPC)

Regional Priority Credits (RPC) were introduced in the Leadership in Energy and Environmental Design (LEED®) 2009 rating systems to provide an incentive to the achievement of credits that address geographically specific environmental priorities. RPCs are not new LEED credits, but instead are existing credits that the U.S. Green Building Council (USGBC) chapters and regional councils have designated as particularly important for their areas. The incentive to achieve the credits is a bonus point. If an RPC is earned, then a bonus point is awarded to the project's total points. The following RPC's are listed by USGBC for the 23665 zip code:

SSc1 Site Selection

Intent: To avoid the development of inappropriate sites and reduce the environmental impact from the location of a building on a site.

SSc4.1 Alternative Transportation-Public Transportation Access

Intent: To reduce pollution and land development impacts from automobile use.

SSc5.1 Site Development-Protect or Restore Habitat

Intent: To conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

SSc6.1 Storm Water Design -Quantity Control

Intent: Limit disruption of natural hydrology by reducing impervious coverage, increasing on-site infiltration, reducing or eliminating pollution from on-site storm water runoff and eliminating contaminants.

SSc6.2 Storm Water Design-Quality Control

Intent: To limit disruption and pollution of natural water flows by managing storm water runoff.

WEc.3 (Percentage Reduction Required, 40 percent)–Water Use Reduction

Intent: Further increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

III. LANGLEY AFB FINDINGS

A. Description

A set of five sustainability indicators has been established to summarize the installation's level of sustainability: 1) Carbon Footprint, 2) Energy Usage, 3) Water Conservation, 4) Waste Reduction, and 5) Land Utilization. These indicators have been established to consolidate the large amount of data analyzed into a few comprehensive outputs.

The findings associated with the indicators presented below are based on the population and consumption numbers presented in the following table.

POPULATION AND CONSUMPTION NUMBERS, LANGLEY AFB

Base Area (acres)	2,901
Usable Building Area (SF, 2010)	5,424,174
Base Population	
Military	12,846
Civilian	2,331
Dependent Population	2,227
2010 Energy Use	
Electric Use (kWh)[1]	145,172,330
Natural Gas (kcf)[1]	279,044
Potable Water (Mgal)[1]	177
2010 Mission Fuel Usage (gal)	
Aviation Fuels	17,751,858
Diesel	95,523
Gasoline Fuel	105,560
2009 Non-mission Fuel Usage (gal)	
Diesel	126,450
Gas fuel	173,483
Bio Diesel	14,680
Ethanol/E85 Fuel	147
Waste	
Total Waste (tons)[2]	851
Waste Recycled (tons)[2]	402

[1]Does not include military family housing.
[2]Includes landfill, recycling, compost, hazardous, and other
Measured units (e.g., energy, fuels, waste, etc.) are per year
SF = square feet, kWh = kilowatts hour, kcf = thousand cubic feet, Mgal = million gallons, and gal = gallons

B. Current Sustainability Indicators

Refer to the following pages for a summary of findings for the five sustainability indicators for Langley AFB.

1. Langley Carbon Footprint

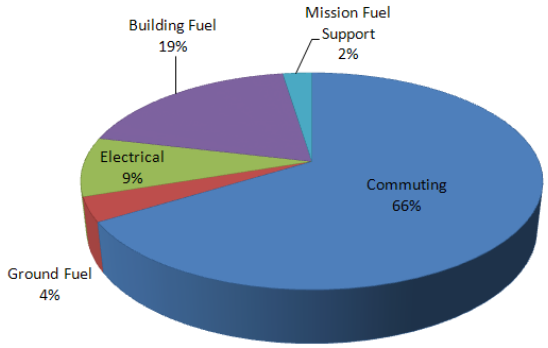
In the context of the ISA, carbon footprint is a measure of the Carbon Dioxide (CO2) and other Greenhouse Gas (GHG) generated to produce energy that is used by the installation. Each energy source has an associated CO2/GHG value based on the source (e.g., gas, coal, solar, etc.) and the process used to convert fuels (e.g. gasoline engine, jet engine, oil furnace, etc.) to a usable form.

Total Carbon Footprint Langley AFB is 197,673 mTons (includes Flying and Support Missions)

ACC and Langley AFB jointly need to establish a goal for the installation's carbon footprint. Currently, based on industry benchmarks, Langley AFB produces a smaller carbon footprint for mission support transportation and facilities and a larger one for flying mission shown on the following page.

Annual Total Mission Support Carbon Footprint for Langley AFB is 27,843 mTons

MISSION SUPPORT—Transportation[5] (No Commuting[3])				MISSION SUPPORT—Facilities[6]		
Annual Total Carbon Footprint:	4,885	mTons		**Annual Total Carbon Footprint:**	22,958	mTons
Baseline (2005):	(A)	mTons/FTE/year	**Per FTE**	Baseline (2003):	1.56	mTons/FTE/year
Previous Year (2008):	(A)	mTons/FTE/year		Previous Year (2009):	1.42	mTons/FTE/year
Current Year (2009):	0.32	mTons/FTE/year		Current Year (2010):	1.51	mTons/FTE/year
Benchmark[1]:	7.54	mTons/FTE/year		Benchmark[1]:	7.54	mTons/FTE/year
% Reduction from Baseline:	-			% Reduction from Baseline:	3%	
% Reduction from Previous Year:	-			% Reduction from Previous Year:	-7%	
Baseline (2005):	(A)	mTons/1,000 SF/year	**Per Built SF**	Baseline (2003):	5.47	mTons/1,000 SF/year
Previous Year (2008):	(A)	mTons/1,000 SF/year		Previous Year (2009):	4.27	mTons/1,000 SF/year
Current Year (2009):	0.90	mTons/1,000 SF/year		Current Year (2010):	4.23	mTons/1,000 SF/year
Benchmark[2]:	20.44	mTons/1,000 SF/year		Benchmark[2]:	20.44	mTons/1,000 SF/year
% Reduction from Baseline:	-			% Reduction from Baseline:	23%	
% Reduction from Previous Year:	-			% Reduction from Previous Year:	1%	



MISSION SUPPORT CARBON FOOTPRINT[4] (INCLUDES COMMUTING[3])

[1]Per the American College and University Presidents' Climate Commitment (ACUPCC), the weighted average for college campus' carbon footprint based on 2008 reportings is 7.54 mTons/FTE.
[2]Per the American College and University Presidents' Climate Commitment (ACUPCC), the weighted average for college campus' carbon footprint based on 2008 reportings is 20.44 mTons/1,000 SF.
[3]Greenhouse gases from personal commuting (i.e., back and forth to work) is not included in the Mission Support Transportation calculation table because personal commuting is not part of the SSPP goals. However, in order to gain an understanding of the base's energy/carbon footprint from commuting it is included in the pie chart as a percentage of the Mission Support footprint.
[4]Definitions for pie chart categories can be found in IV. Glossary of Terms and Abbreviations.
[5]Mission Support—Transportation includes ground fuel and mission support fuel quantities shown in the pie chart.
[6]Mission Support—Facilities includes electrical and building fuels shown in the pie chart.
(A) = Data is incomplete.

1a. Langley Carbon Footprint—Flying Mission

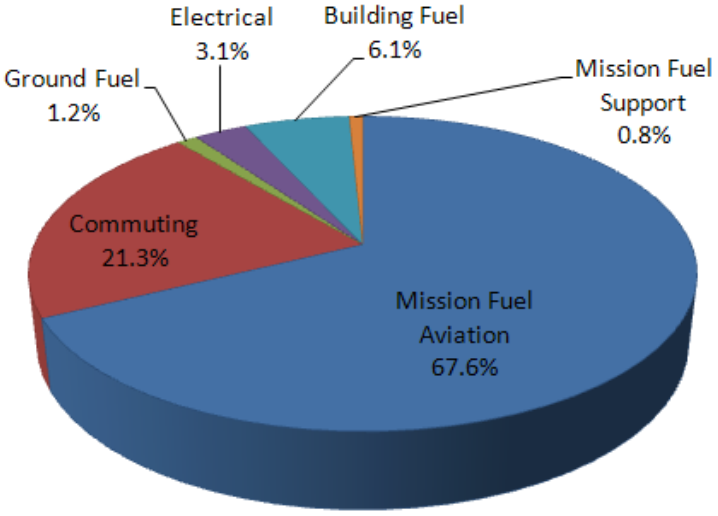
Annual Total Flying Mission Carbon Footprint for Langley AFB is 169,830 mTons

FLYING MISSION[1]

Annual Total Carbon Footprint:	169,830	mTons	
Baseline (2003):	(A)	mTons/FTE/year	Per FTE
Previous Year (2009):	11.79	mTons/FTE/year	
Current Year (2010):	11.19	mTons/FTE/year	
Benchmark[2]:	7.54	mTons/FTE/year	
% Reduction from Baseline:	-		
% Reduction from Previous Year:	5%		

Baseline (2003):	(A)	mTons/1,000 SF/year	Per Built SF
Previous Year (2009):	35.56	mTons/1,000 SF/year	
Current Year (2010):	31.631	mTons/1,000 SF/year	
Benchmark[3]:	20.44	mTons/1,000 SF/year	
% Reduction from Baseline:	-		
% Reduction from Previous Year:	12%		

Flying Mission, Support, and Commuting Carbon Footprint Percentages



TOTAL CARBON FOOTPRINT[4]
FLYING, SUPPORT, AND COMMUTING

- The total grassland needed to offset the total carbon footprint
  for Mission Support is 109,090 acres = 37 times the installation area
  for Flying Mission is 335,530 acres = 115 times the installation area
- The Flying Mission carbon footprint is equivalent to 64 Pentagons
  1 Pentagon = 77,015,000 cu. ft.

[1]From May 2011 to September 2011 (roughly four months) the F-22 was at stand downs. no operations were conducted.
[2]Per the American College and University Presidents' Climate Commitment (ACUPCC), the weighted average for college campus' carbon footprint based on 2008 reportings is 7.54 mTons/FTE.
[3]Per the American College and University Presidents' Climate Commitment (ACUPCC), the weighted average for college campus' carbon footprint based on 2008 reportings is 20.44 mTons/1,000 SF.
[4]Definitions for pie chart categories can be found in IV. Glossary of Terms and Abbreviations.
(A) = Data is incomplete.

2. Langley Energy Usage

Total Energy Usage Langley AFB is 3,241,456 MMBTU (includes Flying and Support Missions)

ACC and Langley AFB jointly need to establish a goal for the installation's energy intensity. Currently, based on industry benchmarks, Langley AFB has relatively low energy usage for mission support transportation and facilities and mission flying.

Annual Total Mission Support Energy Usage for Langley AFB is 848,868 MMBTU

MISSION SUPPORT—Transportation[5] (No Commuting[3])

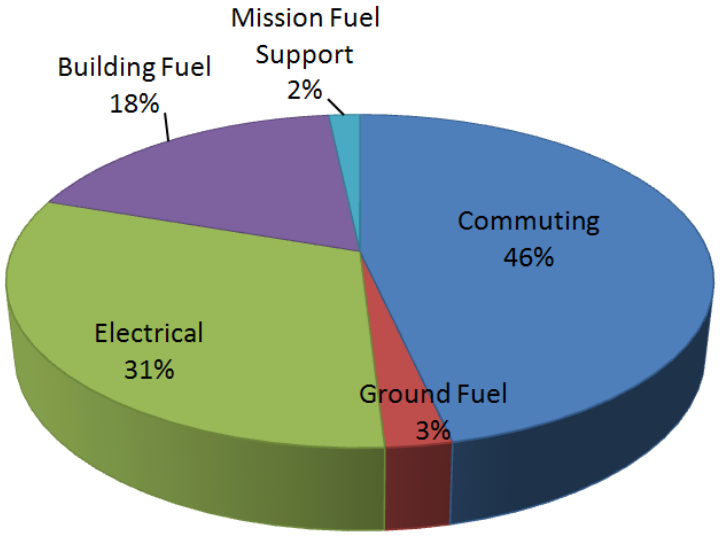
Annual Total Energy Usage:	67,964	MMBTU
Baseline (2005):	(A)	MMBTU/FTE/year
Previous Year (2008):	(A)	MMBTU/FTE/year
Current Year (2009):	4.48	MMBTU/FTE/year
Benchmark[1]:	327.00	MMBTU/FTE/year
% Reduction from Baseline:	-	
% Reduction from Previous Year:	-	

Baseline (2005):	(A)	MMBTU/SF/year
Previous Year (2008):	(A)	MMBTU/SF/year
Current Year (2009):	0.01	MMBTU/SF/year
Benchmark[2]:	0.13	MMBTU/SF/year
% of Energy from Renewable Source:	0.6%	
% Reduction from Baseline:	-	
% Reduction from Previous Year:	-	

MISSION SUPPORT—Facilities[6]

Annual Total Energy Usage:	780,904	MMBTU
Baseline (2003):	45.56	MMBTU/FTE/year
Previous Year (2009):	46.47	MMBTU/FTE/year
Current Year (2010):	51.54	MMBTU/FTE/year
Benchmark[1]:	327.00	MMBTU/FTE/year
% Reduction from Baseline:	-13%	
% Reduction from Previous Year:	-11%	

Baseline (2003):	0.16	MMBTU/SF/year
Previous Year (2009):	0.14	MMBTU/SF/year
Current Year (2010):	0.14	MMBTU/SF/year
Benchmark[2]:	0.13	MMBTU/SF/year
% of Energy from Renewable Source:	1.8%	
% Reduction from Baseline:	10%	
% Reduction from Previous Year:	-3%	



MISSION SUPPORT ENERGY USAGE[4] (INCLUDES COMMUTING[3])

[1]Per the American College and University Presidents' Climate Commitment (ACUPCC), the weighted average for college campus' carbon footprint based on 2008 reportings is 7.54 mTons/FTE.
[2]Per the American College and University Presidents' Climate Commitment (ACUPCC), the weighted average for college campus' carbon footprint based on 2008 reportings is 20.44 mTons/1,000 SF.
[3]Greenhouse gases from personal commuting (i.e., back and forth to work) is not included in the Mission Support Transportation calculation table because personal commuting is not part of the SSPP goals. However, in order to gain an understanding of the base's energy/carbon footprint from commuting it is included in the pie chart as a percentage of the Mission Support footprint.
[4]Definitions for pie chart categories can be found in IV. Glossary of Terms and Abbreviations.
[5]Mission Support—Transportation includes ground fuel and mission support fuel quantities shown in the pie chart.
[6]Mission Support—Facilities includes electrical and building fuels shown in the pie chart.
(A) = Data is incomplete.

2a. Langley Energy Usage - Flying Mission

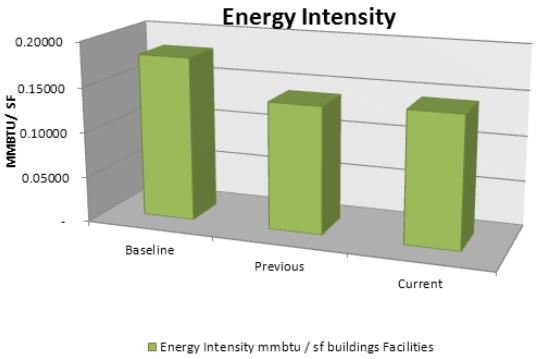
Total Flying Mission Energy Usage for Langley AFB is 2,392,588 MMBTU

FLYING MISSION

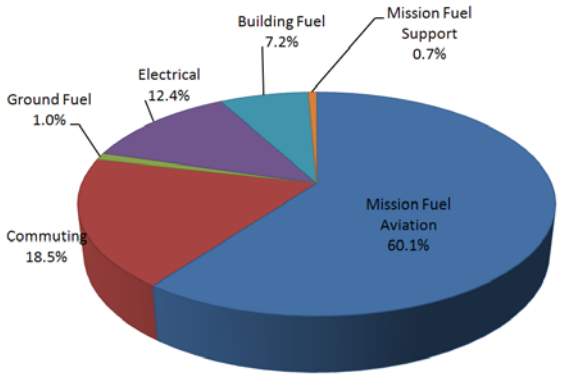
Annual Total Energy Usage:	2,392,588	MMBTU	
Baseline (2003):	(A)	MMBTU/FTE/year	**Per FTE**
Previous Year (2009):	166.15	MMBTU/FTE/year	
Current Year (2010):	157.65	MMBTU/FTE/year	
Benchmark[1]:	327.00	MMBTU/FTE/year	
% Reduction from Baseline:	-		
% Reduction from Previous Year:	5%		

Baseline (2003):	(A)	MMBTU/SF/year	**Per Built SF**
Previous Year (2009):	0.50	MMBTU/SF/year	
Current Year (2010):	0.44	MMBTU/SF/year	
Benchmark[2]:	0.40	MMBTU/SF/year	
% Reduction from Baseline:	-		
% Reduction from Previous Year:	12%		

Energy Intensity per Square Foot of Total Building Space



Flying Mission, Support, and Commuting Energy Usage Percentages



TOTAL ENERGY USAGE[3]
FLYING, SUPPORT, AND COMMUTING

- % of total energy from a renewable source
  for Mission Support is 2%
  for Flying Mission is 0%

[1]Per the American College and University Presidents' Climate Commitment (ACUPCC), the weighted average for college campus' carbon footprint based on 2008 reportings is 7.54 mTons/FTE.
[2]Per the American College and University Presidents' Climate Commitment (ACUPCC), the weighted average for college campus' carbon footprint based on 2008 reportings is 20.44 mTons/1,000 SF.
[3]Definitions for pie chart categories can be found in IV. Glossary of Terms and Abbreviations.
(A) = Data is incomplete.

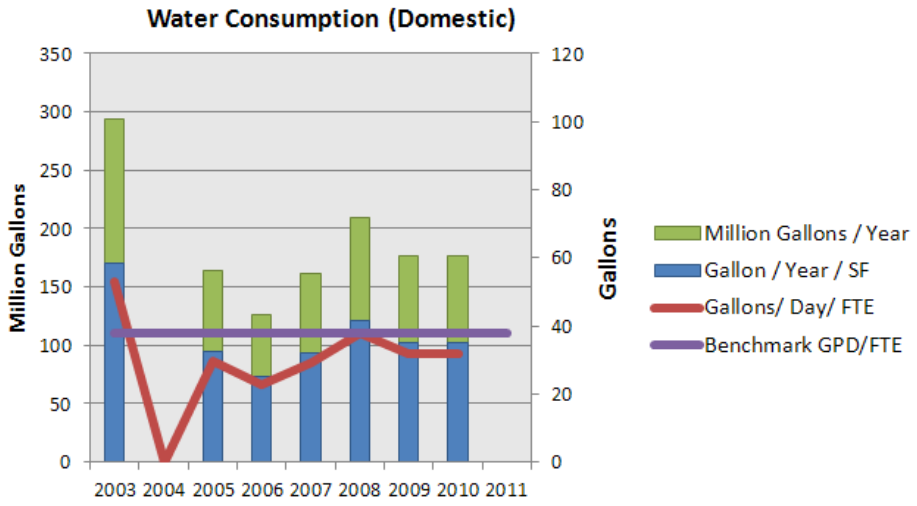
3. Langley Water Conservation

ACC and Langley AFB jointly need to establish a goal for the installation's water conservation. Currently, based on industry benchmarks, Langley AFB has water consumption per FTE within the benchmark range.

MISSION SUPPORT

Annual Total Water Consumption:	176.96	Million Gallons	
Baseline (2007):	29.10	Gallon/FTE/day	**Per FTE**
Previous Year (2009):	31.95	Gallon/FTE/day	
Current Year (2010):	31.99	Gallon/FTE/day	
Benchmark[1]:	28-38	Gallon/FTE/day	
% Reduction from Baseline:	<1%		
% Reduction from Previous Year:	-9%		

Baseline (2007)):	32.03	Gallon/SF/year	**Per Built SF**
Previous Year (2009):	35.17	Gallon/SF/year	
Current Year (2010):	35.21	Gallon/SF/year	
Benchmark[2]:	-	Gallon/SF/year	
% Reduction from Baseline:	<1%		
% Reduction from Previous Year:	-9%		



[1]Per Yudelson Associates, Benchmarking Campus Sustainability, 2010.
[2]Benchmark has yet to be established relative to an AFB. This could be established either through the initial ISA investigation or through an additional research project.

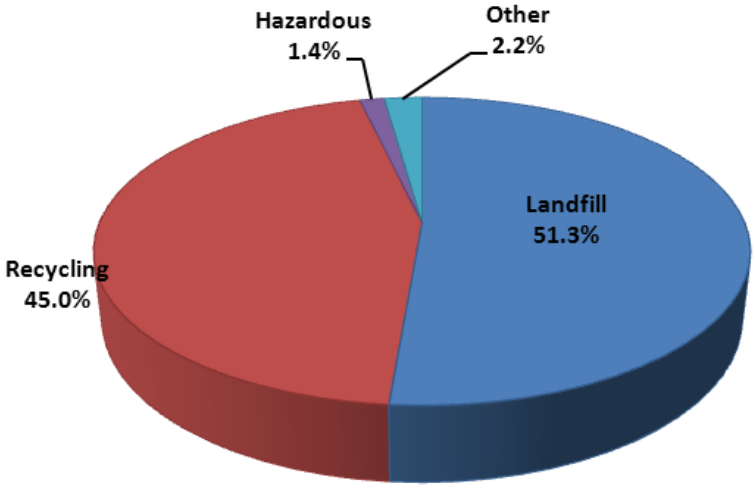
4. Langley Waste Reduction

ACC and Langley AFB jointly need to establish a goal for the installation's solid waste reduction. Currently, based on industry benchmarks, Langley AFB produces a low amount of solid waste.

MISSION SUPPORT

Annual Total Waste Production:	851	Tons	
Current Year (2009):	0.31	LBS/FTE/day	Per FTE
Benchmark[1]:	4.62	LBS/FTE/day	

Current Year (2009):	0.31	LBS/SF/day	Per Built SF
Benchmark[2]:	-	LBS/SF/day	
% Non-Hazardous Waste Diverted from Landfill	-		



- Total % of composted waste material
  Currently is 0%

[1]Per the USEPA Municipal Solid Waste in The United States: 2007 Facts and Figures, the annual municipal solid waste (MSW) generation rate in 1960 was just 2.68 pounds (lbs.) per person per day; it grew to 3.66 lbs. per person per day in 1980, reached 4.50 lbs. per person per day in 1990, and increased to 4.65 lbs. per person per day in 2000. Since 2000, MSW generation has remained fairly steady. The generation rate was 4.62 lbs. per person per day in 2007.
[2]Benchmark has yet to be established relative to an AFB. This could be established either through the initial ISA investigation or through an additional research project.

5. Langley Land Utilization

ACC and Langley AFB jointly need to establish a goal for the installation's land utilization. Currently, based on industry benchmarks, Langley AFB building density is significant under the benchmark of 60,000 SF/acre while the amount of square footage per FTE is significantly higher than the benchmark. Additional studies and comparisons among ACC installations need to be completed to provide a weighted opinion on land utilization.

MISSION SUPPORT

Total Building Density[1]:

Current Year (2010)	2,412	SF/Acre
Benchmark[2]:	60,000	SF/Acre
Previous Year (2009)	2,238	SF/Acre
% Change from Previous Year:	8%	

Total Building Utilization[5]:

Current Year (2010)	357	SF/FTE
Benchmark[3]:	160	SF/FTE
Previous Year (2009)	332	SF/FTE
% Change from Previous Year:	8%	

MISSION SUPPORT

Total % Green Space[6]:

Current Year (2010)	69%	
Benchmark[4]	-	
Previous Year (2009)	69%	

Total % Building/Impervious[7]:

Current Year (2010)	18%	
Benchmark[4]	-	
Previous Year (2009)	17%	

Total % Building/Footprint[8]:

Current Year (2010)	113%	
Benchmark[4]	-	
Previous Year (2009)	105%	

- 12,950 average daily traffic at the gates = 0.85 trips per FTE
- 12.2 people per acre of Mission Support developable area

[1]Building density = Real Property Records building square footage/property acreage.
[2]Per the U.S. Green Building Council (USGBC) LEED-NC guidelines, development density must be equal to or greater than 60,000 SF/acre.
[3]Per building code guidelines, the average gross square foot per FTE figured at 2 times code standard is 160.
[4]Benchmark has yet to be established relative to an AFB. This could be established either through the initial ISA investigation or through an additional research project.
[5]Building Utilization = Real Property Records building square footage/population
[6]% Green Space = Non-Built Green area/Total Installation area.
[7]% Building-to-Impervious = Geobase and real property records, usable building square footage/impervious area.
[8]% Building-to-Footprint = Geobase and real property records, usable building square footage/building footprint area.

C. Year-to-year Sustainability Indicators

This is the initial report for Langley AFB; therefore, year-to-year comparisons do not exist at this time. For reports in future years, comparisons will be provided for the established sustainability indicators:

1. **Carbon Footprint**
2. **Energy Usage**
3. **Water Conservation**
4. **Waste Reduction**
5. **Land Utilization**

D. Current Sustainability Initiatives

Over the years, Langley AFB has undertaken a number of initiatives to reduce consumption of natural resources and its impact on the environment. Future actions planned for the base should enhance and improve upon past actions.

Natural Resource Preservation:

Langley AFB is an installation bounded on the east by the shoreline of a tributary to the Chesapeake Bay. Protecting the quality of the waterway is a significant part of the stormwater management at Langley AFB. The waterway also impacts the land resources of the base through erosion of the shoreline; this was recently addressed through a shoreline restabilization project that included some seawall construction for erosion protection.

Energy Conservation Initiatives:

Langley AFB has taken a number of steps to reduce energy consumption and control costs of energy from its providers.

- Reduction in Energy Consumption:

  The installation is reducing energy consumption by executing an Energy Savings Performance Contract (ESPC) and a Utility Energy Savings Contract (UESC). The contracts include a variety of strategies, such as ground source heat pumps, lighting ballast upgrades, and other short term investment projects. The UESC also includes improvements to the previously mismatched Direct Digital Control (DDC) systems to create an effective Energy Monitoring Control System (EMCS), based primarily on a Siemens platform.

  Langley AFB staff is utilizing the EMCS to watch for trends that identify problems with the building systems connected to the EMCS; one of the items monitored is data from connected advanced meters. The EMCS can be used for controlling building systems based on an operations schedule, however, that function is not currently widely used.

  The installation has completed energy audits exceeding the requirements of Level 2 audits for approximately 40 buildings in FY10 and plans to complete another 40 buildings in FY11. FY10 audits identified a potential for more than 45,000 MBTU of energy reductions, equivalent to annual savings of $566,000. Recommendations from the audit include HVAC motor replacements,

additional lighting ballast upgrades, variable frequency drives on HVAC blowers and better use of the EMCS.

Langley has programmed upgrades to the ramp lighting system that will include additional control options to reduce lighting of unused portions of the ramp.

Langley AFB participates in a demand response program with the electric utility to self-generate 20% of the total electric load of the base (5.4 MW) at a specified time to offset load on the greater electric grid for system maintenance and construction activities.

- Submetering:

  Langley AFB has almost achieved full compliance with current Air Force policy on advanced metering of facilities.

  - Advanced electric meters will be installed on 110 facilities and advanced gas meters will be installed on 31 facilities.
  - Advanced meters are connected to the EMCS for review from a central monitoring station.
  - Some analog meters are still in place for subinvoicing of tenant facilities that do not have advanced meters.
  - All facilities with gas service have some sort of meter for billing by Virginia Natural Gas.

Water Conservation Initiatives

Langley AFB has also reduced potable water consumption through the recently-completed ESPC and UESC, which included installation of faucet aerators and water fixture upgrades. Langley has potential for additional water conservation projects.

A Water Reuse Feasibility study was completed that identified a potential program for retrofitting existing wash racks to recycle wash water. Other options evaluated, including rainwater reuse and wastewater treatment plant effluent reuse, were determined to not be economically feasible.

Langley AFB also recently had a water audit completed as part of a water infrastructure assessment. The audit identified losses in the system through a minimum night flow (MNF) analysis equivalent to 59.7 MGY (million gallons per year). The audit report identified that the total leakage at Langley AFB costs $225,516 per year and that an Economic Level of Leakage, achieved primarily through night time monitoring and repairs, would cost $101,813. The difference of $123,703 represents potential annual savings that could be realized at Langley AFB.

A Sewer System Evaluation Survey (SSES) was completed in 2008. The study included recommendations for $2,500,000 of corrective capital repair and $300,000 annual maintenance for the sewer system to reduce inflow and infiltration (I/I) in the system. The executive summary of the study does not identify potential cost savings resulting from the recommended improvements. A separate study in the 1990s; led to a three-phased approach to improvements for the wastewater system that included repairs in 2005 consisting of mostly slip lining of sewers and some replacements and improvements for the Lighter Than Air (LTA) and Heavier Than Air (HTA) areas that will consists of a vacuum sewer system installation for each area. The 2008 study was unable to determine the effectiveness of those improvements, some of which were ongoing.

Waste Reduction Initiatives

The majority of municipal solid waste from Langley AFB is sent to the local NASA incinerator/steam plant as waste-to-energy fuel. Bulk items and other waste in roll-off containers are sent to landfill.

Langley AFB is currently involved in a temporary activity of crushing a stockpile of concrete from the airfield and roads on base. Crushed concrete is available to contractors for construction projects on base. The activity has been beneficial both for waste diversion and reduced waste disposal costs. Waste management for privatized housing at Langley AFB is managed separately by the privatization contractor.

Langley AFB does limited hazardous waste diversion by recycling silver waste from the dental clinic and F-22 operations, puncturing aerosol cans, and diverting absorbents to the incineration facility. Langley AFB also reduces hazardous wastewater by recycling wash water at the wheel and tires shop, and by operating evaporators for wash water.

The recycling program at Langley includes most recyclable waste materials in a comingled stream, although white paper is collected separately. Revenues from Fort Eustis are currently helping to cover the cost of the Langley program.

Several capped landfills exist at Langley AFB. These capped landfills are considered part of Site OT-64 which is a base-wide groundwater site consisting of 23 individual parcels. Except for IRP sites Landfill (LF)-05 (western lobe), WP-14, SS-24 and OT-51 (at which additional study is planned), groundwater underlying the other 19 IRP parcels of OT-64 is not restricted. However, there are currently 13 IRP sites with Land Use Controls (land use is restricted): LF-01, WP-02, LF-05, LF-07, LF-10, LF-11, LF-12, LF-17, LF-18, LF-22, OT-25, FT-41 and SS-61. Although subject to long-term management, some landfill areas have been successfully redeveloped. Redeveloped landfill areas include the running track, the AAFES mini mall, and the new Visitor's Quarters building. Langley AFB is currently investigating a new Explosive Ordnance Disposal range back by the munitions complex that would also be on a capped landfill.

Other ERP sites include:

Four MMRP sites (SR-148, SR-151, MU-157 and TS-158) are in the study phase and use is restricted until risks are quantified. Currently, one MMRP site (ML-149) is proposed for no action. If accepted by EPA and the state, use will not be restricted.

Five CRP sites that have gone under investigation at the main base: UST-C501, UST-C503, UST-C502, OW-C551 and DA/SD-C514. There is also another site on the main base proposed for investigation: POL Contaminated Sediment at the Fuel Pier

- Two CRP sites (UST-C501 and UST-C503) are in remedial action-operation phase and use is restricted until the sites are closed by the state.
- One CRP site (UST-C502) was recently closed by the state; use is not restricted.
- Two CRP sites (OW-C551 and DA/SD-C514) are in the study phase and use is restricted until risks are quantified.

E. Guidance Compliance Summary and Matrix

Refer to Appendix C to review required compliance with current Federal guidance.

IV. RECOMMENDATIONS

The Langley AFB team has been investigating and implementing a large variety of energy-saving technologies for application into new construction projects. At this installation rich with history, the team is well on its way to reducing resource consumption by incorporating sustainable design into new facilities and adding technology, such as advanced metering, low-flow fixtures, light ballasts, and geothermal, into existing facilities. The staff is already aware of and tracking against SSPP and EO requirements.

Through study and monitoring, the team has already achieved substantial progress in understanding the installation's existing utility and environmental systems and building operations. However, even more will be expected in the future. To name just a few of the demanding goals[2] ahead for members of the federal government, by 2030, all new buildings will need to reduce their fossil fuel-generated energy consumption by 100 percent and, by 2020, greenhouse gas emissions must drop by 28 percent and potable water usage must drop by 26 percent. This is not the first round of tough energy and water reduction goals faced by the Air Force and by the Langley AFB team, and over the last 20 years much of the "low-hanging fruit" has been successfully picked. Our further recommendations to help achieve the new goals fit into the following categories:

- Encourage implementation and/or extension of existing successful programs.
- Enhance sustainability on base for "free" by making the most of natural solutions that mimic ecosystem services and by capitalizing on existing natural assets, such as the sun.
- Implement some "high-hanging fruit" ideas for long-term, significant improvement, possibly requiring programming and investment. Small, incremental gains alone, in many cases, will not be enough to meet the extremely ambitious requirements mandated for the federal government.

Ultimately, the following recommendations should be used to develop a prioritized group of projects.

A. Carbon Footprint

Langley AFB is presently receiving all of its purchased electricity from a local utility company, Dominion Virginia Power (DVP). At present, DVP delivers electricity generated from a mix of fuel sources dominated by nuclear and coal, with gas as another significant fraction, and a small percentage of oil, wind, hydro and other sources.

A.1 Issue/Condition—The peak load during the summer of 2010 at Langley AFB was approximately 27 MW. Base staff did not indicate that they are running any programs for load-shedding to minimize peak use.

Recommendation—Focus on implementing more energy conservation strategies to reduce the total amount and peak rate of energy used. Consider using a sliding scale for thermostat set-points relative to outdoor temperature. A slightly higher interior temperature is more easily tolerated on days where outdoor temperature is significantly increased; increasing the set-point also reduces the electric load for cooling facilities. In addition, review facility schedules, particularly for partially-occupied facilities, to make sure spaces are not being unnecessarily cooled during non-occupied times. In cooperation with facility managers or operations managers, review and determine whether the partial occupancy needs to occur during peak hour use.

[2]See Appendix C for a crosswalk of federal requirements.

Recommendation—If conservation is or becomes capped, consider large-scale opportunities to develop new or replacement on-base electric generation facilities, using a renewable energy source such as biomass or biofuel. These on-site electric generation facilities provide a significant opportunity to help Langley AFB achieve the goal stated in EISA § 433 of using no fossil fuel-based energy by the year 2030, particularly since renewable energy generated on-site counts double towards the goal.

A.2 Issue/Condition—Langley AFB staff has been able to incorporate use of geothermal energy systems into planning for replacement of existing heating and cooling systems at the ACC HQ campus, the Air Base Wing Commander's building, and the Temporary Living Facilities (TLF). Additional geothermal projects should be considered if the technology is proven successful at Langley. Other than the geothermal system put into place, there has been limited use of other renewable energy technologies.

Recommendation—Pursue additional renewable energy technologies for use in heating. A previously completed renewable energy feasibility study reportedly identified solar water heating as a potentially feasible technology for Langley AFB. This should be incorporated into at least one new project so that the technology can be evaluated for effectiveness in the specific climate of Langley AFB, instead of relying solely on estimates of the feasibility of solar water heating. Solar water heating uses could include both heating of potable hot water as well as heating of interior spaces; this type of heating could function either as a standalone system or, more likely, as a system supplementing another heat source. Such systems would also help the base achieve the goals of EISA §523, which calls for 30 percent of hot water demand for the federal government as a whole to be met by solar thermal energy.

Recommendation—Once installed at Langley AFB, solar water heating technologies, as well as any other currently installed technologies, should be studied to measure and verify the benefit of the installed technologies; a new or updated projection of life-cycle cost of the technology, based on measured benefit, should be performed. The study should be summarized in a report identifying the measured benefit and perceived life-cycle cost that can be used by designers for considering maximization of the actual, verified renewable energy potential of new projects at the installation.

A.3 Issue/Condition—The base has still been operating some fuel oil heating systems at golf course maintenance facilities, partly due to their remote locations.

Recommendation—With moderate solar potential at Langley AFB, solar heating walls may be another technology to consider. Solar heating walls utilizing thermosiphoning with operable dampers can accept heat input during the winter and discontinue use during warmer summer months. Adaptations with vents, which allow discharge of interior warmed air to the outside, can also assist with natural air ventilation during more temperate spring and fall months. These principles may be particularly applicable to the golf course maintenance facilities where temperature set-points outside of the base standard may be acceptable due to the nature of the maintenance facilities. Similarly, this practice would be more applicable to shops and warehouse areas than office spaces.

A.4 Issue/Condition—While the tendency to utilize the local utility for electric supply is understandable from a cost perspective, the ability to generate more power on-site would reduce the facility's dependence on outside sources. At present, there are no efforts to decrease the dependence on outside energy producers aside from incorporation of geothermal loops into several new projects. Increasing Langley AFB's on-site generation capacity through the development of a waste-to-energy or biomass boiler facility, using current technology, would also provide significant opportunities to re-centralize the heating and cooling systems of the base by developing those facilities as co-generation

facilities. Such systems would be classified as a source of renewable energy. One forward-thinking project would be a co-generation facility that would generate power through biomass or biosolids gasification or combustion; this process would develop steam to turn turbines to power the electrical grid and provide heating and cooling with steam-powered chillers. Plasma arc technology is another option for an on-base generation facility; however, the technology is not as widely available commercially for waste-to-energy facilities as is fluidized bed combustion technology, which could be used in a combustion type facility.

The use of fewer, larger pieces of equipment in central plants can result in energy savings and decrease maintenance costs. For example, a larger chiller results in a lower cost per ton for maintenance; it also requires a smaller number of pounds of refrigerant per ton to generate air conditioning. A central location for servicing the equipment and storing parts, tools, refrigerants, and chemicals can minimize maintenance and enhance safety for the maintenance staff and building occupants.

Distribution lines (pipes) using current design practices and materials require very little maintenance once they are installed in the ground; in most cases, they have a life expectancy of 50 plus years. Central systems with underground distribution pipes could include the following:

- Steam and steam condensate at anywhere from 15 to 150 lbs. per square inch
- Heating hot water at anywhere from 120F to 350F (medium temperature, pressurized hot water system)
- Ground source geothermal with temperatures from 35 to 95F
- Solar thermal with temperatures from 120 to 210F for heating systems or domestic hot water systems
- Compressed air
- Chilled water for air conditioning with temperatures from 38F to 50F
- Ice storage water with temperatures from 35 to 45F
- Condenser water from cooling towers to chillers or heat pumps at temperatures from 35 to 95F
- River water (another geothermal resource) for condenser water on chillers or heat pumps at temperatures from 35 to 85F.

Recommendation—These projects can provide long-term dividends for energy cost reductions and meeting federal requirements. Executive Orders 13423 and 13514 mandate renewable energy goals for the federal government as a whole, and MSW incineration and biomass combustion are considered "renewable" for purposes of compliance. EPAct 2005 §203 dictates that the facility receives double credit towards the renewable energy mandate for generating that energy on a federal facility. In considering this type of project, the base must also account for its impact on other environmental and sustainability considerations, such as potentially negative impacts on air quality and positive impacts on solid waste management and the local economy.

A.5 Issue/Condition—The average commuting distance for Langley AFB personnel is estimated at 16.8 miles for appropriated funds employees, and traffic congestion is relatively minor. As a result, alternative modes and methods of transportation to/from the base, including ride-sharing, have never been fully embraced.

Recommendation—Create a base-wide, ride-share program to encourage carpooling. Provide preferred parking (the closest spots to the building aside from handicap parking) for car/vanpools.

Preferred parking spots not only encourage ride sharing but also contribute to Leadership in Energy and Environmental Design (LEED) certification of buildings.[3]

Recommendation—At an average of 15 mph (a reasonable speed for an inexperienced cyclist), a bicyclist can do a four-mile commute in 16 minutes. At 16.8 miles for the average commuter at Langley AFB, this means over a one-hour commute, along roadways not made to accommodate safe bicycling, which may not be very appealing to most individuals. However, once on the base, the relatively small size of each of Langley AFB's three main areas makes it easy to traverse on a bike for small errands within those areas. Therefore, the purchase of unit-owned bikes (with helmets and locks) for use on and around the installation should be considered. These bikes can be used for free by unit personnel for short-distance errands within the administrative, unaccompanied housing, and flightline areas of the installation without the inconvenience of moving a car and finding a parking spot for a short trip. Installation of bike racks at main facilities on the installation would complement the purchase of unit-owned bikes.

In conjunction with unit-owned bikes, the installation should accommodate bike travel on main thoroughfares by programming key roads with a wide shoulder or bike lane. Bikeways targeting commuters would connect the primary mission areas with the services/administrative areas and the on-site housing.

Recommendation—Teleworking is another means to reduce the carbon footprint resulting from the commute of Langley AFB personnel, as it eliminates the need for travel. Consideration should be given to teleworking as a means to reduce the Langley AFB carbon footprint as well as achieving goals stated in the DoD Strategic Sustainability Performance Plan A teleworking policy may require planning for implementation of technology to allow working on secure data from a remote location.

A.6 Issue/Condition—Langley AFB and Fort Eustis, now combined as Joint Base Langley-Eustis (JBLE), both send municipal solid waste to the Hampton/NASA Steam Plant for incineration as a waste-to-energy fuel supply. The amount of MSW accepted at the steam plant is occasionally limited by capacity of the plant. The steam plant is located significantly closer to Langley AFB.

Recommendation—As operations under the joint-base arrangement become more coordinated, Langley AFB and Fort Eustis should attempt to coordinate disposal activities to minimize the amount of vehicle miles traveled. A review of map information shows that although disposal from Eustis at the landfill may actually require more miles than disposal of Eustis MSW at the steam plant, the increase in miles is less than the extra miles to ship waste from Langley AFB to the landfill. A coordinated effort to maximize the amount of waste from Langley AFB shipped to the steam plant should reduce total vehicle miles travelled for JBLE MSW disposal.

B. Energy Usage

Langley AFB staff has implemented a wide variety of technologies at the installation to discover appropriate means for managing energy use. Future projects should continue the approach of discovering energy conservation technologies, and build upon the lessons of previously-completed, trial projects to maximize the potential environmental and financial benefits of efficient use of energy at the installation.

[3]To earn LEED credit 4.4 "Alternative Transportation: Parking Capacity" under Option 1, a building project must fulfill two requirements: the size of parking capacity must not exceed minimum requirements and the facility must provide preferred parking for carpools and vanpools for 5 percent of the total provided parking spaces.

B.1 Issue/Condition—Langley AFB purchases electricity from Dominion Virginia Power (DVP) IAW rate schedule GS-3 (Large General Service Secondary Voltage). Schedule GS-3 allows DVP to bill Langley for demand charges associated with Langley's actual peak demands. The kW of demand billed shall be the highest of: A. The highest average kW measured in any 30-minute interval of the current billing month during on-peak hours. B. Seventy-five percent of the highest kW of demand at this location during the billing months of June through September of the preceding 11 billing months. For DVP facilities installed on base Langley AFB pays a fixed fee Facility Charge IAW DVP Terms & Conditions.

B.2 Issue/Condition—Langley AFB's operations staff is actively involved in energy control programs as a means to address the installation's carbon footprint and energy costs. The installation has previously installed a Siemens-based Energy Management Control System (EMCS) that can be used to centrally control temperature set-points and monitor operation of mechanical systems in 110 buildings at the installation. The system is also used to collect data from advanced meters installed. The combined control and data collection system allows the operations staff to control building systems to operate efficiently.

Recommendation—Continue the existing EMCS and Advanced Metering System programs and expand them to more existing buildings where practical. Advanced Metering Systems enable the base energy managers to monitor and document in real time the largest energy users and their energy profiles; with this information, staff can establish programs that will potentially minimize energy usage and costs related to energy billing rates. Installing more of the advanced meters in buildings with EMCS will also allow the energy managers to identify energy wasters and implement demand controlled operations programs to reduce energy costs and make the buildings more energy efficient.

Recommendation—Consider utilizing the EMCS to shave peak use of electricity, particularly that resulting from cooling loads, by a rolling outage of HVAC systems in buildings on the base during high demands. When hot weather is anticipated, couple this program with pre-cooling of buildings to best maintain comfort during the scheduled outage of the building. Such a program can help to limit the peak energy use of the base to avoid additional peak consumption surcharges, but consideration must be given to the cost of wear and tear on HVAC systems and the change in comfort for building tenants.

Recommendation—Consider using available data from the advanced metering systems to establish a mock-billing program for individual buildings and tenants at the installation. This program could be run on a trial basis to gauge effectiveness and then, if shown to be effective, expanded to more facilities on base. Mock-billing makes users at the base more aware of how their actions and the actions taken by others in their building may be contributing to excessive energy consumption.

Recommendation—Install economizers as part of new HVAC systems or where not present in existing systems to use free-cooling when outside air temperatures are low and cooling is required. Some buildings with EMCSs can also use CO_2 monitors to reduce ventilation demand in large spaces when they are lightly staffed so that ventilation equipment doesn't run unnecessarily. Continue this practice on new construction and major renovations for energy savings. This practice also contributes to LEED credits for indoor environmental quality and energy savings.[4]

[4]LEED Indoor Environmental Quality (EQ) credit 1–Outdoor Air Delivery Monitoring and Energy and Atmosphere (EA) credit 1–Optimize Energy Performance.

Recommendation—Langley AFB staff has been involved in upgrading interior lighting systems to use more energy-efficient lamps and installing occupancy sensors to reduce non-occupied use of lighting for areas with low activity. This program needs to continue into the future to accommodate changes in the efficiency of lamps.

Recommendation—The base may consider a study of the nighttime uses of lit parking areas to determine if all parking areas require the lighting that is currently used. If carried over to the daytime use of parking areas, the study may also show that a reduction of parking area is appropriate; refer to recommendations for land utilization for additional information about parking area analysis. Several options for individual control of light fixtures have become available. These options can help the base staff control portions of parking lot lighting systems to provide lighting only where it is needed for security without lighting unused areas. Some technologies also include SCADA feedback for remote monitoring of maintenance needs.

Recommendation—Langley AFB staff may also consider studying the high-mast airfield lighting. Night time review of the lighting by the interview team showed that lighting is generally even with some areas of high intensity, but lighting levels are generally below security standards for restricted areas published in AFI 31-101, "The Air Force Installation Security Program". Review of the airfield lighting also revealed that some of the existing lights may be aimed haphazardly and large areas of the airfield that were lit were not in use. Study of the airfield lighting may recommend improvements for aiming of the lights as well as give consideration to more efficient lighting fixtures that may be able to provide required security levels.

B.3 Issue/condition—Reducing the installation's energy intensity (on a BTU/SF basis) and increasing the use of non-fossil-fuel-generated energy is a complex problem that will be solved only by looking at the base energy situation in a holistic way. The base's infrastructure and facilities systems need to be evaluated, and a resulting energy master plan and program need to be developed as the result of analyzing a tremendous amount of facility, equipment, and energy usage data. An integrated energy master plan can discover base-wide energy savings on the order of 50 percent or better and identify geographically appropriate sources of renewable energy. The function of the master plan is to identify the projects that provide not only the best potential for meeting the goal of 30 percent energy savings by 2015 (EISA §431) and renewable energy goals, but also show economic benefit through a life-cycle cost analysis. An energy master plan goes beyond quick payback periods and individual building projects to illuminate the high-hanging fruit that can provide the greatest energy savings across the entire installation.

Recommendation—Develop an energy master plan to discover the best alternatives to achieve EO, EISA, and EPAct mandates. An energy master plan will identify a base-wide strategy that not only decreases Langley AFB's carbon footprint, but also saves energy use and cost. Alternatives that would be studied and vetted by an energy master plan team would include the following:

A. Use combined heat and power plants (co-gen) that burn biomass or biofuel, if possible, and natural gas, if not. The study would weigh the benefit of on-site renewable energy generation against the relatively low carbon intensity of energy provided by the Virginia Dominion Power.

B. Consider re-implementing district heating and cooling plants on either a large or a more local district scale.

    - District heating enables the use of co-generation plants to heat and power multiple buildings independent of local utilities. In lieu of steam distribution, a high-temperature hot water system

that distributes hot water under pressure could be used to minimize construction and maintenance costs of the distribution network.

- District cooling plants provide the most energy-efficient means to produce air conditioning and also allow more use of thermal energy storage (TES), such as ice storage, to perform electrical peak savings. Developing chilled water overnight results in approximately seven percent savings due to the generation occurring during cooler hours of the day.

C. Change over facilities that use electric heat-to-heat pumps or district heating. A master plan would likely recommend, at a minimum, converting electric-only systems to heat pumps in places that are both heated and air-conditioned, which would also allow retrofitting to district heating in the future.

D. Replace existing heating boilers (and hot water heaters) to 94 percent or higher condensing-type boilers in the event that district heating cannot be used.

E. Use ground source geothermal heat pump systems for future heating and cooling projects if the projects are at remote locations and cannot feasibly be placed on a district system.

F. Use variable refrigerant flow systems that can use internal space heat gains to minimize heating required for the exterior envelope of buildings as an alternative to water-source heat pump systems.

G. Recommend locations for installation of additional advanced meters for electricity and gas to enable individual users to monitor their energy use. Real-time energy use displayed in each facility can result in a significant savings since users take charge of their own habits.

H. Expand the installation of the comprehensive facility-based EMCS that allows trained operations staff to continuously monitor and modify energy use.

B.4 Issue/Condition—Air conditioning systems at the installation are currently a mixture of air-cooled and water-cooled air conditioning systems, generally specific to individual buildings. In general, the air-cooled machines require 1.25 to 1.5 kW per ton of air conditioning to develop the required cooling. Water-cooled systems with screw machines or centrifugal compressors can develop chilled water for air conditioning at less than 1 kW per ton. Not only is the low efficiency of these units creating a greater carbon footprint than water-cooled equipment, but also the loss of refrigerant from the systems is increasing greenhouse gas emissions.

Recommendation—Water-cooled systems for larger facilities will save considerable electrical energy and decrease the amount of refrigerant lost from air conditioning equipment. A large central chiller facility providing chilled water to districts of the base can provide even more significant savings in energy and greenhouse gas emissions. The large distribution system acts as a thermal reservoir (the "flywheel" effect) that a diverse group of buildings use, and a central plant is more efficient in aggregate and easier to maintain than many smaller air conditioning units. Central chilled water plants provide significant opportunities to save on energy use (and therefore decrease the carbon footprint), and can also provide the following benefits:

- Potentially lower maintenance costs and staffing requirements
- Reduce lost refrigerant per year
- Increase occupant safety because no refrigerants are inside occupied buildings
- Improve controllability of air conditioning energy use
- Provide the opportunity to use TES tanks to decrease peak demands
- Provide the opportunity for ice storage to decrease peak demands and improve dehumidification capability

- Enable design of chilled water systems for higher temperature gradients, saving energy and installed costs
- Allow potential for combined heating and cooling with a chiller/heat pump arrangement
- Increase useful space in existing buildings by removing mechanical equipment from buildings
- Eliminate eyesores and the potential for Legionnaires Disease by removing cooling towers where existing water-cooled units are installed. This change would also eliminate the need to store chemicals in occupied facilities.

Recommendation—Since most buildings are provided with gas boilers, consider building Thermal Storage Batteries, similar to ice storage banks. Tie the buildings together with distribution piping to enable the use of either thermal solar systems or ground-source heat pump systems or chiller heat pumps to store low-temperature hot water for heating buildings.

B.4 Issue/Condition—Langley AFB uses the ACC Sustainable Design and High Performance Green Building Design Scorecard as its green building self-assessment metric. The scorecard assembles and consolidates Executive Orders, Public Laws, and Federal Agency rulemaking on Sustainable Development and High Performance Green Building Design requirements with the LEED Rating System. Using the scorecard is a way to achieve the desired LEED rating and meet critical statutory minimum requirements.

When applied in context, the scorecard rating system can illuminate opportunities for sustainable design, often with low- or no-cost choices. Some choices carry an upfront cost but provide long-term operational cost savings and are value-added building features. Starting with programming, the base can direct the design and construction of the building to achieve certain LEED and other federal requirements that base-level engineers deem to add the most value and advance the base towards specific sustainability goals. Without direction otherwise, contractors often choose to satisfy requirements based on upfront cost alone.

Recommendation—Use the ACC scorecard requirements to guide and inform building projects towards lower life-cycle costs and enhanced sustainability.

Recommendation—Train the programming staff and design/engineering staff in the LEED Rating System and scorecard application.[5] A scorecard checklist must be completed for military construction projects, and can also be completed for Sustainment, Restoration, and Modernization building projects to inform their design. The checklist outlines a strategy that will inform all other stages of building design, so it is critical that base-level programmers understand LEED and the application of the scorecard; how it supports broader energy, water, and sustainability goals; and how to choose appropriate points for building projects. The base would do well to have at least one staff member become a LEED AP® or LEED® GA to be a go-to person for assistance with LEED requirements.

Recommendation—Enhanced commissioning of new buildings is a scorecard credit that carries an upfront cost to implement, but provides value to the installation in reducing long-term energy and maintenance costs.[6] As building energy systems become more advanced to meet higher levels of energy efficiency, commissioning becomes even more critical to assure those energy systems function as intended. We recommend enhanced commissioning because of the rapid payback period and long-term operational cost savings.

Recommendation—Choose roofing material and color to earn scorecard credits. For low-slope roofs (≤2:12), the roof surface must have a Solar Reflectivity Index (SRI) of 79 or greater, and for steep-

[5]AFIT's Civil Engineer School offers a one-week course in LEED, for example.
[6]"The Cost-Effectiveness of Commercial Building Commissioning," by Lawrence Berkeley National Laboratory (LBNL), 15 Dec 2004

slope roofs (>2:12) an SRI of 29 or greater is required. One bronze-colored, standing-seam, metal roof product is now available that meets these requirements; however, lightening the color of the roof would bring greater reflectivity and a reduction of heat gain into facilities.

Recommendation—When siting a building and developing early schematic design, maximize the shape and orientation of the building with respect to the sun for passive solar heating, cooling, and daylighting. This siting will maximize the energy performance the building achieves "for free" as a result of the sun and will help earn points in several categories.

Recommendation—Site buildings in places where occupants can walk or bike to adjacent services and amenities instead of driving. Such sitings embody the LEED concept of "Community Connectivity" [7] Include safe pedestrian routes and bikeways in base development plans.

Recommendation—Set aside 5 percent of parking for car/vanpools and 5 percent for low-emitting vehicles in preferred locations near building entrances. This embodies the LEED concept[8] and encourages alternative transportation.

Recommendation—Maximize water use reduction in all new buildings. By choosing plumbing fixtures that use less water than the fixture requirements passed in the Energy Policy Act of 1992, projects can earn scorecard points[9] and will also assist the base in achieving the potable water reduction goal of 26 percent reduction by 2020 compared to a 2007 baseline.[10]

C. Water Conservation

The Langley AFB team has been approaching water conservation at the base by executing water reuse and water leakage studies as well as incorporating water reducing measures through ESPCs and UESCs.

C.1 Issue/Condition: Average annual rainfall at Langley AFB is nearly 48 total inches and the rainfall is on average distributed fairly evenly across all twelve months of the year. Rainwater harvesting for large-scale irrigation was determined by the water reuse feasibility study to not have a good return on investment at Langley AFB. .

Recommendation: Although rainwater harvesting may not have a good return on investment for large-scale irrigation, landscapes that are designed with native species will effectively use the rainfall and not require long-term irrigation. Langley AFB is currently following a policy of no new potable water source irrigation systems. A likely next step for Langley AFB to further reduce water consumption would be the use of rainwater harvesting for any landscaping needs. The Commonwealth of Virginia allows collected rainwater to be reused for non-potable uses such as toilet flushing, linen washing, facility cleaning and irrigation. Virginia also allows for installation of approved treatment systems so that rainwater can also be used to supplement potable water uses.

Recommendation: Rainwater harvesting is utilized by the golf course where rainfall runoff drains to the existing ponds at the golf course that are used for irrigation. The ponds are supplemented with potable water when necessary. Expanding the capacity of the golf course ponds and collecting

[7]Sustainable Site Credit 2.
[8]Sustainable Site Credits 4.3 and 4.4.
[9]Water Efficiency Credit 3.1 and 3.2 and Innovation and Design Credit 1 are all achievable by achieving gradually higher water efficiency. Under LEED NC v2.2, a maximum of three points can be earned by reducing water use by 40 percent. Under LEED NC v3, a maximum of five points can be earned with 45 percent water use reduction.
[10]Executive Order 13514 §2(d)(i).

rainwater in nearby areas to pump water back to the golf course ponds may at least be more economical than the effluent reuse system proposed in the water reuse study.

Recommendation: Langley AFB is located in a relatively humid climate that produces a significant amount of air conditioning condensate from air-handling units. The condensate is generally good quality water and could be used without treatment for non-potable water uses. Combining multi-unit drains into storage tanks and pumping the water to cooling towers for makeup water or for flushing toilets in facilities can result in a significant amount of water. This use especially applies to medical clinic units due to the high percentage of outside air used in these facilities.

C.2 Issue/Condition: Langley AFB is bounded on the east and south by branches of the Back River, which is tributary to the Chesapeake Bay. Discharge of pollutants to these waters in storm water runoff is closely reviewed and regulations for those discharges are becoming stricter. Langley AFB has been proactive in minimizing the discharge of pollutants through storm water by producing manuals to educate contractors on Storm Water Pollution Prevention Plan (SWPPP) requirements and designers on the best Low Impact Development design techniques at Langley AFB.

Recommendation: Langley AFB should maintain and updated the manuals produced as regulations are updated or based on performance of Low Impact Development techniques at the base. The manuals are helpful and informative, but only if they are kept current, with both updates to the regulations as they are renewed and the technologies as they are improved.

D. Waste Reduction

Langley AFB reduces waste disposal from the base by running programs to limit the total amount of waste generated at the base.

D.1 Issue/Condition: Langley AFB is running a temporary on-base concrete recycling operation to recycle concrete debris from recent airfield and roadway reconstruction projects. The debris has been stockpiled at a single location on base where it is crushed and stockpiled for free use by contractors working on base.

Recommendation: Maintain the area as a central location for on-base stockpiling of concrete debris from new projects. A stockpile can be generated until such time as it is cost-effective to renew the temporary crushing program. The base should consider charging for the crushed concrete at a cost per ton lower than new aggregate, instead of providing to contractors working on base at no cost, or allow contractors to perform their own crushing of the concrete debris. Charging for crushed concrete or allowing contractors to perform crushing can provide a means for maintaining a diversion program that already has space allocated on base. Besides reducing the actual material cost for projects, the low-cost crushed concrete material will have a smaller carbon footprint due to reduced production and hauling operations compared to new aggregate material. The crushed concrete can also be beneficial to projects pursuing LEED certification as a reused material. If the existing stockpile is aesthetically not pleasing, consider planting trees at the perimeter of the designated area or provide other screening.

D.2 Issue/Condition: Construction teams executing new construction or major renovation projects must divert at least 60 percent of construction and demolition debris away from the landfill via recycling or reuse, regardless of contracting vehicle (USACE, AFCEE, etc.).[11]

[11]Required by Guiding Principles for Federal Leadership in High Performance and Sustainable Building Memorandum of Understanding (MOU) and Executive Order 13514.

Recommendation: Require all projects teams, regardless of funding source or execution agency, to divert 60 percent of construction and demolition debris away from the landfill and provide reporting of the total diversion directly to appropriate personnel in CES for tracking of construction debris diversion. This will meet the requirement found in the newly published DoD Strategic Sustainability Performance Plan, 2010, and will earn LEED Materials and Resources credit 2.1 "Construction Waste Management-Divert 50 percent from Disposal." ACC command level guidance will also identify 60 percent diversion as a requirement. Another possibility is to write performance-based contracts that encourage teams to achieve 75 percent or higher levels of waste diversion in support of LEED MR Credit 2.2. This requirement should also help to support the concrete stockpile recommended above, just as the stockpile will help support this requirement.

E. Land Utilization

E.1 Issue/Condition—By 2030, all new buildings will need to reduce their fossil-fuel-generated energy consumption by 100 percent, with intermediate goals in the intervening years (i.e., 50 percent by 2010). The Air Force is also required to reduce its energy intensity (BTUs/SF) by 30 percent by 2015, and to reduce greenhouse gas emissions by 28 percent by 2020. Enacting such dramatic improvements in energy efficiency without dramatic construction cost increases will require taking maximum advantage of "free" energy savings. Passive solar design of buildings can reduce a building's energy demand by as much as 30 percent, at essentially no cost. Langley AFB cannot afford to develop new buildings without maximizing solar orientation for energy savings.

Recommendation—Maximize solar orientation through land development planning. All future area development plans (ADPs) in areas without an established road system must be laid out and new buildings must be oriented such that solar heat gains/losses are optimized. This is generally with the long axis of buildings east-west and solar exposures to the north and south. The layout of new streets in an ADP often dictates the future orientation of buildings toward the street and as such, aligning the street grid according to the sun is critical. Aligning streets and buildings on an east-west axis will serve the dual purpose of also optimizing those buildings to host rooftop solar panels, should such an opportunity arise. To ensure compliance, any ADP or building not designed to optimize passive solar gains should require permission/review from a higher level of authority.

E.2 Issue/Condition—Langley AFB uses the ACC Sustainable Design and High Performance Green Building Design Scorecard as its green building self-assessment metric. Use of the scorecard can illuminate opportunities for sustainable development, often with low- or no-cost choices. One opportunity is called "Community Connectivity," which rewards development within a half-mile radius[12] of at least 10 community amenities (restaurants, library, shopping, churches, etc.) and high-density housing, such as dormitories or apartments. There must also be pedestrian access between the amenities, housing, and the building to earn scorecard credit. Langley AFB can apply this metric to future developments and ADPs to see if a plan encourages mixed-use development and connectivity and will enhance the walkability and bikeability of Langley AFB. Developing towards improved connectivity will have many "free" benefits, such as reduced vehicle miles traveled on base, reduced associated greenhouse gas emissions, and improved fitness for those who choose to walk/bike.

Recommendation—Develop, track, and improve over time a community connectivity metric for the installation. Measure the diversity of services/uses within an area with a half-mile radius around future

[12]A half-mile radius was chosen because it is the distance a typical person is willing to walk instead of drive. It equates to roughly a five-minute walk.

development and use the metric to highlight and encourage mixed-use development. This practice will help achieve "free" but meaningful scorecard points.

Recommendation—Seek opportunities to redevelop existing streets as "complete streets" that encourage safe and compatible transportation for all modes, including pedestrians, cyclists, motorists, and future mass-transit shuttle stops, while incorporating sustainable design techniques to minimize the impact of the built infrastructure on the environment.

IV. GLOSSARY OF TERMS AND ABBREVIATIONS

Term	Definition
Alternative work schedule	Work schedules that do not follow the traditional format of an 8-hour day Monday through Friday; alternatively compress the 40 hour work week into fewer days or allow staff to work remotely.
Aviation fuel	All special grades of gasoline for use in aviation reciprocating engines, as given in the American Society for Testing and Materials (ASTM) specification D 910. Includes all refinery products within the gasoline range that are to be marketed straight or in blends as aviation gasoline without further processing (any refinery operation except mechanical blending). Also included are finished components in the gasoline range, which will be used for blending or compounding into aviation gasoline.
Baseline	A standard reference case or condition used as a basis for comparison. Establishing a clearly defined baseline is important and defining a repeatable baseline is essential if the work is to be compared to results of other work.
Baseline year	The year in which the baseline was established.
Benchmark	A standardized problem or test case that serves as a basis for evaluation or comparison. The terms benchmark and baseline are often used interchangeably. Consistent and repeatable benchmarking requires clearly defined performance metrics and protocols for developing the reference case to serve as the baseline.
Buildable area	Land use classification areas including administration, aircraft operations and maintenance, community commercial, community service, manufacturing and production, and medical/dental.
Building Fuel	Includes gas, oil, and liquid propane gas used for buildings.
CO_2 equivalent	A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). CO_2 equivalents are commonly expressed as "million metric tons of CO_2 equivalents (MMTCDE)." The CO_2 equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP. (MMTCDE = (million metric tons of a gas) * (GWP of the gas))
CO_2 equivalent (CO_2e)	A measure for describing how much global warming a given type and amount of greenhouse gas may cause, using the functionally equivalent amount or concentration of CO_2 as the reference. For a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same GWP, when measured over a specified timescale (generally, 100 years).
Carbon equivalent	A metric measure used to compare the emissions of different greenhouse gases based upon their GWP. Greenhouse gas emissions in the U.S. are most commonly expressed as "million metric tons of carbon equivalents" (MMTCE). GWPs are used to convert greenhouse gases to CO_2e–they can be converted to carbon equivalents by multiplying by 12/44 (the ratio of the molecular weight of carbon to CO_2). The formula for carbon equivalents is: MMTCE = (million metric tons of a gas) * (GWP of the gas) * (12/44)
Carbon footprint	The total set of GHG emissions caused directly and indirectly by an individual, organization, event or product.
Climate Registry	A nonprofit collaboration between North American states, provinces, territories, and Native Sovereign Nations to record and track the greenhouse gas emissions of businesses, municipalities and other organizations. Data submitted to the Climate Registry is inputted into the Climate Registry Information System (CRIS), which was developed on EPA's CRAVe-EATS platform.
Commuting	Calculated based on average commuting distance of base FTE using a mix of passenger car and light trucks used for commuting. A typical fuel MPG is calculated for each and summed to calculate the total gallons of fuel used for commuting.
Current year	The FY in progress.
Design guideline	A set of rules and strategies to help building designers meet certain performance criteria such as energy efficiency or sustainability.

Term	Definition
Electrical	Electricity usage entered is for the KWH used by the base annually. Note that the relationship between energy intensity and carbon footprint varies based on the mix of coal, natural gas, diesel, fuel oil, nuclear, wind, solar, and hydro electric energy production within the eGRID region.
Energy	The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Energy has several forms, some of which are easily convertible and can be changed to another form useful for work. Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then used as a transfer medium to mechanical or other means in order to accomplish tasks. In the United States, electrical energy is often measured in kWh, while heat energy is often measured in BTUs.
Energy efficiency	Using less energy to provide the same level of energy service. Also referred to as efficient energy use and is achieved primarily by means of a more efficient technology or process rather than by changes in individual behavior.
Energy intensity	Ratio between the consumption of energy to a given quantity of output; usually refers to the amount of primary or final energy consumed per unit of gross domestic product.
Energy recovery	Includes any technique or method of minimizing the input of energy to an overall system by the exchange of energy from one sub-system of the overall system with another. The energy can be in any form in either subsystem, but most energy recovery systems exchange thermal energy in either sensible or latent form.
Energy Star	An international standard for energy efficient consumer products. Devices carrying the Energy Star logo, such as computer products and peripherals, kitchen appliances, buildings and other products, save 20%-30% on average.
Fiscal Year (FY)	The period used for calculating the annual ("yearly") sustainability indicators. The U.S. government's FY begins on October 1 of the previous calendar year and ends on September 30 of the year with which it is numbered. For example, FY for 2008 is written as "FY08" or as "FY07–08."
Fleet	Two or more vehicles.
Flying Mission	Includes anything that directly effects or has direct participation in flight or deployment operations.
Footprint	The outline of the total area of a lot or site that is surrounded by the exterior walls of a building or portion of a building, exclusive of courtyards. In the absence of surrounding exterior walls, the building footprint shall be the area under the horizontal projection of the roof.
Full-time Equivalent (FTE)	In the U.S. Federal government, FTE is defined by the Government Accountability Office (GAO) as the number of total hours worked divided by the maximum number of compensable hours in a work year as defined by law. For example, if the work year is defined as 2,080 hours, then one worker occupying a paid full time job all year would consume one FTE. Two employees working for 1,040 hours each would consume one FTE between the two of them.
General aviation	That portion of civil aviation, which encompasses all facets of aviation except air carriers. It includes any air taxis, commuter air carriers, and air travel clubs, which do not hold Certificates of Public Convenience and Necessity.
Geographical Information System	An information system that integrates, stores, edits, analyzes, manages, shares, and displays geographic information that is linked to a specific location.
Grassland	Terrestrial ecosystem (biome) found in regions where moderate annual average precipitation (25 to 76 centimeters or 10 to 30 inches) is enough to support the growth of grass and small plants but not enough to support large stands of trees.
Green space	A land use planning and conservation term used to describe protected areas of undeveloped landscape. Also known as open space.

Term	Definition
Greenhouse effect	The effect produced as greenhouse gases allow incoming solar radiation to pass through the Earth's atmosphere, but prevent part of the outgoing infrared radiation from the Earth's surface and lower atmosphere from escaping into outer space. This process occurs naturally and has kept the Earth's temperature about 59°F warmer than it would otherwise be. Current life on Earth could not be sustained without the natural greenhouse effect.
Ground Fuel	Ground Fuel is considered the total of all government vehicle fuel used outside flightline fuel use.
Incentive program	A formal scheme used to promote or encourage specific actions or behavior by a specific group of people during a defined period of time.
Indicator	A parameter, or a value derived from a set of parameters, that points to, provides information about, or describes the state of a phenomenon. It has significance beyond that directly associated with the parameter value. Indicators are one of many tools for simplifying, quantifying, and communicating vast amounts of information in ways that are more easily understood. They are also useful for alerting us to what areas that need more attention, as well as areas that see improvement.
Industrial sector	Construction, manufacturing, agricultural and mining establishments.
Installation	A facility directly owned and operated by or one of its branches that shelters military equipment and personnel and facilitates training and operations.
Land classification	The analysis of land according to its use. Land classifications include agricultural, industrial, recreational, and residential.
Land use	The human modification of natural environment or wilderness into built environment such as fields, pastures, and settlements.
Land use planning	The term used for a branch of public policy which encompasses various disciplines which seek to order and regulate the use of land in an efficient and ethical way.
Leadership in Energy and Environmental Design (LEED)	Green Building Rating System, developed by the USGBC, provides a suite of standards for environmentally sustainable construction.
Lumen	A measure of the perceived power of light.
Meter	Metering devices used on utility mains for electricity, water and gas.
Metric	Any measurable quantity. A performance metric is a metric of some performance characteristic; however, not all metrics are performance metrics. For example, area is a metric, but it is not a performance metric.
Metric ton	Common international measurement for the quantity of greenhouse gas emissions. A metric ton is equal to 2205 lbs. or 1.1 short tons. See short ton.
Military	Any property or aspect of a military.
Mission Fuel	This includes aviation fuel only. That is, the fuel needed for the aircraft to fly..
Mission Support	Includes all other activities on the installation that do not directly affect flight and deployment operations.
Mission Support Fuel	This fuel is used for vehicles working on the flightline. It does not include fuel used for aircraft.
Offset	An agent, element, or thing that balances, counteracts, or compensates for something else.
Performance goal	A specific statement of a desired level of achievement. Performance goals must be measurable and definite such that progress can be evaluated. Performance metrics should be carefully chosen to measure progress toward performance goals.
Performance indicator	A high-level performance metric that is used to simplify complex information and point to the general state or trends of a phenomenon. Performance indicators are used to communicate general trends and are often used on a program planning level to show progress toward goals. See the definition of indicator for more discussion.

Term	Definition
Performance metric	A measurable quantity that indicates some aspect of performance. Performance metrics should measure and communicate progress toward achieving performance goals. There are different levels of performance metrics.
Performance objective	A general statement of a desired achievement.
Population density	A measurement of population per unit area or unit volume.
Potential energy	Energy stored within a physical system that has the potential to be converted into other forms of energy, such as kinetic energy, and to do work in the process. The standard unit of measure for potential energy is the joule, the same as for work or energy in general.
Power generation	The process of creating electricity from other forms of energy. Also known as electricity generation.
Previous year	12-month period prior to the current year.
Procedure	A standard method or set of methods for determining one or more performance metrics.
Procurement	The acquisition of goods and/or services at the best possible total cost of ownership, in the right quality and quantity, at the right time, in the right place and from the right source for the direct benefit or use of corporations, individuals, or even governments, generally via a contract. Simple procurement may involve nothing more than repeat purchasing. Complex procurement could involve finding long term partners or even 'co-destiny' suppliers that might fundamentally commit one organization to another.
Renewable energy	Energy obtained from sources that are essentially inexhaustible, unlike, for example, the fossil fuels, of which there is a finite supply. Renewable sources of energy include wood, waste, geothermal, wind, PV, and solar thermal energy. See hydropower, PV.
Residential sector	An area or portion consisting only of housing units.
Transportation sector	Consists of private and public passenger and freight transportation, as well as government transportation, including military operations.

Abbreviations/Acronyms

AAAF	Alamogordo Army Air Field
Acre	A unit of area equal to 43,560 SF
AFB	Air Force Base
BACnet	building automation and control networks
BMP	Best Management Practice
BTU	British thermal unit: The quantity of heat required to raise the temperature of 1 pound of water 1°F at or near 39.2°F.
BWWSA	Boles Wells Water System Annex
CFS	cubic feet per second
CH_4	Methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent based on the GWP
DoD	Department of Defense
EISA	Energy Independence and Security Act
EMCS	Energy Management and Control System
EO	Executive Order
EPAct	Energy Policy Act
F	Fahrenheit
FTE	full-time equivalent
FY	fiscal year
GHG	greenhouse gas
GWP	global warming potential
kGal	thousand gallon
kW	Kilowatt

Term	Definition
kWh	kilowatt hour
HVAC	high-voltage alternating current
I&I	infiltration and inflow
lb.	Pound
ICRMP	Integrated Cultural Resources Management Plan
INRMP	Integrated Natural Resources Management Plan
LEED	Leadership in Energy and Environmental Design
m	Meter
MMBTU	One Million BTUs. A BTU is the quantity of heat required to raise the temperature of 1 pound of water 1°F at or near 39.2°F.
mph	miles per hour
MSW	Municipal Solid Waste
mTons	metric tones
mW	Milliwatt
N_2O	nitrous oxide
NOAA	National Oceanic and Atmospheric Association
NRCS	Natural Resource Conservation Service
PV	Photovoltaic
SD&HPGBD	Sustainable Development and High Performance Green Building Design
SSPP	Strategic Sustainability Performance Plan
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGBC	U.S. Green Building Council
VMT	vehicle miles traveled
w/m2	watt per square meter
WSMR	White Sands Missile Range

V. APPENDICES (NOT INCLUDED)

A. Data Collection Forms and Supporting Documentation

1. **Development**
2. **Energy**
3. **Water**
4. **Waste**
5. **Operations**

A.1 Development: The following pages include the development data collection forms, data sources and supporting documentation that supports the information reported in the Installation Sustainability Assessment for Langley AFB.

A.2 Energy: The following pages include the energy data collection forms, data sources and supporting documentation that supports the information reported in the Installation Sustainability Assessment for Langley AFB.

A.3 Water: The following pages include the water data collection forms, data sources and supporting documentation that supports the information reported in the Installation Sustainability Assessment for Langley AFB.

A.4 Waste: The following pages include the waste data collection forms, data sources and supporting documentation that supports the information reported in the Installation Sustainability Assessment for Langley AFB.

A.5 Operations: The following pages include the operations data collection forms, data sources and supporting documentation that supports the information reported in the Installation Sustainability Assessment for Langley AFB.

B. Data Sources

The following are data sources received from HQ ACC/A7PS and Langley AFB:

1. Reports
   a. Design Compatibility Standards, Langley AFB, 2010
   b. Integrated Natural Resources Management Plan, 2010
   c. Langley AFB, eGP, as of December 2009
   d. Installation Environmental Restoration Program (ERP) Site Summary
   e. 2010 Economic Impact Statement
2. Langley AFB, Virginia, Miscellaneous Data Provided by Langley AFB
   a. Building Management systems, as of 2010
   b. 7115 Report, as of January 2010
   c. Hazardous Waste Generation/Cost, for 2009
   d. Building Metering Information, as of January 2010
   e. Storm Water Multi-Sector Permit
   f. Hazardous Waste Recycling, for 2009
   g. Buildings Retrofitted with Water Saving Device, as of 2010
   h. Area Development Plans
3. Langley AFB, Virginia, Data Provided by HQ/ACC/A7PS
   a. Mission Fuel Data Use for 2010
   b. Non-Mission Fuel Data Use for 2009
   c. Potable water, Electric, and Natural Gas for the Main Base and Military Family Housing (2003, and 2006-2010)
4. Geobase Data
   a. Data provided by both HQ ACC/A7PS and Langley AFB
5. Meeting Minutes
   a. See the following pages for meeting minutes

C. Expanding Requirements

There are expanding requirements for military facilities constantly being developed and issued. The expanding requirements include new EOs, Statutes, Directives, Rulemaking, and Guidance.

1. EO 13514
2. EO 13423
3. EPAct 2005
4. EISA of 2007
5. Higher Level DoD and HAF directives
6. MAJCOM directives
7. Key Air Force Environmental Goals
8. Other Federal Agency rulemaking and guidance
9. See the following pages for a Crosswalk of regulations

D. References

Building and Electric Metering Data

Cooperative Agreement for the White Sands Pupfish, 2006

Community Center Transportation Improvement Plan, 2010

Langley AFB, 7115 Report

Langley AFB Design Compatibility Standards, 2010

Langley AFB, eGeneral Plan

Langley AFB, Gate Study Out Brief, June 2009

Langley AFB, 2010 Integrated Cultural Resource Management Plan, 2010

Langley AFB, 2010 Integrated Natural Resource Management Plan, 2010

National Renewable Energy Laboratory, http://www.nrel.gov/gis/wind.html

NOAA, 2008, http://lwf.ncdc.noaa.gov/oa/climate/online/ccd/avgrh.html

Toxic Release Inventory

Water metering Data

Z-Transit information

Other publications and websites used as resources:

1. http://epa.gov/
2. http://www.epa.gov/oar/oaqps/greenbk/ancl.html#VIRGINIA
3. http://www.eere.energy.gov/
4. www.un.org/esa/dsd/susdevtopics/sdt_land.html
5. http://www.nps.gov/sustain/spop/jtree.htm
6. http://www.eia.doe.gov
7. ISAUK Research Report 07-01, A Definition of Carbon Footprint, June 2007.
8. http://acupcc.aashe.org/ghg-scope-statistics.php
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