National Aeronautics and Space Administration

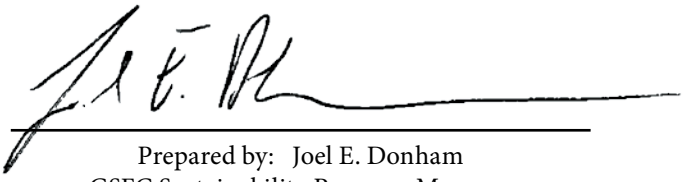
2015
Goddard Space Flight Center
Sustainability Plan



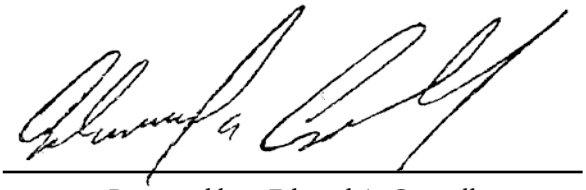


7.21.15 Rev.
www.nasa.gov

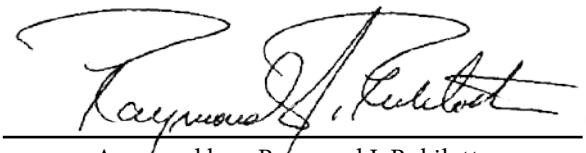
NP-2015-7-311-GSFC



Prepared by: Joel E. Donham
GSFC Sustainability Program Manager



Reviewed by: Edward A. Connell
Chief, GSFC Medical and Environmental Management Division



Approved by: Raymond J. Rubilotta
GSFC Center Sustainability Officer

Executive Overview

Purpose

Following the release of Executive Order (E.O.) 13693: Planning for Federal Sustainability in the Next Decade on March 19, 2015, NASA has reviewed its efforts to ensure the impacts of NASA operations are compatible with the environmental systems that support us. As a global leader in Earth Science, NASA's Goddard Space Flight Center (Goddard) has a unique understanding and obligation to lead the way in identifying and implementing operations strategies to ensure continued human progress, productivity, and prosperity while sustaining natural species and systems.

This plan builds on the 2014 Goddard Space Flight Center Sustainability Status Report (the 2014 Report) to outline initiatives the Center is pursuing to address sustainability objectives expressed in E.O. 13693, other E.O.s, legislation, and regional sustainability issues. The plan focuses on the performance of Goddard's principle facilities in Greenbelt, Maryland (Greenbelt) and at the Wallops Flight Facility in Wallops Island, Virginia (Wallops), however aspects of all planned initiatives will be applied to Goddard's smaller facilities at the Goddard Institute for Space Studies (GISS) in New York, Goddard's Independent Validation and Verification Facility (IV&V) in Fairmont, West Virginia and the White Sands Complex in Las Cruces, New Mexico, where appropriate. Initiatives relevant to each principle facility are identified in section headings by the symbols '*G*' for Greenbelt and '*W*' for Wallops.

Sustainability at Goddard

Goddard views sustainability as a way to decouple the growth of NASA missions from the environmental concerns and impacts that could disrupt future missions – in other words, we want to do more work in science and engineering with less impact on the environment. In the 2014 Report we evaluated the relationships between Goddard's activities and natural systems, resources, and local communities. Now, in 2015, Goddard is implementing strategies at all levels of management and operations to improve these relationships through five sustainability objectives:

Objective 1: Reduce Energy Consumption

Energy is a major operational cost for Goddard ranging from $20M to $25M per year. Additionally, energy consumption by Goddard's buildings and equipment contributes more than 70 percent of Goddard's greenhouse gas emissions (GHGs) reported under the annual Federal Energy Management Program (FEMP) annual GHG Data Report, which includes GHGs from NASA activities, utility purchases, Federal employee commuting and contractors' business activities. Goddard is acutely aware of the impacts of energy use on the environment and on federal budgets, and has a strong program of planning projects and implementing strategies to reduce energy consumption.

One major energy project is the Building Energy and Water Evaluations currently underway (p. 11). The Center expects these evaluations to identify numerous energy conservation measures for each building projected to result in a potential savings of $3M per year for an investment of approximately $350k. These evaluations will identify simple measures, such as replacing broken HVAC thermostats, which have been demonstrated to result in significant energy savings.

Objective 2: Manage Water Impacts

Goddard manages water in three ways: water consumption, stormwater management, and climate and coastal resilience. Water consumption impacts operating budgets and natural resources; stormwater affects Center operations through potential flooding, and the natural environment through high-intensity runoff that can lead to water pollution and erosion; and at Wallops, beach erosion and storm surge have long impacted the facility and are projected to increase in severity as the climate changes.

Regarding climate and coastal resilience, one example initiative is Goddard's Future Coastal and Climate Conditions Assessment. Goddard is planning to develop an assessment of predicted temperatures, sea level changes and other conditions at Wallops and Greenbelt at various stages of climate change. The assessment will support facility planning and design processes about the future conditions Goddard facilities will operate in (p. 25). This process ensures that capital investments made today operate efficiently as rainfall, temperature, storm activity, and sea level rise continue to intensify as they have for the past 150 years.

Objective 3: Reduce Waste

Goddard disposes of tens of millions of pounds of waste every year ranging from acutely hazardous laboratory materials to common trash. All of these materials have the capacity to impact the environment and Goddard takes care to identify opportunities to reduce and properly manage its waste to prevent pollution. Due to the unique characteristics of Goddard's waste composition, Goddard will continue its process of identifying significant waste streams and developing tailor-made solutions to our unique requirements.

This process can be seen in the recent purchase and use of a centrifuge to remove hazardous solvent waste from cleaning wipes used in electronics and spacecraft hardware assembly (p. 28). Centrifuging the wipes reduces the mass of hazardous waste to be disposed by 50 percent and provides wipes that can be reused in less sensitive cleaning applications at Goddard, such as automotive parts cleaning.

Objective 4: Promote Transportation Alternatives

Goddard facilities are located in areas that are difficult to access without a personal vehicle. This reliance on personal vehicles complicates access for people with disabilities and for those who prefer not to drive, leads to increased commuting costs, and contributes 11 percent of Goddard's GHGs as reported on the annual FEMP GHG Data Reports (or the equivalent of 27 percent when accounting for contractor commuting which is not included in the FEMP reports). In the interest of promoting universal and low-impact access to the Center, Goddard is planning numerous strategies to promote transportation alternatives at its facilities.

One project that Goddard is leading for the Agency is identifying a means of facilitating private, fee-for-service electric vehicle charging for employees' private vehicles. This service would support an E.O. 13693 goal to support low-carbon commuting for employees.

Objective 5: Support Local Ecosystems

Goddard manages considerable open space needed to isolate sensitive operations from incompatible private activities and land uses. In keeping with legislative and executive guidance, Goddard manages these spaces to allow native plants and animals that struggle to maintain vitality in the heavily developed mid-Atlantic region.

One specific effort Goddard is planning is to improve management of its forested areas. While Goddard has long managed specific aspects of the forests at its facilities, Goddard is now planning to develop a comprehensive forest management plan to ensure the iconic forests at Wallops and Greenbelt retain vital ecosystem functions while addressing security and safety issues that arise from unmanaged forests.

Pursuing these five objectives will have numerous benefits for both natural systems and for NASA including the following:

- Ensuring that NASA's missions are not adversely affected by changes to the climate, environment, natural resources, civil infrastructure, or energy supplies;
- Mitigating the impact of Center operations on the natural environment; and
- Enhancing the efficiency of Goddard operations by reducing utility costs.

Implementation Strategies

Due to the diverse nature of environmental sustainability issues, sustainability initiatives are pursued using four different implementation strategies at Goddard:

Center Operations Initiatives

Most sustainability goals are directly related to Center operations organizations such as the Management Operations Directorate (MOD) [including the Facilities Management Division (FMD), Logistics and Transportation Management Branch (LTMB), Protective Services Division (PSD) and Medical and Environmental Management Division (MEMD)] and the Information Technology and Communications Directorate (ITCD). Subsequently most sustainability initiatives are implemented by these institutional management organizations. Initiatives led by the MOD and ITCD are identified by their respective logos above.

Goddard Voluntary Sustainable Work Practices Program

Some aspects of sustainability, such as recycling and affirmative procurement ("green purchasing") are implemented by all members of the Goddard community and promoted by the MEMD through the Voluntary Sustainable Work Practices Program. Broadly applicable sustainable work practices are incorporated in the Goddard Green Office Program. Offices can participate in the program to receive guidance and recognition for incorporating sustainable practices in their office activities. Initiatives associated with the sustainable work practices program are identified by the Green Office logo above.

Earth Science Research

Goddard's science community supports sustainability concerns by developing science-based management tools through the Climate Adaptation Science Investigators (CASI) program, Mid-Atlantic Coastal Resilience Institute (MACRI), and general Earth and water science research. CASI, MACRI, and other scientists work with NASA management and regional partners to support planning for environmental resilience using state-of-the-art science-based projections of future environmental conditions relevant to each facility — e.g. flooding risk, salt water intrusion in fresh water supplies, temperature regime changes, etc. Initiatives involving the NASA research community are identified by the Global Precipitation Mission (GPM) Core Observatory satellite image above.

Mission Program Innovations

Goddard operates a wide array of equipment to conduct mission activities including rockets, spacecraft production and testing facilities, and world-class supercomputing and communications hardware. This equipment intrinsically uses large amounts of energy and generates potentially hazardous byproducts. Mission leaders, however, are increasingly considering the impacts of their activities on the planet and are striving to reduce impacts while successfully accomplishing missions. The sustainability program at Goddard invites all individuals involved with mission, or any activities at Goddard, to reach out and participate in sustainability planning and project development.

Many sustainability innovations in mission activities involve computing enhancements. To reflect this increased role in mission program sustainability, initiatives directly associated with mission activities are identified by the Discover supercomputer rack image above.

Structure of the Plan

The 2015 Goddard Space Flight Center Sustainability Plan addresses each sustainability objective by discussing requirements from E.O. 13693 compared to previous E.O.s and other requirements, initiatives updated since the 2014 Report, and by presenting three programs of planned activities: a program of standard sustainability practices currently being evaluated for implementation at Goddard; a program of strategic initiatives that will help pave the way for cross-cutting benefits and strategic management; and a more ambitious program of cutting-edge concepts formulated to push Goddard to the next level of leadership in sustainable operations over the next ten years. The practices in this plan are in varying levels of maturity and may not ultimately prove feasible, but will be pursued until they are deemed impractical.

Table of Contents

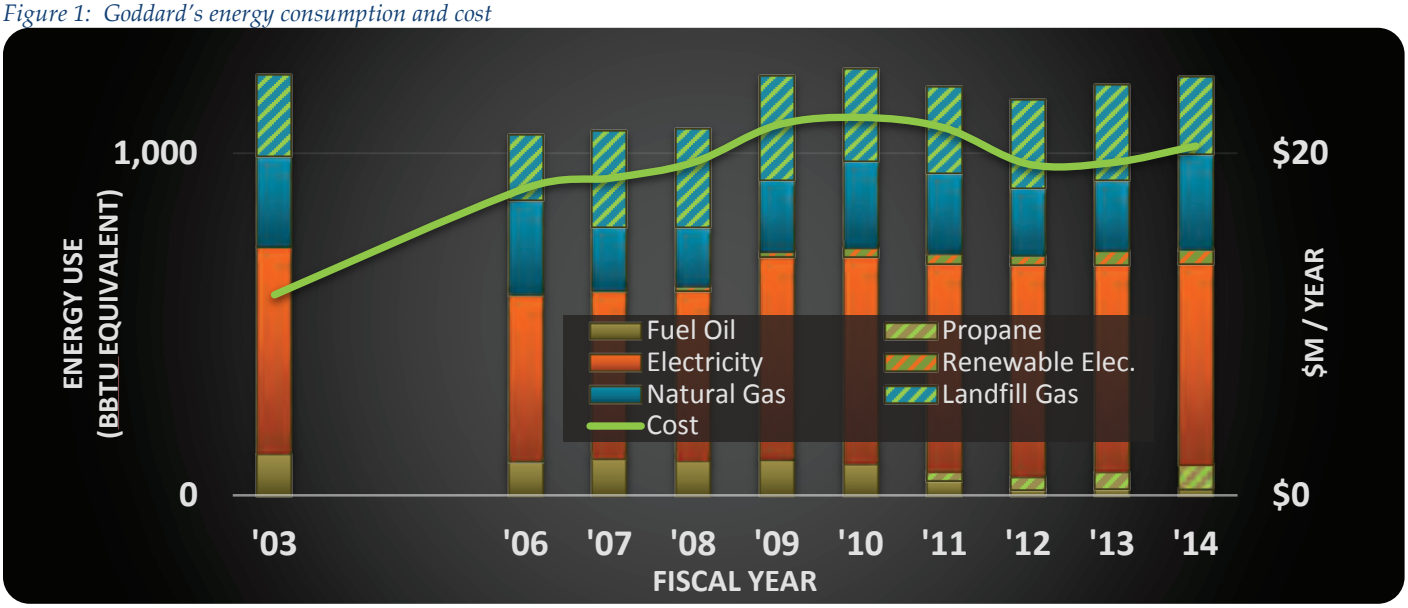
Objective 1: Reduce Energy Consumption

Both principal Goddard campuses have successfully used energy savings service contracts (e.g. ESPCs) to implement energy savings projects. At WFF, one ESPC project has resulted in an 18.4% energy intensity reduction compared to the FY 2003 baseline – and an even greater percentage reduction in total energy use based on the concurrent 10.5% growth in square footage. Energy-efficiency projects at Greenbelt have had a smaller proportional impact due to the significantly larger energy consumption of the entire Greenbelt campus, however, they have managed to control further escalation in energy use that would otherwise accompany the mission growth and facility aging at Greenbelt.

In 2015, Goddard is revising its energy management program to take a more holistic view of energy consumption across the facilities portfolio to ensure that major fundamental building systems are in good repair and operating correctly, and to assess and efficiently manage the ever increasing energy consumption of mission equipment.

On a longer timeframe, Goddard is developing numerous renewable energy concepts to further reduce energy costs and emissions while ensuring continued mission operations success in the face of an increasing need to reduce GHG emissions and energy costs in the future.

Figure 1: Goddard's energy consumption and cost



Energy.1 – Goals

Most of Goddard's energy goals are based on requirements applicable to all Federal agencies. While performance on such goals is assessed at the Agency (i.e. NASA-wide) level, Goddard strives to make proportional reductions to contribute to overall Agency efforts. Goddard's status related to energy conservations goals is provided in Table 1.

Table 1: Goddard's energy goals

Sustainability Concern	Previous requirement (E.O. 13423, 13514, legislation, etc.)	New requirement (E.O. 13693)	Change from previous requirement	Current Status
GHGs	Agencies to set GHG reduction targets for FY 2020 based on FY 2008 levels. NASA set goals of: **18.3%** for Scopes 1 & 2[1], and **12.6%** for Scope 3[2].	NASA set reduction goals of **47%** for Scopes 1 & 2, and **32%** for Scope 3 based on FY 2008 levels.	More than doubles previous goal level.	Most recent (FY 2012) Goddard GHG reduction numbers available: Scope 1 & 2: **4%** reduction Scope 3: **7%** increase
Energy Intensity	Reduce intensity[3] by **30%** from FY 2005 to 2015, based on 2003 baseline.	Reduce intensity[3] by **25%** from FY 2015 to 2025, based on 2015 baseline.	Extends previous **30%** reduction goal to a total reduction goal of **48%** below 2003 levels by FY 2025.	Goddard intensity **27%** below 2003 levels in 2014 (individual reductions were 27.5% and 26.2% for GB and WFF, respectively).[4] Goddard is developing project concepts to reduce energy consumption, but will need Center management support to implement them with direct funding or performance contracts.
Data Centers and Electronics	Implement best management practices for energy-efficient management of servers and Federal data centers.	Install energy meters in data centers by FY 2018. Target PUE[5] of 1.2-1.4 for new data centers and 1.5 for existing centers.	New specific requirements for metering and quantitative performance targets.	Goddard is developing an inventory of data center metering status and PUE at Greenbelt and plans to extend the inventory effort to Wallops. Once the inventory is complete, Goddard will need to address metering gaps and pursue PUE targets.
	Implement power management, duplex printing, and other environmentally preferable practices on all relevant electronic products.	Implement power management, duplex printing, and other environmentally preferable practices on all relevant electronic products.	No change.	Desktop power management pilot in progress.
Alternative Energy	Increase renewable energy use up to **20%** of electricity use in FY 2020 and beyond.	Increase alternative energy[6] use up to **25%** of electric and thermal energy by FY 2025.	Adds separate accounting of thermal energy and extends increases to 2025.	**22%** of 2014 Goddard thermal and electrical energy was alternative, meeting interim target through 2023.
		Increase renewable energy use up to **30%** of electric energy by FY 2025.		**10%** Goddard electricity is renewable in 2015, meeting interim target through 2017.

[1] Emissions from fuel use (e.g. boilers and vehicles), and electricity.
[2] Emissions from employee commuting, third party equipment, etc.
[3] Intensity refers to consumption per square foot of floor area in subject buildings.
[4] Where energy sourced from landfill gas is counted as energy use reduction starting in 2011.
[5] Power usage effectiveness: total amount of electricity and other power consumed in running a data center (i.e. cooling and processing power) divided by the power consumed by data processing alone – lower PUE is more efficient.
[6] Renewable or low-emissions energy.

Sustainability Concern	Previous requirement (E.O. 13423, 13514, legislation, etc.)	New requirement (E.O. 13693)	Change from previous requirement	Current Status
Buildings	In FY 2020 and beyond, design new buildings to achieve net-zero energy by FY 2030.	In FY 2020 and beyond, design new buildings to achieve net-zero energy by FY 2030. Also pursue net-zero waste and water where feasible.	Added motivation for net-zero waste and water.	Currently designing Goddard's first net-zero capable building, B37, to be complete in 2019.
		Identify existing buildings to be net-zero energy, waste, or water by FY 2025.	Added requirement to identify existing buildings to be renovated to meet net-zero standards.	Need to identify potential net-zero existing buildings.
	Ensure new construction, renovation, or building repair complies with the Guiding Principles.[7]	Ensure new construction, renovation, or building repair complies with the revised Guiding Principles.	Address revised Guiding Principles in new construction and major renovation when they become available.	Continue pursuing the 2008 Guiding Principles for new construction and transition to the revised Guiding Principles for new projects entering design after they become available.[8]
	Ensure that at least 15% of existing buildings and leases (above 5,000 sq. ft.) meet the Guiding Principles by FY 2015 and that the Agency make annual progress toward 100% conformance.	Conform to the revised Guiding Principles[9] in 15% of the Agency's building square footage *or* number of buildings >5,000 sq. ft. by 2025, and make annual progress towards 100% conformance.	Guiding Principles to be revised and new target date set for 2025. Agencies can now meet the 15% requirement by number of buildings *or* square footage alone.	One building fully evaluated and confirmed to meet the 2008 Guiding Principles for existing buildings. Waiting to receive revised principles to gauge status on new requirement.
	Energy Managers shall evaluate energy and water consumption in 25% of buildings each year and identify energy and water saving measures.	No new requirement.	No change (previous requirement was from legislation and was not revoked).	Goddard's annual energy auditing programs address the requirement.
	No analogous previous requirement.	Include energy efficiency and energy or GHG data provision requirements in lease solicitations over 10,000 sq. ft., beginning FY 2016.	New requirement.	Will need to include in future lease solicitations.

[7] Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings MOU.

[8] Inferred, expect additional guidance in 8/2015.

[9] To be completed by the Chair of CEQ by 8/15/2015.

Sustainability Concern	Previous requirement (E.O. 13423, 13514, legislation, etc.)	New requirement (E.O. 13693)	Change from previous requirement	Current Status
Performance Contracting	Develop a planned performance contract implementation schedule.	Develop annual performance contracting plans to help deploy water and energy saving measures.	Requires annually updated performance contracting plans.	Plans developed at HQ level, but Goddard is developing proposals for energy performance contracts that will support plan development. Will need support of Center management to implement proposals.
	Enter into $4B of performance contracts government-wide.	Fulfill existing commitments to achieve the $4B government-wide performance contracting goal.	No change.	NASA has committed to sign $74M in performance contracts by end of 2016 towards the $4B goal and has currently signed $52M. Goddard has contributed $2.8M towards NASA's commitment, and is fulfilling three energy performance contracts saving $2.3M in energy per year.

Energy.2 – Updated Ongoing Practices

1. G *Combined Heat and Power Retrofit—no longer being pursued*

Combined heat and power generation (CHP or cogeneration) was discussed in the 2014 Report (p. 20). After a promising Phase I feasibility assessment, Greenbelt conducted a more rigorous Phase II assessment of a CHP system with steam powered chillers to utilize steam in summer when heating demand is low.

Unfortunately, after more rigorous analysis, the CHP system evaluated for Greenbelt was determined not to be financially viable. Goddard may reevaluate the concept as utility markets develop, however, at present CHP is no longer being pursued.

2. G W *Energy and Water Evaluations*

In accordance with requirements for Federal agencies in the 2007 Energy Independence and Security Act (EISA), Goddard is expanding its energy and water evaluation programs at both Greenbelt and Wallops. Greenbelt has partnered with PEPCO Energy Services to perform an energy audit of the entire campus from December 2014 to June 2015, and Wallops has added a requirement to audit 25 percent of the building inventory each year to its O&M contract. The audits will identify energy conservation measures (ECMs) and re/retro-commissioning opportunities that will be pursued through the energy management program.

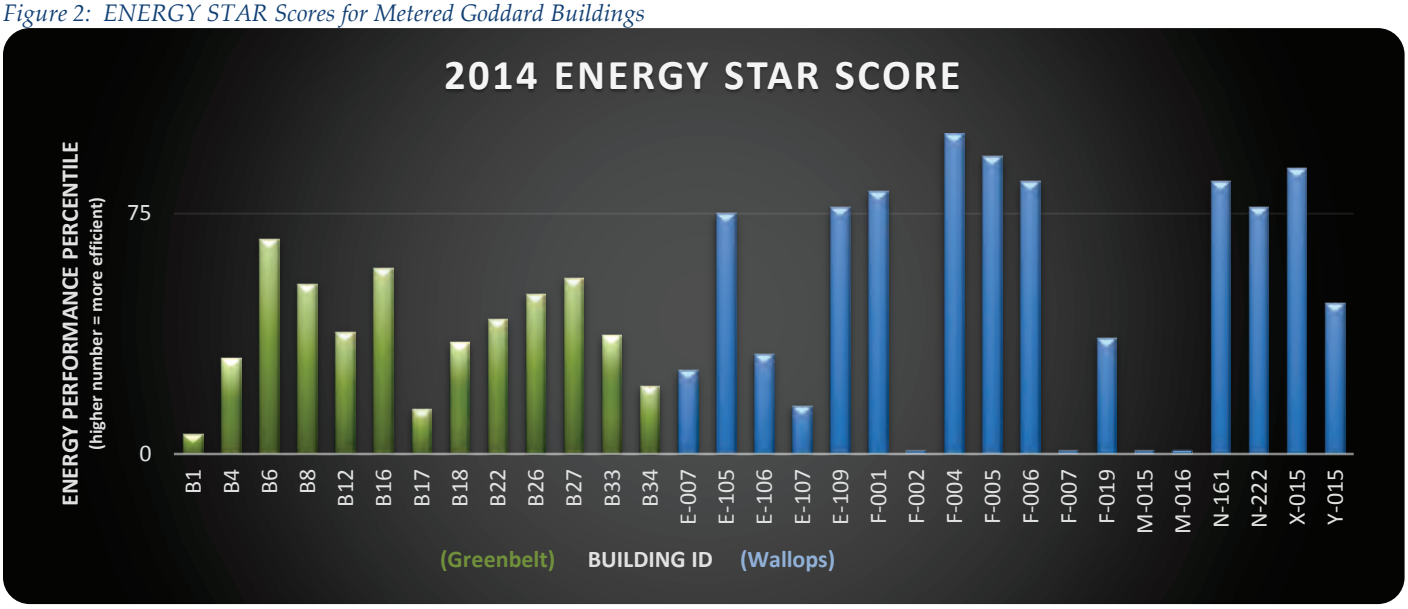
Retro-commissioning provides some of the greatest returns of all types of energy investments. ENERGY STAR® has observed a median 15 percent reduction in energy use for a median expenditure of $0.27 per square foot – the equivalent of about $350,000 for all Goddard facilities.[10] This type of savings at Goddard could result in avoiding $3M per year in energy costs. As an added benefit, retro-commissioning also improves occupant comfort by identifying causes of uncomfortable indoor air temperatures and humidity.

[10] See Chapter 5 of the *ENERGY STAR® Building Upgrade Manual*, US EPA Office of Air and Radiation, 2008 Online, http://www.energystar.gov/sites/default/files/buildings/tools/EPA_BUM_CH5_RetroComm.pdf

3. G W *Benchmark Energy Performance in ENERGY STAR® Portfolio Manager*

Energy benchmarking was discussed in the 2014 Report (p. 22). Since then, Goddard has enrolled all metered Wallops and Greenbelt buildings in EPA's ENERGY STAR® *Portfolio Manager* online software to benchmark and track energy and water performance (Figure 2). *Portfolio Manager* scores buildings' efficiency, corrected for size, weather, and other specifications. Having this regularly updated performance information will improve Goddard's ability to identify poorly performing buildings (i.e. those with low ENERGY STAR Scores) with consideration for year-to-year weather effects and building peculiarities that can make identifying poor performance difficult. This information will help Goddard strategically target corrective action where there is the most opportunity for efficiency gains.

Figure 2: ENERGY STAR Scores for Metered Goddard Buildings



4. G W *Operate Demand Response Program*

Regional electricity demand fluctuates throughout the day, week, and year with the highest peaks occurring during summer afternoons due to increased air conditioning energy demand. Such regional demand peaks can exceed the capacity of local electricity production and distribution systems leading to brownouts and blackouts. As a service to the local community, large energy users like Goddard's Greenbelt and Wallops installations participate in demand response programs to help reduce impacts of peak electricity demand and prevent electricity service failure. Demand response involves reducing grid-sourced electricity consumption during high demand periods to prevent demand spikes that could lead to electricity service failure. Goddard is given a credit on its electricity bills for participating in demand response averaging about $60,000 per year.

At Greenbelt, the demand response program involves cycling HVAC systems where possible, and requesting that staff take voluntary actions to reduce non-critical energy consumption as much as possible through Center-wide "Code Gold Day" email announcements.

The Wallops demand response program takes advantage of its more modern energy management and control system to 'level' HVAC loads by alternating which chillers are running around the entire campus, such that only a fraction of the total number of chillers are running at one time. Greenbelt and Wallops' demand response performance can be seen during a demand response event in 2013 (Figure 3).

In addition to these procedures, Goddard has a second tier demand response program that involves running on-site emergency generators to offset grid-sourced energy demand. Due to the environmental impacts of running the generators, especially during elevated temperatures, the Tier 2 program is only employed during emergencies declared by regional electricity transmission grid managers and limited to 15 hours per year.

As an effort to further strengthen the demand response program, Goddard is currently evaluating the benefits of encouraging staff to telework during demand response events where feasible to further reduce the Center's energy consumption.

Figure 3: Wallops and Greenbelt's Demand Response Performance

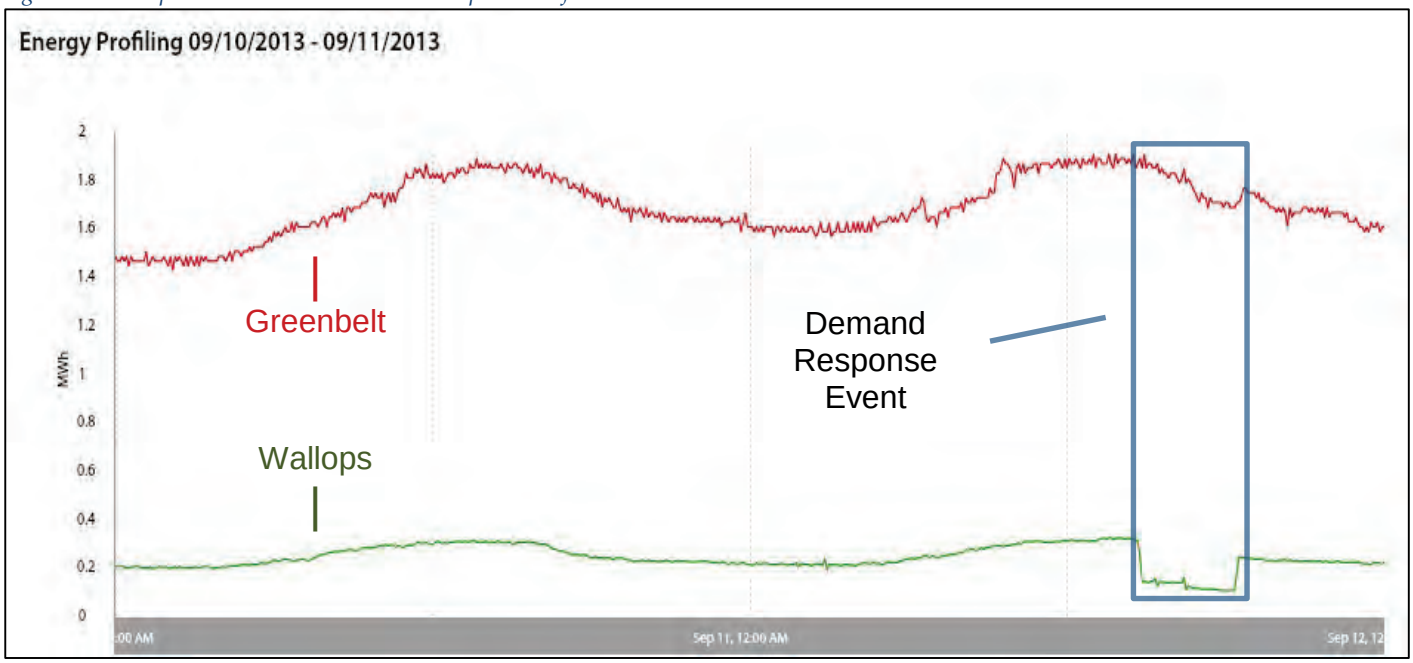


Image Credit: EnerNOC - reproduced with permission

5. G *Implement Modern Energy Management and Control System*

As discussed in the 2014 Report (p. 21), energy metering systems at Greenbelt are insufficient for today's energy monitoring needs. Additionally, the lack of a modern centralized control and management of energy systems makes it impossible for Greenbelt to capitalize on basic energy management strategies (phased equipment startup, set-back control, etc.) or cut back energy demand for the demand response program as evidenced by the difference between Greenbelt and Wallops demand response performance in Figure 3.

Since publication of the 2014 report, Greenbelt has received funding to begin planning and implementation of a modern energy management control system (EMCS). The new system will greatly increase the effectiveness of the EMCS, streamline data collection and processing, increasing the accuracy of reported energy metrics, and reducing the labor required to provide required performance data. Design began in FY 2015 and construction of the new system will begin in FY 2016.

6. G W *Purchase Renewable Energy Credits (REC)*

Because Goddard does not currently operate or host any renewable electricity generation, Greenbelt purchases renewable energy through its general electricity contract and Wallops purchases RECs to contribute to Agency-wide renewable energy goals. In 2014, Greenbelt and Wallops purchased 7.5 percent of their combined electrical energy from renewable sources and is currently on track to purchase 10 percent in 2015.

7. G *Use Landfill Gas to Offset Natural Gas Consumption*

As discussed in the 2014 Report (p. 16), Greenbelt has used landfill gas (LFG) to offset traditional natural gas use since 2003. While the LFG is projected to last until 2030, Greenbelt is constantly pursuing additional alternative energy and energy conservation measures to ensure continued performance on alternative energy goals when LFG eventually runs out.

8. G W *Implement User-end Data Center Efficiency Strategies*

The 2014 Report discussed numerous strategies for reducing energy consumption and cost of data centers (p.27). MEMD has begun to pursue such practices by transitioning its hazardous materials management system (HMMS) application from dedicated server hosting at Greenbelt to a virtualized cloud environment hosted by the Defense Logistics Agency.

9. G W *Inventory Data Center Metering Status and Efficiency*

As part of the building energy and water evaluations (p. 11), FMD is compiling a comprehensive data center inventory, metering evaluation and power usage effectiveness (PUE) assessment of all data centers at Greenbelt, with plans to inventory data centers at Wallops as well. This assessment will help Goddard pursue E.O. 13693 targets for data center energy monitoring and performance. Many of the data center efficiency strategies discussed in the 2014 Report (p.27) will be implemented to pursue the required PUE performance. Attaining this goal will require collaboration with all Goddard directorates that operate data centers.

10. G W *Support Personal Computer Power Management Program*

Due to the requirements of the Agency-wide centralized management system for employees' laptop and desktop computers, the sleep function in these machines is partially disabled to ensure they can receive updates when not in use. In addition to the energy impacts of not being able to enter sleep mode, the high energy consumption when a computer is not in use can lead to overheating, damage, and data loss if a laptop's ventilation is restricted (as when it is put in a bag for transport) without being shut down.

NASA's Langley Research Center has been working with NASA's personal computer management contractor to implement a fix that will allow computers to enter full sleep mode. Assuming all employees currently leave their computers on around the clock, enabling sleep mode could result in a Goddard-wide energy savings around $1,500,000 per year, in addition to providing operational benefits of reduced overheating during transport. The program is still in beta test phase but is expected to be made available to the entire NASA community once it is fully tested.

11. G W *Replace Inefficient Buildings*

As part of the government-wide 'Freeze the Footprint' policy, Federal agencies are required to maintain their gross square footage of property while accommodating growing and changing mission needs. This policy facilitates disposal of energy and maintenance intensive buildings that are well past their service life, and paves the way for modern high efficiency buildings tailor-made to meet current mission needs.

As discussed in the 2014 report (p. 17), Greenbelt's Building 2 and Wallops' Building E-108 were deconstructed in 2008 and 2012, respectively, to facilitate construction of Greenbelt Buildings 34 and the Wallops Mission Launch Control Center. Goddard is currently planning deconstruction of Buildings 16, 16W, 17, 86 and buildings in outlying Areas 100, 200, and 400 at Greenbelt to facilitate additional construction of modern, high-efficiency buildings including Building 35, Building 36, and the planned net-zero capable energy Building 37 at Greenbelt projected for completion in 2015 and 2019, respectively. Early design estimates indicate that replacing Building 16W with the net-zero capable Building 37 on the same site could reduce energy demand by 15 billion BTU's per year, even before accounting for renewable energy generation capacity planned for Building 37.

Energy.3 – Planned Standard Practices

1. G W *Implement Guiding Principles for Sustainable Federal Buildings*

While NASA pursues LEED certification as an indicator of sustainable building design and operation, the definition of sustainable building design and operation relevant to Federal goals is conformance with the *Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings* (Guiding Principles). E.O. 13693 called to update the 2008 Guiding Principles initiated by E.O. 13423 for implementation in all new construction and, by 2015, 15 percent of the Agency's existing buildings by number of buildings and total square footage. The revised Guiding Principles will be released in August, 2015 and are again to be implemented in all new construction and 15 percent of the Agency's building portfolios by 2025, however, the 2025 goal performance can be based on the number of buildings and square footage. Upon receipt of the revised Guiding Principles, Goddard will begin identifying opportunities to implement them in support of the 15 percent Agency-wide goal.

2. G W *Pursue LEED Certification in Major Building Projects*

In addition to its Guiding Principles program, Goddard is continuing its longstanding LEED certification program to meet NASA's requirement of a minimum Silver rating for new construction and major renovation. In addition to the four currently certified LEED buildings (E-109, 26, 34, and 35), Goddard plans to certify three additional buildings over the next four years (Greenbelt Buildings 36 and 37, and the Wallops Island Firehouse and Mission Launch Control Center). With these buildings, 24 percent of Agency-identified candidate LEED buildings at Goddard will be certified by 2020.

Energy.4 – Planned Strategic Practices

1. G *Optimize Building 24 Utility Plant*

Significant energy savings are available with more efficient operation of the Central Utility Plants (CUP) at Greenbelt. A recent study performed by PEPCO Energy Services has identified an optimization strategy and energy savings measures to optimize the Building 24 CUP which can reduce energy use at the plant by 10% to 20%. This is a significant reduction to one of the largest energy loads at Greenbelt. The project includes installing variable frequency drives (VFDs) for the cooling tower fan motors, replacing impellors in condenser water pumps to improve flow, and optimizing the operation of the plant using a new control algorithm to determine the most efficient plant operation. PEPCO Energy Services accomplished a similar optimization project to their "Midtown Thermal Control Center" in Atlantic City, New Jersey, achieving nearly 25% improvement in operating efficiencies[11].

2. G W *Pursue On-Site Renewable Electricity Installations*

While Goddard does not currently host any renewable electricity production, the Center continually evaluates opportunities to implement on-site generation to address Federal goals to develop renewable energy generation capacity on Federal land and reduce energy costs. Goddard is currently evaluating and seeking funding for three renewable energy projects: (1) demonstration-scale wind at Wallops; (2) airfield-adjacent solar at Wallops; and (3) ground-based, parking canopy, and on-building solar to support targeted net-zero energy status for Building 37 at Greenbelt (Figure 4).

[11] See Tus Sasser, "Central Plant Optimization Yields up to 25% Efficiency Improvement for PEPCO Energy Services' Chiller Plant" *Chiller & Cooling Best Practices*, March 2015: p. 16-19.

Figure 4: Renewable energy generation concepts being pursued at Goddard.

(1)

(2)

(3)

Image Credits: NASA/Goddard, 2014 and www.xzeres.com – reprinted with permission.

3. G W *Reestablish Energy Efficiency Investment Fund*

Most energy savings initiatives at Goddard have been pursued through performance contracting. While performance contracts are a sound means to implement projects with high up-front costs and overall life-cycle cost benefits, they do carry significant financing costs – as much as doubling the cost over the life of an energy efficiency project. 42 U.S.C. 8256 provides and alternative to performance contracting for savings projects with high upfront costs.

Under this statute, agencies can retain 50 percent of the appropriated savings realized through energy savings initiatives to reinvest in additional energy conservation measures. Wallops has used this opportunity in the past, however, it does require a significant amount of planning and management to ensure savings can readily be reinvested in implementable projects to keep the fund below the $100,000 limit. NASA's *Guidance for Implementation of Energy Management Program Requirements* details how to establish and operate an energy savings reinvestment fund.

Goddard is currently in a good position to establish this type of fund. Goddard's current energy and water evaluation program (p. 11) will identify numerous potential low-cost energy savings projects expected to save as much as $3M per year in energy costs for an estimated investment of $350,000 (based on typical retro-commissioning results). Such low-cost/fast payback projects present ideal candidates for direct funding and subsequent energy savings reinvestment. Pursuing the identified retro-commissioning projects through an energy savings reinvestment program could save $300,000 in performance contracting financing costs, while creating an annual energy efficiency fund of $3M – as long as energy (CM&O) appropriations delegated to the Center remain constant.

4. W *Transition from Propane to Natural Gas Heating Fuel*

Building on Wallops' success transitioning from fuel oil to liquefied petroleum gas LPG fired heating systems, the facility is investigating going one step further in reducing its GHG emissions by transitioning to natural gas made available by a recent extension of natural gas distribution infrastructure on the Eastern Shore. Burning natural gas in place of LPG would reduce Wallops' heating GHG emissions by an additional 14 percent and save $500,000 per year in energy costs. The newly installed LPG equipment is readily adaptable to natural gas and Goddard is currently performing a cost-benefit analysis of the transition to gauge potential implementation.

Energy.5 – Planned Innovative Practices

1. G *Modify Land Cover to Improve Micro-Climate for Efficiency*

CASI Greenbelt has been evaluating the urban heat island effect of various land cover types on campus since the fall of 2013 (2014 Report, p. 19). Based on preliminary results of this research, the total impact of land cover changes at Greenbelt results in $150,000 per year in increased energy costs. Interestingly, because natural land cover types (i.e. forest, water, tall grasses) mitigate both extreme heat and extreme cold, the impact of changed land cover on heating cost is nearly equal in magnitude to the effect on cooling costs. Greenbelt is planning to revise the landscaping guidance to address numerous sustainability concerns (p. 24) and will incorporate these findings in the process.

2. W *Evaluate Potential to Harvest Phragmites for Building Heating Fuel*

Individuals and organizations around the world are adopting biomass fuels for building heat. Such fuels can be made from materials such as wood and wood processing waste, grain processing wastes or specifically grown energy crops, such as Miscanthus grass. Goddard currently pays to manage *Phragmites australis* (Phragmites), a problem invasive grass at Wallops in the same family as Miscanthus, which could potentially be harvested as a heating fuel (Figure 5).

Noting that many homes and businesses on the Eastern Shore utilize heating fuels often replaced by biomass, such as fuel oil or propane, Goddard identified a potential opportunity to harvest the invasive Phragmites, currently being burned off in-place to limit its spread and impact on operations and ecosystems, and use it for building heat in buildings on or off site. In the summer of 2015, Goddard is evaluating the feasibility of revising the Phragmites Management Plan to include harvesting, processing the Phragmites, and providing it to the local community for building heat. Goddard estimates that Wallops could produce $1.5M worth of biomass fuel each year, saving biomass fuel users a total of $180,000 if displacing fuel oil. Additionally, this use would result in net GHG reduction equivalent to 5 percent of Goddard's climate change impact.

Figure 5: Potential biomass energy sources: (left) Miscanthus and (right) Phragmites grasses

Source: MrPanyGoff (Own work) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons, and Hamsterdancer (Own work) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

3. *G* *Identify Beneficial use for Supercomputer Waste Heat*

The potential to reuse waste heat generated in the Discover supercomputer was introduced in the 2014 Report (p. 29). Goddard has continued to evaluate different direct liquid cooling technologies to identify a viable business case, however, a dedicated effort is needed to determine the cost avoidance benefit of utilizing the waste heat. Without a financial benefit of waste heat reuse it is difficult to develop viable cost justification for transitioning to direct liquid cooling. Therefore, Goddard is planning to study the opportunities and implications of utilizing waste heat from the supercomputer to support advanced cooling technology.

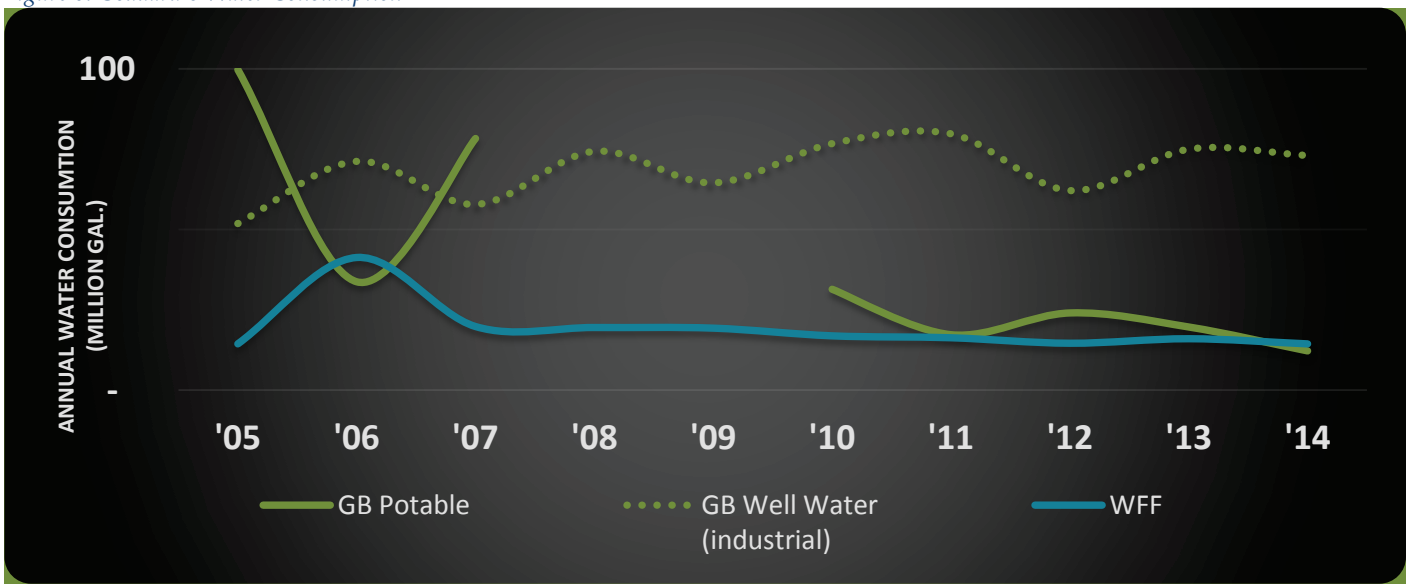
In addition to the energy benefits, however, infrastructure constraints may motivate a transition to direct liquid cooling for the supercomputer currently housed in Building 28. Desired expansion of the Discover computer is currently limited by the supply of chilled water available through the existing chilled water distribution pipe. Due to the reduced need for chilled water in direct liquid cooled systems, direct liquid cooling could eliminate this constraint and facilitate desired growth for the computer.

Ultimately, it is likely that the Discover computer will transition to direct liquid cooling in the near future to enable needed growth with constrained chilled water supply. At current computing capacity, direct liquid cooling with waste heat reuse could save 3.5 percent of total Goddard energy, 2.4 percent of GHGs, and $300,000 in annual energy costs. If the waste heat isn't utilized, however, benefits would be less than 60 percent of those savings.

Objective 2: Manage Water

Goddard's water management objective is composed of three major priorities: (1) water use reduction; (2) stormwater management; and (3) climate change resilience. As discussed in the 2014 report, Goddard has addressed water use by transitioning to low-flow automatic toilets and faucets wherever feasible, maintaining aging water-intensive industrial equipment and utilizing non-potable well water where possible to reduce potable water demand (2014 Report, p. 47; Figure 6: Goddard's Water Consumption). Until recently, Goddard has not striven to address industrial water consumption at Greenbelt due to the reduced cost of well water used for industrial purposes at Greenbelt. In 2015 Goddard is focusing on reducing industrial water use to address EO 13693 and avoid the ground water and industrial discharge impacts of using millions of gallons of ground water for industrial purposes.

Figure 6: Goddard's Water Consumption



Goddard is also building on its experience with best practices for stormwater management that reduce pollution and erosion effects by retaining and treating stormwater (2014 Report, p. 47), by developing an extensive stormwater treatment retrofit plan for the Greenbelt campus, and including best stormwater management practices in new construction.

Finally, through NASA's climate change research and Wallops' firsthand experience with storm surge flooding, Goddard is involved in extensive research, planning, design, and construction to bolster the Wallops Island launch assets from sea water inundation and intensifying wave action expected to result from sea level rise and increasingly severe storm surge.

Water.1 – Goals

Goddard's water goals are based on requirements for Federal agencies, agreements with other research and government institutions and state environmental regulations. Goals relevant to water can be found in Table 2.

Table 2: Goddard's water goals

Sustainability Concern	Previous requirement (E.O. 13423, 13514, legislation, etc.)	New requirement (E.O. 13693)	Change from previous requirement	Current Status
Water Use	Reduce water usage intensity[3] by **26%** from FY 2007 levels by 2020.	Reduce water usage intensity[3] by **36%** from 2007 levels by FY 2025.	Extends previous 26% by 2020 reduction goal to 36% by FY 2025.	Goddard consumption **43%** below 2007 levels in 2014.
		Reduce ILA[12] water use by **20%** from FY 2010 levels by FY 2025.	New Requirement	Goddard industrial well water consumption **5%** above 2010 levels in 2014.
	Install water meters at agency buildings where cost-effective and appropriate.	Install meters and collect building water balance data to improve water management.	Adds requirement to perform source-to-sink accounting of water use.	Need to install missing meters and perform water balance analysis.
Stormwater Management	Restore **20%** of impervious surface relative to 2002 baseline.	State of Maryland Requirement, i.e. not addressed in Federal guidance		**2%** of 2002 baseline restored through stormwater features in recent construction.
	For building projects that disturb more than 5,000 sq. ft., maintain or restore predevelopment hydrology (EISA Sec. 438[13]).	Install green stormwater infrastructure and water meters necessary to manage consumption.	No change (more rigorous EISA requirement was not revoked).	Green infrastructure being planned. Will need financial support for installation and maintenance to meet the E.O. and associated State of MD impervious surface restoration requirement at Greenbelt.
Climate Resilience	Evaluate climate-change risks to manage the effects of climate change on the Agency's operations in both the short and long term.	Incorporate climate resilient design elements in operation, renovation and new construction.	Specific requirement to include climate considerations in design.	Climate considerations integrated into strategic planning. Working to strengthen climate resilient design standards based on evolving research.

Water.2 – Updated Ongoing Practices

1. *G* *Treat Industrial Effluent to Protect Receiving Waters*

As discussed in the 2014 Report (p. 47), Greenbelt uses millions of gallons of well water per year for the HVAC boilers and cooling towers. Well water used in such industrial applications is discharged to the storm sewer system, reducing costs associated with the sanitary sewer system. Unfortunately, Greenbelt has experienced spikes in pH and copper in the discharged water that could impact local receiving waters. Greenbelt is currently in the process of implementing sand filters in the Building 31 chilled water plant that will remove copper solids and other particulate contaminants, and a pH neutralization system in the Building 24 steam and chilled water plant that will treat water before it leaves the site.

[12] Industrial, landscaping and agricultural.

[13] Energy Independence and Security Act, Section 438: Storm water runoff requirements for Federal development projects.

2. W *Save Water Through Geothermal Cooling*

As discussed in the 2014 Report (p. 17) Wallops recently installed geothermal wells to serve 20 of its buildings. In one such building (Building X-79) not enough cooling could be obtained through geothermal wells, so a combined system was installed consisting of both geothermal and the existing cooling tower. The geothermal system is used as much as possible to reduce the amount of water used by the cooling tower. This hybrid system has reduced water consumption from 634,000 gallons to 295,000 gallons from 2013 to 2014. Other purely geothermal installations at Wallops and Greenbelt are resulting in even greater savings.

3. W *Maintain Storm Surge Protection Infrastructure*

Wallops enhanced its longstanding storm surge protection program in 2011 with the construction of a seawall and expansion of the island beach (2014 Report, p. 44). The seawall was in place to protect the island during Hurricane Sandy in the fall of 2012 preventing damage on the order of the $3.8M suffered during Hurricane Irene in 2011.

As of spring 2013, hurricane induced beach erosion and general wave action had removed 25 percent of the sand comprising the beach expansion. In 2014, with financial assistance from the 2013 Disaster Relief Appropriations Act, Goddard undertook an $11.4M project to nourish the eroded beach. The project was completed in winter of 2014-2015 and resulted in restoring the beach to 95 percent of the original expanded beach sand volume.

This type of maintenance was expected in the original design of the beach expansion. Initial estimates called for a need to replenish 25 percent of the beach sand every three to seven years. To address this ongoing expense, Goddard's Management Operations Directorate is developing an ongoing Shoreline Sustainment working capital fund to secure future funding to maintain the protective capability of the beach expansion and seawall into the future.

Figure 7: Replenishing the Wallops Island Beach, August 2014

Source: NASA/Goddard

4. W *Flood-proof Critical Facilities*

Goddard is also addressing coastal resiliency at Wallops by flood proofing critical facilities at risk of inundation. The Island Communications Terminal (Building X-75) currently resides in a flood-prone area of Wallops Island (Figure 8) and is susceptible to flooding during heavy storms or excessive rain. Flooding in X-75 shortens the life cycle of the cable plant and electronics and has led to failure of multiple corporate and mission systems. Approximately $4M worth of mission critical electronic equipment is housed within this facility, and flooding has already led to required replacement of $100K of it.

Figure 8: The Wallops Island Communications Terminal (in 2012, after the original beach expansion).

Source: NASA/Goddard

To prevent these impacts, Goddard has undertaken a $1.6M project to upgrade the building to be more resistant to the impacts of flooding. The project will upgrade the foundation and structure of the building, construct a new second story room structure, and install elevated electrical systems and cable trays.

Water.3 – Planned Standard Practices

1. G W *Improve Water Metering Infrastructure*

E.O. 13693 requires installation of water meters to enable source-to-sink water balance analysis and advanced water use management. Goddard's current water meter infrastructure is only at the installation-wide level, and is insufficient for detailed analysis. Goddard is assessing water metering needs and planning updates to the metering system to meet the E.O. requirements.

2. G W *Assess and Maintain Water, Chilled Water, and Steam Plumbing*

After Wallops' success in reducing water losses by replacing heritage steam and chilled water distribution systems (2014 Report, p.48), Goddard is turning its attention to the drinking water distribution system at Wallops and steam, chilled, and drinking water systems at Greenbelt to determine the extent of leakages and the need for corrective action.

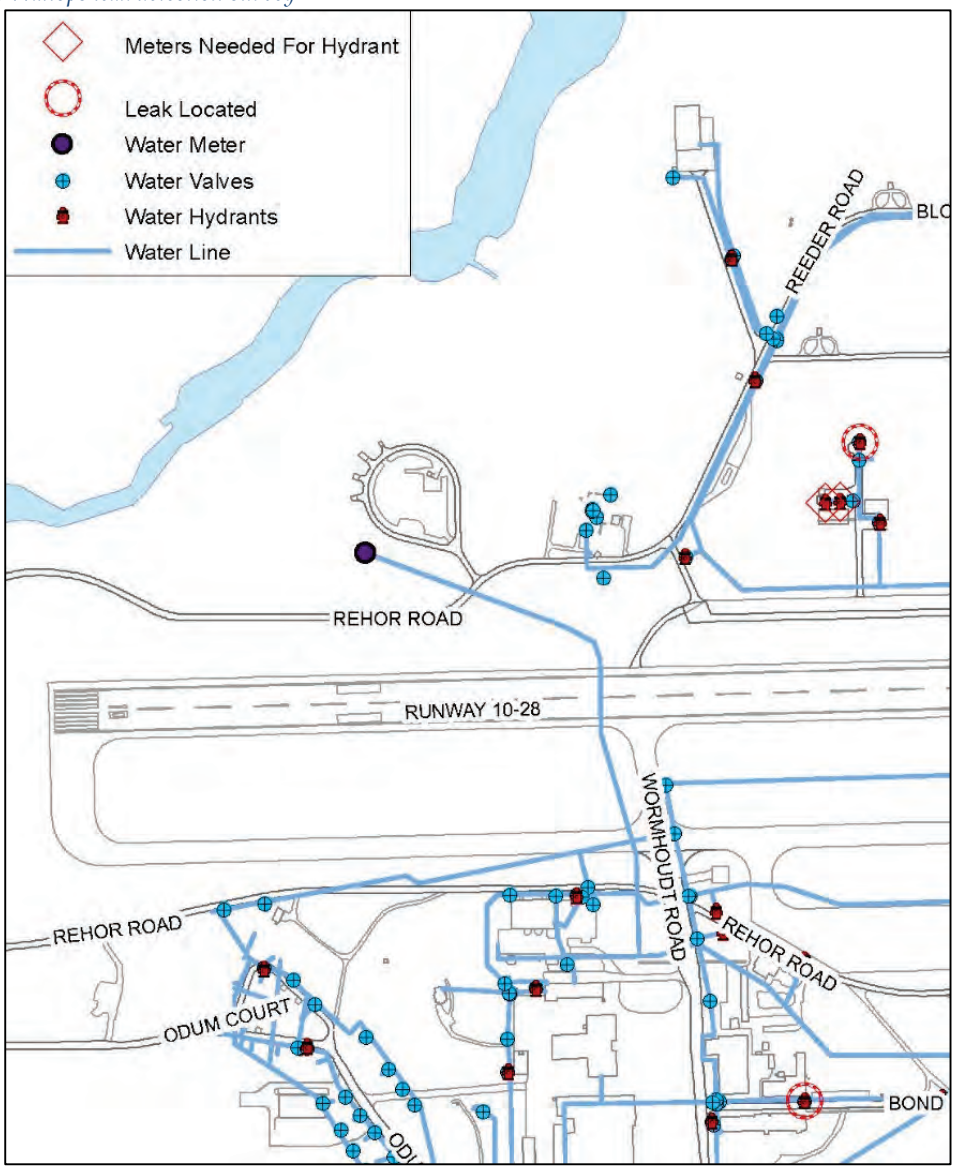
Beyond the impacts of water consumption, there are significant mission risks associated with undetected and potential water leaks. Undetected leaks can slowly dissolve and wash away soil below ground leading to sinkholes. Additionally, leaks in buildings can impact sensitive equipment and operations. For example, in 2013 deteriorated roof drain piping began leaking near the Global Precipitation Measurement (GPM) satellite hardware being built in the Integration and Testing Facility at Greenbelt. The leak was addressed by stationing personnel around the clock to respond to leaks as long as critical hardware was located in the facility.

Greenbelt is pursuing multiple projects to prevent such incidents, including a leak detection study to address 80,000 gallons per day of leakage in the chilled water system, and an indoor leak potential evaluation to ensure unexpected water leaks don't compromise mission activities.

Due to the replacement of the central heat and chilling systems at Wallops, the only remaining plumbing infrastructure is for the domestic well water system. Goddard conducted a leak survey of the well water system in October of 2014. Two leaks were detected totaling ten thousand gallons per day, or roughly 4 percent of total Goddard consumption and $20,000 of potable water production cost at Wallops (Figure 9). The identified leaks have a total estimated repair cost of $15,000. Goddard is in the process of repairing these leaks.

The Wallops survey also identified numerous unmetered hydrant locations that would benefit from the addition of meters to improve the ability to audit water usage and easily identify future leaks.

Figure 9: Excerpt from Wallops leak detection survey



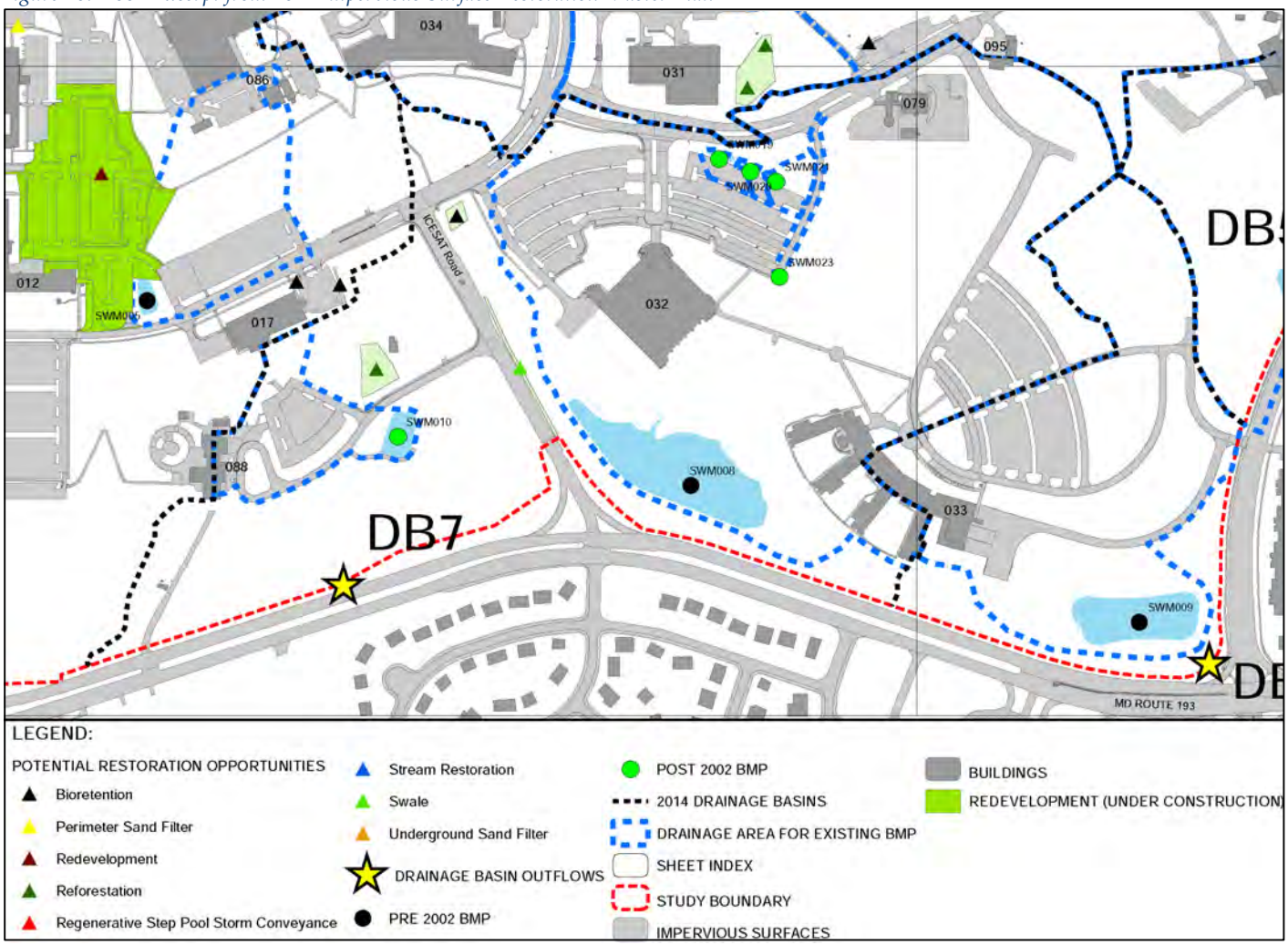
Source: NASA/Goddard, 2014

3. G W *Restore Impervious Surfaces*

Greenbelt will be receiving a revised storm sewer permit (NPDES MS4 general permit) in the near future to replace the current permit which expired in 2009. The delay in receiving the new permit is likely due to the extensive revisions to the MS4 permit program and the associated workload on the Maryland Department of the Environment (MDE). The new permits being issued to facilities similar to Greenbelt require ambitious restoration of existing impervious surface that contributes to erosion and stormwater pollutant loading. MDE anticipates the permit will require restoration of 20 percent of the impervious area of the Center (e.g. buildings, pavement, etc.) based on site conditions in 2002. Goddard will need to implement storm water management practices to treat runoff from impervious areas – thus *restoring* it to natural hydrological conditions.

In 2014 Goddard completed a study to evaluate the baseline conditions (Figure 10) and develop a master plan of recommendations to address the restoration requirement at Greenbelt. The plan focuses on modifying heritage stormwater management ponds to increase pollution removal, installing new systems, and simply rerouting storm drainage systems to discharge to natural areas that can filter and infiltrate rainfall. In all, Greenbelt would need to restore nearly 28 acres of impervious surface using a combination of such practices to meet the anticipated permit requirements. So far, 2 percent of this required area has already been restored through modern stormwater management practices included in the construction of Building 36.

Figure 10: 2002 Excerpt from 2014 Impervious Surface Restoration Master Plan



Source: NASA/Goddard, 2014

Goddard has similar objectives to restore impervious surfaces at Wallops to reduce impacts from runoff directly into coastal waters. These objectives will be met by pursing EISA Sec. 438 stormwater requirements for new building projects.

Water.4 – Planned Strategic Practices

1. *G W Address Non-potable Water Consumption*

Water reduction efforts at Goddard have generally focused on reducing consumption of potable water, however, EO 13693 has new requirements to reduce industrial, landscaping, and agricultural (ILA) water use. Goddard uses no water for irrigation, and transitioned to on-site well water for non-potable uses in the heating and cooling plants at Greenbelt to reduce millions of gallons of potable water consumption. Greenbelt is now planning to go one step further to reduce this non-potable water demand as well.

One opportunity to reduce ILA water use at Greenbelt is in boiler operation. A recent evaluation of Greenbelt's heating and chilling plant conducted for the CHP feasibility assessment (p. 11) indicated that the current amount of water discharged from the boilers to prevent a buildup of impurities in process water (i.e. blowdown) could potentially be reduced by a factor of five with certain operational changes. Goddard will evaluate this and other opportunities to reduce non-potable water consumption to meet the EO goal for ILA use.

Wallops uses the on-site well-sourced potable water for industrial and general use, however, the installation has made great strides in industrial water savings through the heating decentralization (2014 Report, p. 48), and will continue to evaluate consumption and strive to contribute to the Center's water use reduction Goal.

2. G W *Revise Landscaping Standards to Reduce Maintenance Costs and Runoff*

Goddard has long implemented traditional industrial landscaping standards of clear-cut turf grass lawns and exotic ornamental plants. This type of landscape has numerous drawbacks including vulnerability to invasive species, increased stormwater erosion and runoff, reduced wildlife habitat, pollinator forage (p. 38), and higher maintenance costs. Goddard's Environmental and Facilities Management divisions are currently working to update the landscaping plant species standards to advocate the use of low-maintenance native species. The species selected will restore some of the values provided by natural landscapes lost when they are replaced with traditional landscaping species such as pollinator forage and stormwater infiltration.

Water.5 – Planned Innovative Practices

1. G W *Develop Coastal and Climate Change Impact Assessment*

Goddard has pursued numerous initiatives to characterize future coastal inundation risk at Wallops and projected impacts of environmental trends including increasing temperatures, intensifying rainfall, and urban heat island effects at all primary Goddard facilities (2014 Report, p. 41). With this preliminary data in hand, Goddard is planning to refine, streamline, and compile this research into a concise impact assessment that can support planning and engineering decision making.

The impact assessment will be developed through a partnership of NASA's CASI program (2014 Report, p. 10), the MACRI consortium (2014 Report, p. 46) and Goddard's Management Operations Directorate, each providing input to ensure accurate and easily understood data that will support management decisions with rigorous probability-based risk assessments of various potential environmental impacts to the Center over the foreseeable future.

In the interest of ensuring that the assessment contains the most current and credible data, Goddard plans to update the assessment every five years.

2. W *Assess Feasibility of Using Seawater for Fire and Sound Suppression Systems*

Using seawater for fire and sound suppression systems was introduced in the 2014 Report (p. 50). Since the previous report, climate change resilience has been identified as an additional benefit to a potential transition to seawater for the suppression systems. There is growing potential that with projected sea level rise and increasingly severe storms, sea water could intrude into the domestic water wells at Wallops, rendering the water supply unsuitable to support launch activities that require fresh water. Developing seawater sound and fire suppression technology would increase the resilience of Wallops and other coastal launch facilities facing water constraints due to supply shortages or the threat of seawater intrusion.

3. G W *Implement Rainwater Harvesting for Industrial Use*

The 2014 Report discussed the potential benefits of harvesting rainwater for industrial use including (1) improved compliance with stormwater permit requirements, (2) potentially increased efficiency and reduced maintenance requirements for industrial equipment, and (3) reduced water consumption (p. 49). Based on these potential benefits, Goddard is continuing to evaluate and develop opportunities to implement rainwater harvesting for industrial use.

4. G *Implement 30 Percent Impervious Surface Restoration Program*

The impervious surface restoration master plan for the Greenbelt campus presented previously presents options to restore up to 30 percent of the Center's 2002 impervious surface. Goddard is evaluating opportunities to implement all available restoration options. While 30 percent restoration would surpass the regulatory requirement, capitalizing on these available opportunities will help the Center develop more efficient, larger scale practices that will inoculate the Center from future regulatory changes and streamline conformance with the requirements of EISA Sec. 438 for any future development or redevelopment projects.

Objective 3: Manage Materials

While Goddard is striving to reduce the environmental impact of its activities directly, there are significant but less visible environmental impacts associated with products and materials Goddard uses to carry out its missions. These impacts stem from all stages of a product's life cycle: from obtaining raw materials, manufacturing, transportation, use, or disposal.

Goddard preferentially buys products that have a lower potential impact on the environment during production and transportation including recycled, biobased, SmartWay certified fuel efficient products, and many other standards as applicable. During the useful life of products, Goddard reduces the potential for pollution during use through advanced materials and equipment management. When products are used up or no longer needed, Goddard ensures the lowest possible impact of disposal through reuse, recycling, and proper hazardous waste disposal. These activities strive to address all stages of the product lifecycle to prevent waste, however, Goddard sees opportunities to continue to improve performance.

Materials.1 – Goals

Goddard's waste goals are based on requirements for Federal agencies in Executive Orders and Legislation. Goals relevant to waste can be found in (Table 3).

Table 3: Goddard's waste goals

Sustainability Concern	Previous requirement (E.O. 13423, 13514, legislation, etc.)	New requirement (E.O. 13693)	Change from previous requirement	Current Status
Affirmative Procurement	Ensure that 95% of new contract actions for products and services are energy-water-efficient, biobased, environmentally preferable, non-ozone depleting, contain recycled content, or are less-toxic alternatives where feasible.	Purchase recycled, energy efficient, biobased products, and EPA designated chemicals, plumbing, food, and logistics products. Implement biobased product purchasing management program until **95%** compliant with biobased purchasing requirement.	New requirements are more streamlined. Required enhanced management of biobased product requirements where agencies are not meeting the requirement.	Identified green purchasing requirements incorporated in boiler-plate language for more than **95%** of procurement contracts at Goddard (i.e. Goddard is not subject to enhanced management requirements).
Waste Prevention	Reduce printing paper use.	Implement practices to reduce copier and printer paper use.	No change.	Duplex printing default repealed due to employee complaints, however, other paper use reduction initiatives are in place.
	Divert **50%** of non-hazardous waste, and **50%** of C&D[14] waste from landfill.	Divert **50%** of non-hazardous waste, and **50%** of C&D waste from landfill.	No change.	Goddard diverted **32%** of non-hazardous waste in FY 2014 and **99%** of C&D waste.
	Minimize the quantity of hazmat[15] acquired, used, or disposed of.	Minimize the quantity of hazmat acquired, used, or disposed of.	No change.	Source reduction and Hazmat reuse programs implemented through the HMMS[16] have reduced hazwaste generation by **30%** since CY 2011.

[14] Construction and Demolition

[15] Hazardous materials

[16] Hazardous Materials Management System.

Sustainability Concern	Previous requirement (E.O. 13423, 13514, legislation, etc.)	New requirement (E.O. 13693)	Change from previous requirement	Current Status
Electronics Stewardship	Dispose of Agency excess or surplus products in environmentally sound manner.	Dispose of Agency excess or surplus products in environmentally sound manner.	No change.	Excess electronics disposed of through reuse or recycling.

Materials.2 – Updated Ongoing Practices

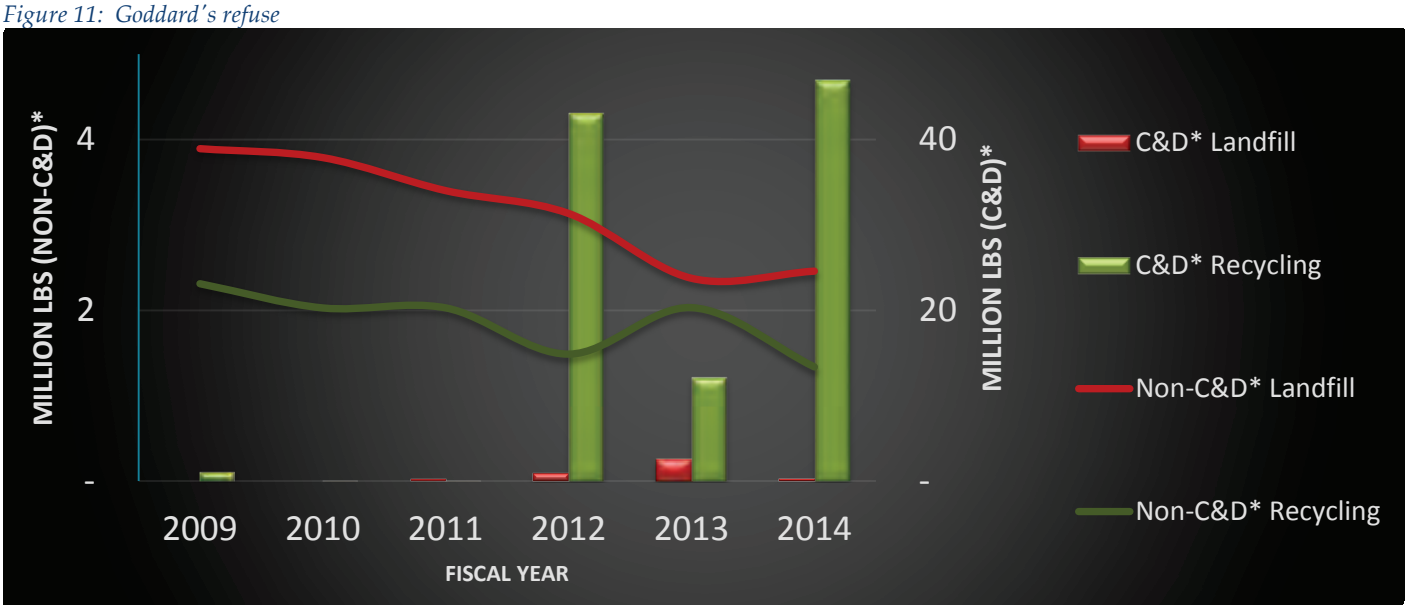
1. *G W Implement Used Solvent Wipe Reuse Program*

Goddard uses thousands of pounds of disposable cleaning-solvent wipes to clean parts when building delicate space flight hardware. Because these wipes contain hazardous solvent, they formerly had to be handled as a hazardous waste with significant management costs. To reduce these concerns, MEMD implemented a centrifuge to remove the remaining hazardous liquid solvent from the generally benign fabric wipe material for some solvent types. This process reduces the volume of hazardous material disposed by 50 percent and reduces disposal costs by about $1,000 per year. The used wipes are then provided to other users on Center such as the employee auto club to be reused as cleaning cloths or oil rags.

2. *G W Educate Employees on Recycling Procedures*

As discussed in the 2014 Report (p. 52) Goddard transitioned to single stream (i.e. comingled) recycling for general waste in 2012, however recycling rates continue to lag. MEMD suspects the poor performance is attributable ongoing contamination issues (e.g. employees throwing trash in the recycling bins, causing the entire bin to be discarded as trash) and insufficient utilization of the recycling program to meet the 50 percent Federal waste diversion standard (Figure 11). To address this issue, MEMD and FMD continue to do outreach including signage (Figure 12), public events, and web-based communication to ensure employees understand how to use the recycling system.

Figure 11: Goddard's refuse



* Construction and Demolition waste

Figure 12: Goddard recycling information poster

Photo Credit: NASA/Goddard, 2014

3. G W *Support USPS Blue Earth Electronics Recycling Program*

On January 17, 2015, NASA signed a Memorandum of Understanding with the U.S. Postal Service to support employees in recycling their own household electronics waste (eWaste) through the mail. Goddard employees can go to the USPS's BlueEarth℠ Recycling Website to learn more about recycling eWaste, and go to the Goddard Recycling Webpage to learn how to recycle other recyclable and potentially harmful products.

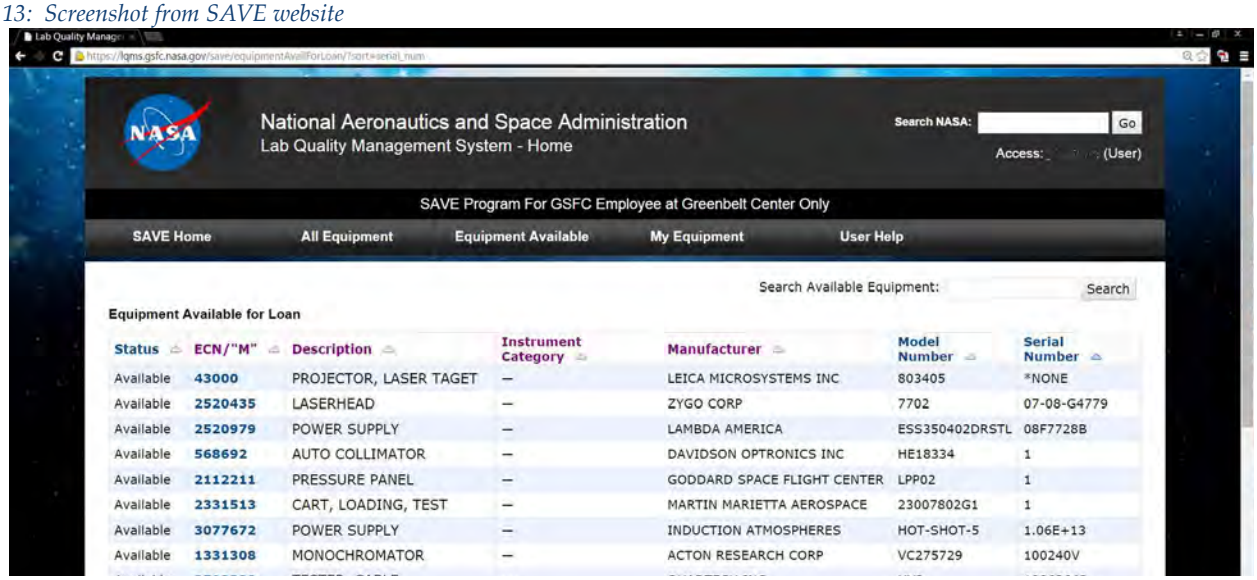
4. G W *Plan Building Projects to Reduce Waste*

Due to the large, homogeneous waste streams from construction and demolition (C&D) activities, as compared to general post-consumer waste, C&D activities present ample opportunities for waste diversion. Goddard has identified these opportunities in its facilities projects and has implemented plans and processes to ensure maximum recycling of C&D wastes. As a result, C&D recycling has consistently been over 80 percent since 2012 (Figure 11), more than double the recycling rate of non C&D waste.

5. G *Operate SAVE Equipment Sharing Program*

In 2014 Goddard's Applied Engineering and Technology Directorate (AETD) implemented the SAVE equipment sharing program to create a platform for labs, researchers, and engineers to lend and borrow underutilized engineering equipment (Figure 13). The program will increase utilization of underused equipment reducing cost, time delay, and environmental impacts of acquiring new equipment. With 14 percent of eligible equipment enrolled in the program, AETD estimates there is nearly $4M of equipment available to offset the need for new equipment acquisitions, enable low-budget activities, and satisfy incidental needs for specialized equipment.

Figure 13: Screenshot from SAVE website



6. G *Manage Logistics Garage to Reduce Waste*

Like shipping and construction, vehicle maintenance produces large volumes of a few discrete types of waste. This facilitates high levels of recycling for specific items such as tires, batteries, and used vehicle fluids. LTMB manages the maintenance garage at Greenbelt and has done an exemplary job of identifying waste streams for recycling (Figure 14). Additionally, garage operations support the recycling industry outside Goddard by preferentially purchasing recycled products and re-treaded tires.

Figure 14: Recycling related activities flyer for the Logistics Garage

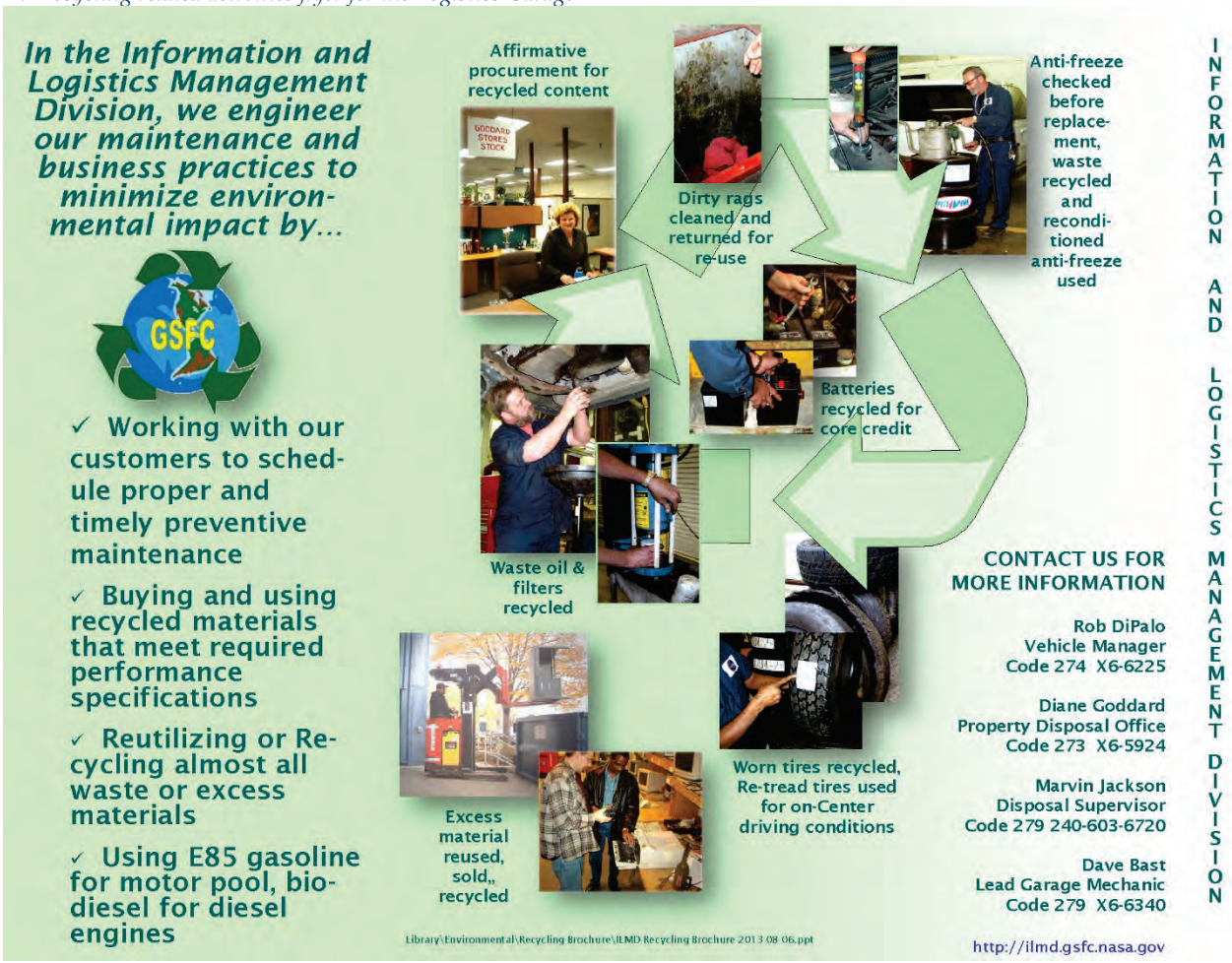


Image Credit: NASA/Goddard

Materials.3 – Planned Standard Practices

1. G W *Identify More Opportunities in Technical Facilities to Prevent Waste*

Noting the success of capitalizing on homogeneous waste streams from construction and vehicle maintenance, Goddard plans to extend this concept to other technical facilities such as labs, testing facilities, and fabrication shops. The University of Illinois Chicago implemented this type of approach to ensure comprehensive recycling of pipette tip boxes in their labs (Figure 15). Typically biology labs don't offer recycling because most waste is hazardous. Disposable plastic pipette tip boxes, used only to hold unused, sterile pipette tips were being needlessly thrown away until a simple collection system was implemented. Goddard plans to look for opportunities to work with technical facilities to determine opportunities to maximize responsible waste disposal.

Figure 15: University of Illinois, Chicago pipette tip box recycling program

Image Credit: University of Illinois Chicago, Office of Sustainability - reprinted with permission

2. G W *Transition to Reusable Shipping Materials Wherever Feasible*

Goddard disposes of tens of thousands of pounds of shipping pallets and other shipping materials each year. It may be possible, however, to entirely prevent a significant amount of shipping waste generation through reusable shipping materials. Many high throughput manufacturers are transitioning to shipping products designed to be collected and reused. Some shipping industry professionals have implemented high-spec reusable pallets and shipping crates, and associated logistics systems that allow shippers to reclaim crates and pallets for reuse. In addition to the waste elimination benefits provided by reusing pallets, the higher build quality and recurring inspection prior to each shipment provides more reliable and secure shipping materials. Goddard plans to pursue increasing utilization of these types of services to reduce waste and increase the security of shipments.

Materials.4 – Planned Strategic Practices

1. G W *Collect More Detailed Information on the Center's Waste*

As presented in the 2014 Report (p. 53), it has been nearly 20 years since Goddard has done any detailed analysis of its waste streams. Goddard plans to identify cost-effective ways to increase knowledge about the composition of the waste leaving the Center to make informed decisions about solid waste management. The needed data could be obtained as simply as by visual inspections of trash and recycling dumpsters at each pickup.

2. G W *Support Green Purchasing by Front-Line Staff*

Goddard has pursued affirmative procurement from the top down by including green purchasing requirements in procurement contracts. Unfortunately, due to the size and diversity of product procurements that take place at Goddard, it is difficult to ensure that all staff involved with purchasing decisions on a procurement contract are aware of the green purchasing options and requirements. Goddard plans to promote affirmative procurement from the bottom up by providing education and outreach to staff-level individuals involved with procurements to help them understand green purchasing requirements, evaluate current practices, and identify opportunities to improve.

Materials.5 – Planned Innovative Practices

1. G W *Evaluate Potential to Transition to Zero-waste Food Service*

While many Goddard operations require the use of materials that cannot be diverted from landfills, food service is one area that similar organizations have had success eliminating all waste. By specifying that most disposable products are biodegradable, and segregating non-biodegradable materials prior to disposal, it may be possible to ensure that the entire waste stream from a food service operation is compostable.

Managing the resulting compostable waste stream would involve composting, anaerobic digestion, or another biodegradation process. Unfortunately, there is not currently a composting hauler available to serve either Greenbelt or Wallops, so implementing zero-waste food service would currently require developing on-site management practices. Goddard will continually evaluate options to manage compostable waste on site, and availability of compost hauling contractors to determine the feasibility and potential benefits of implementing a zero-waste cafeteria.

Objective 4: Promote Transportation Alternatives

Goddard facilities were designed in an era where single occupancy vehicle transportation was standard. As such, the Wallops and Greenbelt facilities are difficult to access and navigate without a personal vehicle. This reliance on single occupancy vehicles causes Goddard to be a disproportionate contributor to, and victim of many of the negative impacts of single occupancy vehicle transportation. The impacts of reliance on single occupancy vehicles include air and water pollution, but also the following less obvious impacts:

- restricted access for employees unable to drive or disinterested in driving,
- increased risk to Center operations from road network disruptions (e.g. snow, traffic, or accidents)
- increased costs to maintain intra-center road and parking infrastructure.

Goddard has numerous goals and initiatives to provide employees a variety of alternatives to commuting and travel for work as shown below.

Transportation.1 – Goals

Goddard's Transportation goals are shown in Table 4.

Table 4: Goddard's Transportation Goals

Sustainability Aspect	Previous requirement (E.O. 13423, 13514, legislation, etc.)	New requirement (E.O. 13693)	Change from previous requirement	Current Status
Fleet Management	Identify optimal fleet inventory and develop plan to attain the target inventory.	Continue to eliminate unnecessary vehicles.	No substantive change, just focus on fleet reduction efforts.	Unnecessary vehicles are eliminated through annual vehicle utilization reviews.
	Reduce petroleum fuel use by **20%,**	Reduce per-mile fleet GHGs by 30% by end of FY 2025 (relative to FY 2014).	Metrics revised to focus on GHGs rather than fuel consumption.	As of FY 2014, petroleum fuel use reduced by **5.8%.**
	and increase non-petroleum fuel use by **100%** from 2005 levels by 2015.			Non-petroleum fuel use increased by **211%.**
	Purchase plug-in hybrid vehicles when lifecycle cost is comparable to petrol-fueled vehicles.	Starting CY 2020, 20% of new vehicles shall be plug-in or zero-emissions vehicles, 50% by the end of CY 2025.	Added specific quantitative requirements for purchasing new vehicle technologies.	Will need to invest in vehicles and alternative fueling /charging infrastructure to meet the goal.
		Implement fleet data management and telemetric data tools in new vehicles starting 3/19/17.		Vehicle-level management systems currently in place will likely meet EO requirements.

Sustainability Aspect	Previous requirement (E.O. 13423, 13514, legislation, etc.)	New requirement (E.O. 13693)	Change from previous requirement	Current Status
Building Design	No previous analogous design requirements.	Incorporate fleet vehicle charging in building projects.	Added fleet charging design requirement.	Will need to formalize design standards for fleet vehicle charging.
	Consider sites that are pedestrian friendly, transit accessible, and emphasize existing cities or planned town centers in planning for new facilities or leases.	Plan strategies to optimize sustainable space usage and consider existing community transportation planning and infrastructure, including transit.	No change (i.e. same intent).	Could pursue by increasing connectivity with Greenbelt business and residential areas as proposed in the 2002 Goddard Space Flight Center Transportation Management plan.
Other Initiatives	Implement strategies for travel, and communications that support lower-carbon commuting and travel by Agency staff.	Support workplace vehicle charging, telecommuting, carpooling, bicycling and public transit use, where consistent with Agency authority and appropriations law.	Added specific workplace vehicle charging objective.	Goddard developed a model to legally implement electric vehicle charging. Model is under review at HQ.
	Coordinate with regional partners on fleet assets and managing natural resources.	Coordinate with regional partners on fleet assets, water resources, climate change, and renewable energy.	Added climate change resilience, and renewable energy as area of collaboration.	Goddard collaborates with regional partners in local government, academia, Federal agencies and DoD on climate resilience, natural resource management, transportation and energy.

Transportation.2 – Updated Ongoing Practices

1. G W *Implement Communications Tools to Support Productive Telework*

As discussed in the 2014 Report (p. 36), NASA is continuing to strengthen its *Work from Anywhere* program to support alternatives to commuting, improve interaction between colleagues at other NASA facilities and institutions, and strengthen continuity of operations in the face of weather disruptions and other factors that may complicate access to NASA facilities. Since the 2014 Report, Goddard has continued to increase employees' ability to work from anywhere by implementing Microsoft *Lync* screen sharing, text, voice, and video communicator, and Next Gen Voice telephone and voicemail systems. These tools improve employees abilities to communicate face to face, collaborate on on-screen documents and programs, and access their office phone system from anywhere.

Recommendations and support are available to help orient employees to the advanced communications tools available. Support for the Next Gen phone system can be obtained by calling the telephone trouble line for Greenbelt at 301-286-5046 or Wallops at (757) 824-4357. Computer and mobile application support can be obtained through the NASA Enterprise Service Desk at 1-877-677-2123.

Transportation.3 – Planned Standard Practices

1. G *Transition to Low-Emission Goddard Taxi*

The 2014 Report identified a class of low-emission electric vehicles that could potentially serve as the Goddard Taxi (p. 33). Goddard plans to evaluate the concept of using some such alternative fueled vehicle for intra-Center taxi operations.

2. W *Evaluate Feasibility of Expanding Bikeshare Program to Wallops*

The Bikes Around Goddard program (2014 Report, p. 36) has been a huge success in supporting non-motorized travel within, to, and from campus. Based on their support for the program, mission projects have contributed bikes to the program bringing the total fleet to 50 bikes. After receiving some inquiries from staff at Wallops, Goddard is planning to evaluate the feasibility of extending the program to Wallops.

3. G W *Reinstitute the Goddard Cyclist Wiki to Support Bicycle Commuting*

The Goddard Cyclist Wiki (2014 Report, p. 36) served as a clearing house for information related to bicycle commuting and recreational cycling in the Goddard area. Since 2014, the site's subscription has expired and the content is no longer available. Goddard plans to reestablish the page to continue support for bicycling among Goddard personnel.

Transportation.4 – Planned Strategic Practices

1. G W *Promote use of Electric Vehicles by Contractors*

Numerous vehicle functions at Goddard facilities could be performed using electric vehicles, including local travel, trades work, and protective services activities. While traditional fuel-based vehicles are often the default choice for these roles, electric vehicles have numerous advantages that may render them a better fit for some roles.

Specific benefits of electric vehicles include the following:

- Reduced operations and maintenance costs (especially in idle-intensive applications such as protective services);
- Lower acquisition costs when specifying low-speed electric vehicles for intra-Center travel;
- Reduced hazardous materials impacts (no coolant, oil, or fuel are needed, so there is less opportunity for a release); and
- Reduced air pollution emissions.

Based on these benefits, Goddard plans to identify resources to help contractors operating at the Center to identify and evaluate potential benefits of electric vehicles in their fleet management decisions.

2. G W *Identify Opportunities to Implement Partial Zero-emissions Fleet Vehicles*

E.O 13693 requires that 20 percent of new vehicle acquisitions are zero-emissions (e.g. plug-in electric or fuel cell) or partial zero-emissions (plug-in hybrid) vehicles by the end of 2020, and 50 percent by 2025. Goddard will begin identifying roles best suited to these technologies to ensure a cost-effective and mission-focused transition to this procurement policy.

3. G W *Support Regional Bicycle and Public Transportation Planning*

Goddard's Greenbelt and Wallops facilities are a major destinations in their respective communities that generate a significant portion of the local traffic. Goddard plans to leverage this influence to advocate for alternative transportation access to the facilities. To do so, Goddard will use data on alternative transportation demand from the biannual commuter survey, conducted by NASA Headquarters, to advocate for employees alternative transportation interests with Prince George's County Bicycle and Trails Advisory Group, Greenbelt City Council Washington Metropolitan Area Transportation Authority, and Accomack-Northampton Transportation District Commission.

Transportation.5 – Planned Innovative Practices

1. G W *Implement Scalable Employee EV Charging Solution*

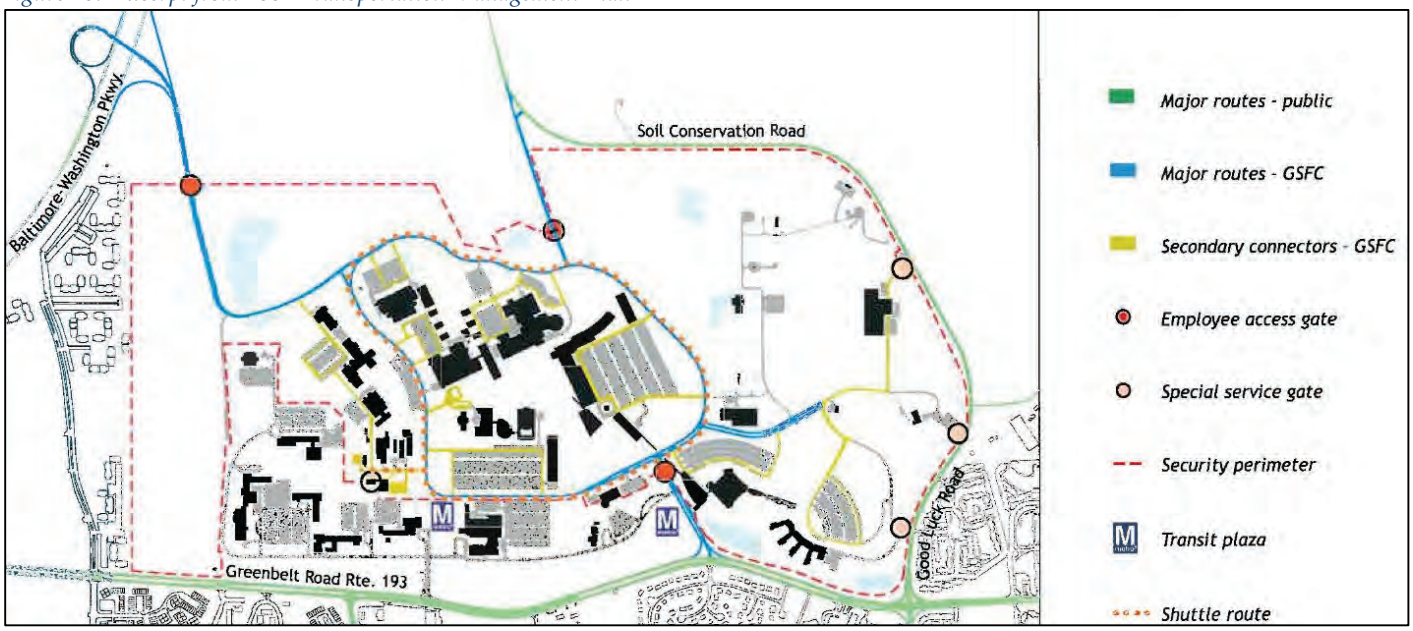
Goddard has proposed a scalable private market fee-for-service electric vehicle (EV) charging concept for employees that is consistent with Agency authority and appropriations law. Goddard is currently working with NASA Headquarters to vet any remaining issues with the concept and implement employee EV charging as soon an operational model is approved.

2. G W *Update and Implement 2002 Transportation Management Plan*

Alternative transportation options such as walking, biking, or mass transit present numerous benefits to Goddard employees, including health benefits from active transportation, reduced commuting costs, and better access for persons with disabilities. Additionally, commuting by employees and contractors contributes more than 30 percent of the Center's GHGs[17]. The automobile dependent layout of Goddard's campuses, however, present numerous barriers to alternative transportation options.

As part of the 2002 Master Plan development, the Center developed a transportation management plan for the Greenbelt campus (Figure 16). The plan identifies numerous strategies to facilitate alternatives to single occupancy vehicle transportation to and on the Greenbelt facility. While competing mission and management requirements have delayed implementation of much of the plan for Greenbelt, many of the strategies presented are still viable. To revitalize the transportation program at Goddard, the Center is planning to review and update the 2002 plan, extend transportation management planning to Wallops, and move towards implementation.

Figure 16: Excerpt from 2002 Transportation Management Plan



Source: NASA/Goddard, 2002

[17] Goddard is only accountable for civil servant commuting emissions under E.O. 13693, which are about 11% of Goddard's entire GHG inventory.

Objective 5: Support Local Ecosystems

Due to the need for large amounts of open space to isolate NASA activities from potential physical and electromagnetic interference, Goddard maintains large tracks of open space. Goddard feels a strong obligation to use these areas to promote native species and ecosystems, as well as to compensate for destruction of habitat and animal food sources in the highly developed mid-Atlantic region through efforts such as the pollinator support program.

Ecosystems.1 – Goals

Goddard's ecosystem goals are based on agreements with regional ecosystem management partners and requirements for Federal agencies in Executive Orders and Legislation. Ecosystem goals can be found in Table 5.

Table 5: Goddard's ecosystem goals

Sustainability Concern	Goal	Current Status
Forest Ecosystems	Promote collaborative strategies for the restoration, conservation and stewardship of shared forested ecosystems and managed lands in the Baltimore-Washington corridor.	Would benefit from comprehensive forest management plan and program.
Island Endangered Species	Monitor and protect sea turtles, piping plover, bald eagles and marine mammals.	Successful ongoing management program in place.
Non-endangered species	Manage deer, birds, ticks, and other species to ensure healthy populations and minimize impact to aircraft and personnel operations.	Successful ongoing management program in place.
Wetlands	Delineate existing wetlands and mitigate impacts on wetlands.	Successful ongoing management program in place.
Pollinator Support	Take measures to support pollinators including planting pollinator-friendly vegetation, limiting mowing practices, and avoiding the use of pesticides through integrated vegetation and pest management practices.	Mowing has been reduced, pollinator-friendly plantings have been implemented, and Goddard is in the process of developing landscaping species selection guide to support pollinators and other ecosystem objectives.

Ecosystems.2 – Updated Ongoing Practices

1. *G W Wildlife Management*

Wallops has contracted with the Virginia Department of Agriculture's Wildlife Service to control the deer population on the Main Base and to institute methods to frighten birds off the runways. The Wildlife Service also traps problem predators on the island that prey on endangered species.

At Greenbelt wildlife is managed to ensure their populations don't surpass the natural carrying capacity of the site or impact transportation, operations, or human health.

2. G W *Wetlands Management*

Of the 4200 acres that comprise Wallops Island, approximately 2800 acres are considered wetlands. Wetlands fulfill numerous valuable ecological functions. They offer nurseries for fish species, foraging grounds for waterfowl, filter pollutants from stormwater runoff, and their primary productivity forms the basis of the food chain. It has been the policy of the Federal Government since the early nineties that there be "no net loss" of wetlands. This means that for every square foot of wetlands destroyed, at least one square foot of new wetlands be created.

Since most of the "dry" areas of the Island have been developed, this means that every new building project on Wallops Island will have some sort of wetland impact.

The Wallops Environmental office determines the extent and location of wetlands on Wallops property, permits wetlands impacts, and arranges the compensatory wetland mitigation that is required by Federal, state, and local laws.

Similarly, Greenbelt has several wetlands with the largest comprising just over one acre near Building 25. This area was constructed as a wetlands mitigation area for the realignment of Soil Conservation Service Road in 2006 which impacted approximately half an acre of wetlands. As part of the required monitoring for wetland mitigation projects, Greenbelt environmental management staff discovered that invasive species were overtaking the area. To address this, Greenbelt hosted volunteer invasive species removal activities in 2009 and 2010, focusing primarily on three species of concern: Japanese stiltgrass, Mile-a-Minute vine, and Phragmites that is also managed at Wallops (p. 17). Invasive species continue to be present in the Greenbelt wetlands, however, the facility has no current program to address them due to competing interests.

3. G *Goddard Child Development Center Certified Green School Practices*

Goddard operates a daycare center and kindergarten for employees' children at the Greenbelt campus (Goddard Child Development Center, or GCDC). Being a part of the Goddard community, GCDC strives to embody the values of the Goddard populations by creating an inquisitive, healthy, and environmentally aware environment for the two- to five-year-old students. In recognition of the environmental awareness education at GCDC, the daycare recently earned Certified Green School status from the Maryland Green School Program on May 5, 2015.

The Green School program's goals are to enrich education by integrating hands-on, inquiry-based instruction to empower youth to practically apply knowledge at school, home, and in their communities to reduce pollution, support critical habitats, and create healthy living and learning environments. Goddard is particularly proud of this achievement in creating both a nurturing habitat for our children, one of our most precious natural resources, and for fostering awareness and independent thinking that will ensure the goals of sustainable human advancement and environmental stewardship continue past our generation.

4. G *Goddard Green Office Program*

In the spirit of the Certified Green School program, MEMD launched a Green Office Program in 2014 to promote sustainable work practices at Greenbelt. The program certifies office areas that volunteer to meet the Green Office checklist requirements for environmentally preferable purchasing, waste reduction and management, transportation, energy and water use, and other practices. As of July 2015, six offices at Greenbelt have participated in the program.

Ecosystems.3 – Planned Standard Practices

1. G W *Pollinator Support Efforts*

A June 20, 2014, presidential memo instructs agencies to take efforts to support pollinating species essential for agriculture and natural ecosystem function. Goddard has addressed these requirements through a limited number of native flowering plantings. On a larger scale, in summer 2015, Goddard is revising the landscaping plant species selection guide used by the FMD to specify native species that will support pollinators in all landscaping applications.

Ecosystems.4 – Planned Strategic Practices

1. G W *Develop Forest Management Plan to Enhance Ecosystem Benefits*

First mentioned in the 2014 Report (p. 49), Goddard plans to develop a forest management plan to reduce forest based risks such as fire, invasive species propagation, and human safety, while enhancing ecosystem functions such as stormwater filtration, visual screening, and wildlife habitat at both Greenbelt and Wallops.

2. G W *Create Award Program for Employees Who Implement Sustainable Practices*

While implementation of sustainability initiatives falls largely on operations organizations, many organizations including Goddard have had great success in leveraging the creativity and passion of the entire organization to pursue sustainability initiatives. For example, the Goddard bikeshare program was the product of a group of Goddard employees that got together to develop a feasible strategy and work with MOD to implement it.

To further promote this kind of innovation, Goddard will evaluate the possibility of establishing an award program for employees that develop and/or implement sustainable practices that lead to demonstrable results. The award program would not need to be limited to ecosystems issues, but was included in this section because of its broad applicability.

Conclusion

From the beginning, NASA has provided a vision for a prosperous human future. As we took the first of many steps outside our planet we began to look back and realize the impacts of human activities on the earth. With this knowledge, we understand that a prosperous human future requires more than just discovery, it needs awareness. NASA Goddard has led the way in understanding the interactions between human activity and our home world, and now is leading the way towards a prosperous human future that addresses both our understanding of the universe and care for our home planet.

> "As we peer into society's future, we – you and I, and our government – must avoid the impulse to live only for today, plundering for, for our own ease and convenience, the precious resources of tomorrow. We cannot mortgage the material assets of our grandchildren without risking the loss also of their political and spiritual heritage."
>
> President Dwight D. Eisenhower
> *January 17, 1961*
> *Farewell Address to the Nation*

NP-2015-7-311-GSFC