GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

Environmental Resource Document
November 2018

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List of Acronyms

ACHP	Advisory Council on Historic Preservation
ARMD	Aeronautics Research Mission Directorate
ANSI	American National Standards Institute
AQCA	Air quality control areas
BARC	Beltsville Agricultural Research Center
Bay TMDL	Bay Total Maximum Daily Load
bgs	Below ground surface
BMP	Best management practices
BOD	biological oxygen demand
BTU	British thermal unit
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	Chlorofluorocarbons
CFR	Code of Federal Regulations
CHP	Combined Heat and Power
CO_2	Carbon dioxide
COMAR	Code of Maryland Regulations
CY	Calendar year
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
DAP	Discharge Authorization Permit
dBA	A-weighted decibel
DFA	Debris fill area
DRO	Diesel range organic
E-85	ethanol fuel
EA	Environmental Assessment
ECM	Energy conservation measures
EIS	Environmental Impact Statement
EJIP	Environmental Justice Implementation Plan
EMCS	Energy Management Control System
EMS	Environmental Management System
EO	Executive Order
EOSDIS	Earth Observing System Data Information Systems Building
EPCRA	Emergency Planning and Community Right-to-Know Act
ERD	Environmental Resources Document
ER&T	Exploration Research & Technology
ESB	Exploration Sciences Building
ESD	Environmental Site Design
ESPC	Energy Savings Performance Contract
ESSB	Earth System Sciences Building
FLIR	Forward Looking Infrared Radiometer
FMD	Facilities Management Division
FOG	Fats, oils, and grease
FPB	Flight Projects Building
FY	Fiscal year
GEWA	Goddard Employee Welfare Association
GGAO	Goddard Geophysical and Astronomical Observatory
GGRA	Greenhouse Gas Emissions Reduction Act

GHGs	Greenhouse Gases
gpd	Gallons per day
GPR	Goddard Procedural Requirement
Gsf	Gross square feet
GSFC	Goddard Space Flight Center
HCFC	Hydrochlorofluorocarbons
HCFC-22 or R-22	Chlorodifluoromethane
HEOMD	Human Exploration and Operations Mission Directorate
HFCs	Hydrofluorocarbons
HMMS	Hazardous Materials Management System
HVAC	heating, ventilation, and air conditioning
ICP	Integrated Contingency Plan
IWMP	Industrial Waste Monitoring Point
JPL	Jet Propulsion Laboratory
KCI	KCI Technologies, Inc.
LEPC	Local Emergency Planning Commission
LID	Low Impact Development
LUC	Land Use Control
MDE	Maryland Department of the Environment
MEMD	Medical and Environmental Management Division
MEP	Maximum extent practicable
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
MMBTU/hr	Million British thermal unit per hour
MOU	Memorandum of Understanding
MS4	Municipal Separate Storm Sewer Systems
MSD	Mission Support Directorate
msl	Mean sea level
$MTCO_2e$	Metric tons or more of CO_2 equivalent
MW	Monitoring well
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NFRD	No Further Requirements Determination
NOAA	National Oceanic and Atmospheric Administration
NO_X	Nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPMC	National Plant Materials Center
NPR	NASA Procedural Requirements
NRC	Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
ODP	Ozone Depletion Potential
ODS	Ozone depleting substances
Pepco	Potomac Electric Power Company
PCB	Polychlorinated biphenyl
PFCs	Perfluorocarbons
PM	Particulate matter
PWRC	Patuxent Wildlife Research Center
R-11	Trichlorofluoromethane
R-12	Dichlorodifluoromethane

R-134A	1,1,1,2-Tetrafluoroethane
RCRA	Resource Conservation and Recovery Act
RPC	Routine Program Change
SAA	Satellite accumulation area
SARA	Superfund Amendments and Reauthorization Act
Scf	Standard cubic foot
SDS	safety data sheet
SERC	State Emergency Response Commission
SHEtrak	Safety, Health, and Environmental Tracking
SIP	State Implementation Plan
SMD	Science Mission Directorate
SPCC	Spill Prevention, Control, and Countermeasure Plan
SSPP	Strategic Sustainability Performance Plan
STMD	Space Technology Mission Directorate
SWPPP	Stormwater Pollution Prevention Plan
TAP	Toxic Air Pollutants
TCE	Trichloroethylene
TDS	Total dissolved solids
TOMP	Toxic Organic Management Plan
TMP	Transportation Management Plan
TPH	Total petroleum hydrocarbon
TPQ	Threshold planning quantities
TRI	Toxic Release Inventory
TSS	Total suspended solids
UESC	Utility Energy Service Contract
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UST	Underground storage tank
VOC	Volatile organic compounds
WMATA	Washington Metropolitan Area Transit Authority
WSSC	Washington Suburban Sanitary Commission
$\mu g/m^3$	Microgram per cubic meter

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1.0 Introduction

This Environmental Resources Document (ERD) has been prepared by the Medical and Environmental Management Division (MEMD) for the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) located in Greenbelt, Maryland.

1.1 Purpose and Need

NASA Procedural Requirements (NPR) 8580 for Implementing the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114, require each NASA Center to have an ERD. An ERD is specific to NASA and is not required by NEPA or Council on Environmental Quality NEPA regulations. The purpose of the ERD is to provide a baseline description of all environmental aspects of the facility at the time of preparation. The ERD can be used as a tool to assist with ongoing management and planning decisions for Center projects and activities. The ERD forms a baseline environmental description for use in the preparation of NEPA documents such as Environmental Assessments (EA) and Environmental Impact Statements (EIS).

The ERD is a living document and will be updated periodically as new information and maps become available and as required by changing conditions. The document will be reviewed thoroughly at five-year intervals and revised, if necessary, to ensure it contains the most current and comprehensive environmental information available.

1.2 ERD Format

The ERD is organized by environmental media and topic. **Section 1.0** provides an introduction describing the format of the ERD, the purpose of the ERD, and the history of previous ERDs. **Section 2.0** describes GSFC, its mission, and Environmental Management System (EMS). **Section 3.0** describes the facilities and ongoing activities at GSFC, including a summary of environmental permits. **Section 4.0** discusses environmental resources (land, air, water, biological, cultural, waste, socioeconomic, etc.). **Section 5.0** provides the references used in this document. The appendices contain every figure (**Appendix A**), every table (**Appendix B**), and a list of endangered/threatened species (**Appendix C**).

1.3 History of Previous ERD Documents

Prior to this document, NASA prepared seven ERDs pertaining to GSFC/Greenbelt. The first ERD was published in 1980 (GSFC. (1980)), the second in 1986 (GSFC. (1986)), the third in 1991 (GSFC. (1991)), the fourth in 1993 (GSFC. (1993)), the fifth in 2002 as part of the Master Plan EA, the sixth in 2007 (GSFC. (2007).), the seventh in 2012 (GSFC. (2012)) and the eighth in 2017. This ERD is an update to the 2017 ERD.

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2.0 GSFC Mission

2.1 Introduction

GSFC is one of ten NASA centers in the United States. GSFC is comprised of six unique sites: GSFC, Greenbelt, Maryland; the Wallops Flight Facility, Wallops Island, Virginia; the Goddard Institute for Space Studies New York City, New York; the Independent Verification and Validation Facility, Fairmont, West Virginia; the Columbia Scientific Balloon Facility, Palestine, Texas; and the White Sands Complex, Las Cruses, New Mexico GSFC has additional facilities located both inside and outside the United States. This ERD is for the GSFC Greenbelt site only and references to GSFC pertain solely to Greenbelt.

2.2 Mission

NASA's mission is to lead an innovative and sustainable program of exploration with commercial and international partners to enable human exploration across the solar system and bring new knowledge and opportunity back to Earth; support growth of the Nation's economy in space and aeronautics; increase understanding of the universe and our place in it; work with industry to improve America's aerospace technologies; and advance American leadership (NASA. (2018)). Headquarters organizations lead Agency budget development, execution, performance planning, and assessment functions. Each Directorate draws on the capabilities of one or more Centers, while each Center contributes to multiple Directorates. NASA's structure as of early 2018 is the following:

- The Science Mission Directorate (SMD) expands the frontiers of Earth science, heliophysics, planetary science, and astrophysics. Using robotic observatories, explorer craft, ground-based instruments, and a peer-reviewed portfolio of sponsored research, SMD seeks knowledge about our solar system, the farthest reaches of space and time, and our changing Earth.
- The Aeronautics Research Mission Directorate (ARMD) transforms aviation with research to dramatically reduce the environmental impact of flight and improves aircraft and operations efficiency while maintaining safety in increasingly crowded skies. ARMD also generates innovative aviation concepts, tools, and technologies for development and maturation by the aviation community.
- The Space Technology Mission Directorate (STMD) pursues transformational technologies that have high potential for offsetting future mission risk, reducing cost, and advancing existing capabilities. STMD uses merit-based competition to conduct research and technology development, demonstration, and infusion of these technologies into NASA's missions and American industry. This mission directorate is being refocused as a new Exploration Research & Technology (ER&T) organization to support exploration as a primary customer.
- The Human Exploration and Operations Mission Directorate (HEOMD) leads human exploration in and beyond low Earth orbit by developing new transportation systems and performing scientific research to enable sustained and affordable human life outside of Earth. HEOMD also manages space communication and navigation services for the Agency and its international partners.
- The Mission Support Directorate (MSD) enables the Agency's missions by managing institutional services and capabilities. MSD is actively reducing institutional risk to NASA's current and future missions by improving processes, stimulating efficiency, and providing consistency and uniformity across institutional standards and practices.

GSFC advances NASA's mission by leading scientific research and building, launching and operating scientific instruments, spacecraft and information systems. As a science center, Goddard seeks to understand Earth and explore the universe through robust programs in Earth science, astrophysics, heliophysics and planetary science. As a spaceflight center, Goddard utilizes its core technical and programmatic expertise and facility capabilities to execute a broad range of flight missions and field campaigns. We are committed to enabling innovation and developing new technologies that expand

NASA's technical capabilities in support of its overarching mission. Goddard then applies its breakthroughs to society: stimulating economic growth, educating future generations, and inspiring the nation and the world.

GSFC helps answer crucial science questions through complex missions that depend on dedicated and innovative teams to develop pioneering technologies. Goddard is one of the few organizations worldwide that manages a mission from the concept phase through operations, utilizing internal, partner and industry expertise and resources along the way. The depth and expertise of our scientists, engineers, technologists, project managers and support personnel form the foundation of our unique strength. With our leadership in scientific research and instrument and spacecraft development, the center has a renowned capability of conceiving and managing advanced science, technology and space systems through the entire mission life cycle. GSFC's supports NASA's mission thorugh the following primary lines of business:

- Earth Science
- Astrophysics
- Heliophysics
- Planetary Science
- Space Communications and Navigation
- Suborbital Programs and Range Services

2.3 GSFC's EMS

GSFC's Environmental Policy (see Goddard Policy Directive 8500.1) has been developed by the Center as a primary focus for the EMS. The Center's Environmental Policy covers all the elements of NASA's Environmental Policy (see NPD 8500.1).

The scope of GSFC's EMS includes all GSFC operations housed on the Greenbelt main site, as well as Outlying Areas 100, 200, 300, and 400, and is applicable to GSFC personnel, contractors, grantees, tenants, clubs and other persons operating under the auspices of GSFC or on GSFC property. The identification of the High Priority Aspects are determined by impact and risk assessment evaluations as described in NPR 8553.1, NASA EMS. Aspects are identified and assessed annually by the EMS Core Team, a cross-functional team comprised of representatives from each of the GSFC Directorates and many of the Division Offices. The Team considers normal, abnormal, and emergency situations. Environmental Objectives, Targets, and Management Programs are developed for High Priority Aspects or aspects that need attention. Consideration is given to the legal and other requirements, technology options, financial resources, operational/mission impact, GSFC's ability to control and influence the aspect, and the views of stakeholders. The most current aspect analysis, Objectives and Targets, and Management Programs are documented and maintained on the GSFC EMS SharePoint site.

Metrics and progress toward meeting the Objectives and Targets are tracked on the EMS SharePoint site. All High Priority Aspects and Objectives and Targets are reviewed at least annually by Center management during the EMS Management Review.

Environmental non-conformances, either with the EMS, permit conditions, or environmental laws and regulations, are tracked to closure using the Safety, Health, and Environmental Tracking (SHEtrak) system. This system requires the identification of root cause, corrective and preventive actions for all problems entered into the system as well as responsibility for the corrective/preventive action and target dates.

All employees and contractors who work at the GSFC Greenbelt site are required to take the GSFC Environmental Awareness Training every three years. The training provides an overview of the GSFC – Greenbelt EMS, the basic principles of GSFC's environmental policy, and employee/contractor environmental responsibilities. The training is accessible on the System for Administration, Training, and Educational Resources for NASA.

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3.0 Description of Facilities and On-Going Activities

3.1 Location

GSFC lies within the Washington D.C. metropolitan area located in Prince George's County Maryland, about 7 miles northeast of the District (**Figure A-1** and **Figure A-2**). The distance between the western site boundary and the I-95/I-495 Washington Beltway interchange with the Baltimore-Washington Parkway is about one mile. GSFC facilities are located in six site areas: the eastern and western parts of the Greenbelt site and Outlying Areas 100, 200, 300 and 400. **Figure A-3** shows the eastern and western layouts and **Figure A-4** shows the Outlying Areas. **Table B-1** shows the approximate acreage of GSFC. An aerial photograph of the GSFC site is shown in **Figure A-5**.

Prior to October 2006, GSFC was divided in half by Soil Conservation Service Road. At that time, a major construction project rerouting Soil Conservation Road, aimed at easing traffic flow for employees and creating a safer, unified Center, was completed. Non-GSFC employees can continue onto Soil Conservation Service Road by taking Good Luck Road. ICESat Road stops at Explorer Road. Hubble Road begins from the building 34 area and extends north to Soil Conservation Service Road. In this document, every effort has been made to refer to the former East and West areas as the eastern and western sides of the Greenbelt site and the remote sites as "Outlying Areas." For reference, the western side of the Greenbelt site is that area west of ICESat and Hubble Roads and the eastern side of the Greenbelt site is that area east of ICESat and Hubble Roads.

GSFC is bounded on the south side by Greenbelt Road, Maryland Route 193. It is surrounded by city land use patterns common in many Washington DC suburbs. The City of Greenbelt lies to the west and southwest and abuts GSFC on the west side and a short distance on the south side. The community of Glenn Dale is centered about one mile to the southeast of GSFC. A mix of commercial and residential development comprised chiefly of shopping malls, office parks, and low-rise apartments and condominiums is found along Greenbelt Road. Remaining areas to the west, south, and east of Goddard are residential. All of the property for a considerable distance to the north of GSFC is government-owned. Most of the property abutting GSFC is owned by the U.S. Department of Agriculture (USDA). The USDA Beltsville Agricultural Research Center (BARC) is the largest agricultural research facility in the world. Operated by the USDA Agricultural Research Service, BARC encompasses 6,615 acres equivalent to more than 10 square miles in area. BARC extends about six miles to the west of the Baltimore-Washington Parkway through Beltsville, Maryland, to Interstate Highway 95. BARC is divided into an office complex in Beltsville along US Route 1 and five farms. Each farm is subdivided into areas. The easternmost section of BARC, the East Farm, abuts GSFC facilities and surrounds Area 100 and part of Area 200. The remainder of Area 200 abuts the Patuxent Wildlife Research Center (PWRC). East Farm Area 500 covers all BARC property between the Baltimore-Washington Parkway and Springfield Road.

The parcel immediately to the north of the eastern side of the Greenbelt site is occupied by the Norman A. Berg National Plant Materials Center (NPMC) in Beltsville. The facility is located on several separate tracts within BARC. The largest tract abuts NASA, totaling 285 acres. Although the property is owned by the USDA, it is not a part of BARC. The center is run independently by the U.S. Natural Resources Conservation Service. It is one of several regional centers that conduct studies of local ecosystems with emphasis on resource conservation. Research at the Beltsville NPMC is oriented toward Chesapeake Bay restoration and preservation studies. The parcel adjacent to GSFC is completely undeveloped and covered by a prototype Mid-Atlantic pine-oak research forest.

Prince George's County operates a Trap and Skeet Center (shooting range), located off Good Luck Road. The firing direction is to the north. A 75-foot-wide right-of-way for the range entrance road separates the eastern side of the Greenbelt site from Area 300.

The PWRC is owned and operated by the U.S. Department of the Interior, Fish and Wildlife Service

(USFWS). The center is nearly twice the size (12,750 acres) of BARC. It extends for more than 10 miles to the north from GSFC, across the Patuxent River into Howard County. PWRC contains the Patuxent Wildlife Refuge, the National Wildlife Visitor Center, and wildlife research facilities. PWRC's Visitor Center is the largest wildlife education center operated by the Department of the Interior. The southernmost section of the Visitor Center is adjacent to GSFC Area 400 on Springfield Road. This area is used for research on wildlife and habitat relationships, on effects of environmental contamination, and on endangered species and migratory birds.

3.2 Installation History

Land now occupied by GSFC was acquired by the USDA from private owners between 1929 and 1936. GSFC is located on five unconnected tracts of land that, with one exception, were subsequently purchased outright or occupied under revocable permit from the USDA in a series of transactions (**Figure A-6. GSFC Deed Composite Map**). These tracts correspond to the eastern and western portions of the Greenbelt site combined; Outlying Areas 100, 200, 300, and 400 combined; and a small parcel on the west side of the Baltimore-Washington Parkway.

The western side of the Greenbelt site covers the parcels or tracts of land west of ICESat and Hubble Roads. The main parcel forming the western side of GSFC, together with two parcels covering 103.45 acres in the southern third of the east portion of the Greenbelt site, made up the original GSFC site purchase in June 1961. This purchase also included 4.03 acres of Soil Conservation Service Road right-of-way so that the eastern and western portions of the Greenbelt site are contiguous in ownership.

Two additional tracts were purchased in 1964 to allow construction of direct road access to the Baltimore-Washington Parkway. These tracts consist of a triangle shaped parcel on the eastern side of the Parkway that was obtained from USDA, and a small isolated rectangular parcel on the western side that was bought from the City of Greenbelt. GSFC owns the bridge connecting the two parcels, but not the parkway right-of-way underneath that has been retained by the U.S. National Park Service.

The northern sector of the eastern side of the Greenbelt site, and Areas 300 and 400, were occupied under a revocable permit by GSFC as early as 1961. GSFC ultimately obtained title in 1981. The eastern side of the Greenbelt site is separated from Areas 300 and 400 by a narrow access strip to the otherwise landlocked Prince George's County Trap and Skeet Center. No distinct property boundary or internal fence line separates Areas 300 and 400, but Area 300 encompasses approximately 153 acres and Area 400 about 97 acres. Areas 100 and 200 are tracts predominantly within BARC. The pond north of building 29 is held under a revocable permit from BARC and covers approximately 3 acres.

Verizon Communications, Inc. has a permanent easement for right-of-way granted to its predecessor, the Chesapeake and Potomac Telephone Company, for operation and maintenance of communications lines. Other minor temporary leases for building space facilities and utility rights-of-way are also in effect but change with time.

3.3 Main Site

Operations at GSFC may be most easily explained on a mission or program basis. In the broadest terms, a mission or program involves launching a spacecraft with scientific equipment and devices on board to collect space and earth science data. The data is subsequently analyzed. GSFC has the personnel and facilities to perform all the necessary tasks, in whole or in part, except for the launching of the spacecraft. In practice, GSFC performs many of the tasks, but assigns others to outside contractors, partners, or other NASA Centers. The mission process is complex and involves many interrelated tasks. A typical launch mission has the following general tasks.

- Planning and Management. In early mission or program phases, decisions are made as to whether tasks will be completed by GSFC scientists, engineers, and facilities or be assigned to outside partners. Mission Teams are formed based on these decisions. Budgets, schedules, and project

concepts are developed. Planning and management continue through subsequent tasks even to scheduling the availability of spacecraft equipment for research, such as the Hubble Telescope for observing scientists.

- Design and Development. The experimental devices and equipment as well as the carrying spacecraft are designed and developed on a one-of-kind, state-of-the-art basis. Design of experiments emphasizes minimum weight and maximum utility of retrieved data. Generally, several experiments are included to optimize mission results. The spacecraft itself must be designed to protect the experiments in an anticipated, generally harsh, operating environment, and the means for control from, and communications with, earth developed. All of the systems are integrated.
- Fabrication and Assembly. Once designed, the spacecraft and its components must be fabricated and assembled. GSFC has many specialized spaces and facilities to accomplish this task, although individual elements or entire experimental devices may be done by others. Examples of specialized spaces include shops that can fabricate and machine alloys, plastics and ceramics or exotic combinations of these materials; clean rooms, including one of the few Class 100 (100 particles of dust up to 5 microns in diameter per cubic foot) clean rooms in the world; and also one of the largest Class 10,000 clean rooms in the world.
- Testing and Quality Assurance. Once launched, spacecraft can be accessed for maintenance and repairs only with great difficulty, if at all. High precision and reliability are required for mission success. Testing and checking of designs, fabrications, and assemblies are conducted continually through their development. GSFC also has many specialized facilities that can duplicate the low and high extremes of temperature, pressure, and gravitational and magnetic fields to which spacecraft and experiment components can be exposed. Examples of specialized facilities are the High Capacity Centrifuge, which can simulate gravitational forces many times higher than on Earth, and a magnetic heat facility that can either cancel the earth's magnetic field or produce one that would be encountered in the vicinity of Jupiter. More mundane laboratories test for items such as geometric tolerances and material failure points.
- Launch. GSFC is not directly involved in launches, but it must have the capability of transporting spacecraft and components assembled at GSFC to the launch site.
- Tracking and Control. The orbital path of spacecraft and on-board experimental instruments are controlled through radar or laser tracking and radioed commands. A worldwide communications network is needed to maintain contact. GSFC is one station in that network.
- Data Processing, Analysis, and Archiving. Spacecraft signals sent back to earth are processed and analyzed as necessary to convert the signal into useful visual or numeric products. Personnel in GSFC computer facilities and processing laboratories extract useful information in many formats. Photographs, for example, may be in true or false color, or enhanced in a variety of ways to maximize information gained. Raw and analyzed data are archived for future reference and made available to researchers throughout the world.

At GSFC, many scientists and engineers are on specific mission teams. Other scientists (both theoretical and applied), engineers, and technical personnel are not. They work in general development in space and earth sciences and its associated technology and are available to mission teams as needed. Facilities and building spaces, such as shops, testing, and computer facilities, and communications are shared.

The ongoing activities are supported by a wide variety of support personnel that operate and maintain utilities, roads, buildings, and grounds, and provide day-to-day services.

The number of workers GSFC employees can vary. At present, GSFC employs approximately 8,200 civil servants, contractors and consultants at Greenbelt. Of the approximately 8,200 total employees, an estimated 2,840 are civil servant workforce. The remaining are private contractors providing scientific, technical or supporting services, visiting research scientists and engineers, or partnering personnel. Among the federal employees, about 62 percent are scientists or engineers, and 38 percent are

professional/administrative, clerical, technicians, or operations and maintenance support (from http://wicn.nssc.nasa.gov/wicn_cubes.html, as of January 2018).

The majority of employees work in one of the major buildings on the Greenbelt site, and about 10 employees work in Outlying Areas 100 to 400. Approximately 100 employees are located in trailers scattered around GSFC and about 300 people work in two off-site, leased buildings in the Greenbelt area. The major buildings have a total floor area of approximately 3,400,000 gross square feet (gsf). About 50 additional miscellaneous small buildings accommodate a wide variety of specialized facilities such as antennas and their control sheds, small telescope and laser observatories, test facilities, storage sheds and Goddard Employee Welfare Association (GEWA) facilities. Many of the specialized facilities are located in the outlying areas and individually occupy less than 1,000 gsf. There are approximately 50 buildings in the Outlying Areas with a combined area of about 49,000 gsf.

Buildings on the western side of the Greenbelt site are arranged in two orthogonal grids; the northeast sector is on a northeast-southwest axis and the remaining areas on the western side are on an east-west axis. Except for minor additions, and buildings 97 (circ. 1979), 28 (circ. 1980), 90 (circ. 1987), 29 (circ. 1990), and 30 (circ. 1993), the buildings on the western side of the Greenbelt site were built prior to 1970. Many of the buildings have mixed uses. Technical space consists of laboratories, shops, test facilities, computer spaces, and specialized areas such as clean rooms. Buildings 3, 13, and 14 comprise a combined spacecraft support center. Buildings 5, 7, 10, 15, and 29 are engineering and technical spaces primarily devoted to the fabrication, testing, and assembly of spacecraft and their components. In addition, the Instrument Development Facility (IDF) is scheduled to start construction in fiscal year (FY) 2019. Infrastructure facilities that support all operations at GSFC include building 35, primarily used as a warehouse, and buildings 24, 31, 90, and 97. The Flight Projects Building (FPB), building 36, was completed in 2017 and is occupied by the Flight Projects Directorate. The FPB is sited just northeast of building 12, within the Program/Project Management neighborhood to facilitate synergy within the community.

The design for the development of the east side of campus began in 1990. Construction of buildings 31 and 32 began in 1992. Earth Science is primarily housed in newer, modern facilities on the eastern side of the Greenbelt site. Building 32, the Earth Observing System Data Information Systems Building (EOSDIS), was first occupied in 1994; building 33, the Earth System Sciences Building (ESSB), in 1998; and building 34, the Earth Science Building (ESB), in 2009. The building 27 area provides a number of site-wide support functions such as the vehicle motor pool, equipment storage, and sand and salt storage for road maintenance. Other support facilities on the eastern side include building 25, the Network Testing and Training Facility and a few small isolated facilities. A Logistics Facility (building 35) was completed in 2012, along with a new access road and gate for all incoming deliveries to GSFC. This entrance is accessible from the rerouted Soil Conservation Service Road.

GEWA recreation facilities are scattered throughout the site. The GEWA Recreation Center (building 92) with adjacent tennis courts is located on the eastern side of the Greenbelt site off Good Luck Road. The Radio, Ski, and Flying Clubs have been relocated to Area 100. Building 95, which housed The Auto Club is also located on the eastern side of the Greenbelt site. Auto club activities at this location were terminated in July 2018. The building is scheduled for deconstruction. Roads north of Explorer Road have little traffic and are used for recreation. The GEWA facilities on the western side of the Greenbelt site include a picnic pavilion (building 78) to the north of the child care center (building 90). A rectangular athletic field that is adaptable to many activities is located along the western boundary. Area 100 contains softball and baseball fields that are available to GEWA members.

All of GSFC is surrounded by security fencing and is access controlled. Visitors generally enter GSFC through the Main Gate off Greenbelt Road. Employees can also gain access via Gate 3 from the Baltimore-Washington Parkway, the North Gate (on Hubble Road), and the South Gate (off ICESat Road). Other site gates are always closed, unless exceptional circumstances occur. GSFC's Visitor Center (building 88),

located in the southeast corner of the western portion of the Greenbelt site, is the only site building outside the security perimeter.

The main traffic artery through the Greenbelt site is Explorer Road, which crosses the eastern and western sides of the Greenbelt site and provides access to the south end of the western side of GSFC. Explorer Road then loops up north around the ESB to Hubble Road. Goddard, Cobe, and Tiros Roads serve as important traffic collector and distributor roads on the western side of the Greenbelt site.

3.4 Outlying Areas (100, 200, 300, and 400)

GSFC has four research areas that require isolation from the main activities at the Greenbelt site (**Figure A-4**). There are approximately 10 permanent employees in the outlying areas; other employees are available from various projects on the site. The following are summary descriptions of each area.

3.4.1 Area 100 – Antenna Test Range

Area 100 is used by GEWA Softball Club members for playing softball, and by the Radio, Model Airplane, and Flying Clubs. The farm house, building 101, which predates GSFC's occupancy, was used in the past for offices, laboratories, and had a machine shop. Building 101 is no longer used.

3.4.2 Area 200 – Goddard Geophysical and Astronomical Observatory (GGAO)

The Goddard Geophysical and Astronomical Observatory (GGAO) is the home of pioneering research in many scientific areas. Scientific application of lasers, astronomy, and solar physics are just a few examples. Specialized telescope and laser domes, together with their supporting offices, laboratories, and shops are clustered in cleared areas on a knoll near the entrance to the site on Springfield Road. The old abandoned Beltsville Airport bounds these same two sides.

The facility was formerly called the Goddard Optical Research Facility and was originally established to provide a low background (light) level for optical instrumentation development and observation. Minimal development of government properties in the vicinity of Area 200 is important. Maintenance of an unobstructed view down to the horizon is essential.

3.4.3 Area 300 – Magnetic Test Facility

This is a highly specialized facility, unique to GSFC, which is used to study the magnetic fields of spacecraft and the environment in which they will travel when in space. The site has two facilities: the Magnetic Field Component Test Facility and the Spacecraft Magnetic Test Facility.

The Magnetic Field Component Test Facility is capable of simultaneously simulating the magnetic fields, temperature, and vacuum conditions of outer space, or near planets and moons. The Spacecraft Magnetic Test Facility is used to determine the magnetic fields of spacecraft and their component subsystems, parts, and instruments prior to launch. Area 300 is completely wooded except for clearings for buildings and one lane roads. The buffer zone around the facilities extends to the Area 300 property boundaries. The area must be isolated to minimize or eliminate the magnetic influences of outside sources.

3.4.4 Area 400 – Bi-Propellant Test Facility

Current work at Area 400 involves development and testing of cryogenics. Cryogenic research involves working with materials at extremely low temperatures. Typical research involves the development, testing and evaluation of cryogenic coolers (cryocoolers) for spacecraft. In the past, work in Area 400 involved development and testing of propellants. Currently, GSFC is working with a green propellant that is less hazardous and has been developed by the Unites States Air Force and is a pripriatory chemical.

The facility requires isolation from outside influences such as vibrations and shock waves. The buffer area is conservatively defined as the property or fence line around Area 400. Except for the compound, all of Area 400 is forested.

3.5 Land Use Controls (LUCs)

GSFC has implemented Land Use Controls (LUCs) to manage the potential risk from environmental sites identified at the Center. The LUCs establish procedures and practices to protect workers from potential risks associated with the trichloroethylene (TCE) groundwater plume and four former debris filled areas (DFAs). The plume and DFAs are further described in **Section 4.6**, Restoration Program.

The following LUCs are implemented at GSFC:

- Use of groundwater from the shallow unconfined Upper Patapsco Aquifer at GSFC is restricted to investigative and monitoring purposes.
- Prior to commencing with intrusive activities (i.e., activities requiring penetration/excavation to the subsurface of the land area) at land comprising DFA A1, DFA A2, DFA B, and/or DFA C, or requiring contact with the TCE-contaminated portion of the shallow, unconfined Upper Patapsco Aquifer, the activity will be required to implement actions to assure appropriate personal protective measures are implemented through site/project health and safety plans instituted through the Center's dig permit process.
- Land comprising DFA A1, DFA A2, DFA B, and/or DFA C will not be used for residential uses or for daycare facilities.

Preventive measures such as confirmatory sampling or vapor mitigation systems may be required to be implemented prior to the construction of building structures on top of DFA A1, DFA A2, DFA B, and/or DFA C or in contact with the TCE-contaminated portion of the shallow, unconfined Upper Patapsco Aquifer.

3.6 Summary of Environmental Permits

The following section describes GSFC's environmental permits. GSFC receives additional temporary permits for new construction projects and transfers the permit to the appropriate contractor once the contract has been awarded. This section discusses permits currently maintained by GSFC.

In addition, GSFC has established agreements with other organizations for the conservation of resources not governed under a specific permit. For example, GSFC has been a member of the Maryland Green Registry, an organization dedicated to improving sustainability, since 2009. Due to GSFC's commitment to sustainable practices and initiatives, the center received a Leadership Award from the Maryland Green Registry in 2011 recognizing GSFC for implementation of an EMS program, waste reduction efforts, and employee outreach initiatives.

On January 23, 2006, GSFC signed a Memorandum of Understanding (MOU) with the State of Maryland and adjacent landowners to form the Baltimore-Washington Partners for Forest Stewardship. Under the MOU, the partners have committed to enhance and protect a 25,660-acre natural area in the National Capital Region. The MOU was updated in 2011 to introduce new partners. To date partners include; the Patuxent Research Refuge, the U.S. Secret Service, the U.S. Forest Service, the U.S. Geological Survey, Maryland Department of Natural Resources, USDA BARC, GSFC, U.S. Army Fort George G. Meade, and the Center for Chesapeake Communities.

Under the Forest Conservation Act, activities that disturb 40,000 square feet or more, must submit a forest conservation plan. If afforestation or reforestation is necessary, the plan must outline how and where this will occur. GSFC has numerous forest conservation areas on the Greenbelt site (**Figure A-7**). These conservation areas were preserved as a result of the construction of buildings 32, 33, and 34, and the re-routing of Soil Conservation Service Road.

In July 2016 a License was signed with the University of Maryland Extension Service (UMDES) with the purpose of allowing MEMD to collaborate with the UMDES in establishing a native wildflower meadow within the 0.1 acre in front of the main entrance to building 33. The purpose is to demonstrate the feasibility of a more sustainable landscape that also provides pollinator (bees, butterflies, birds, etc.) habitat and encourages biological diversity.

3.6.1 Title V Operating Permit

Federal and state air quality laws and regulations require facilities that are major sources or include fossil fuel-fired combustion sources subject to the acid rain emissions limitations to obtain a Title V operating permit. Title V permits are sometimes referred to as Part 70 permits since the federal regulations that establish the minimum standards for state permit programs are found in Part 70 of 40 Code of Federal Regulations (40 [CFR] Part 70). General information on and the applicability of Title V permits issued by the Maryland Department of the Environment (MDE) can be found at: http://mde.maryland.gov/programs/Permits/AirManagementPermits/Pages/title5factsheet.aspx. MDE defines a major source as a stationary source or group of stationary sources that are located on one or more contiguous or adjacent properties, and are under common control of the same person, or persons, belonging to a single major industrial grouping, which have the potential to emit above the major source thresholds.

GSFC maintains a Maryland Title V operating permit since the Center's facility-wide nitrogen oxides (NO_X) potential emissions are greater than the major source threshold of 25 tons per year for NO_X in Prince George's County, Maryland. GSFC received its initial Title V permit from MDE on October 26, 2000. Renewal Title V permits were issued on August 17, 2005, November 30, 2009, and December 22, 2014. GSFC's Title V permit is a combination of federal and state standards. The permit establishes, among other requirements, emissions and throughput limits. Permit renewal is planned for 2019.

3.6.2 National Pollutant Discharge Elimination System (NPDES) Permits

GSFC maintains various National Pollutant Discharge Elimination System (NPDES) permits issued by the Maryland Department of Environment (MDE). These permits direct discharges of industrial wastewater and stormwater into waters of the State. GSFC maintains NPDES permits to include an industrial discharge permit and several general permits. GSFC provides oversight for site-specific construction approvals and permits; the contractor performing the work is responsible for maintenance of site-specific approvals/permits. The details of each permit or approval are discussed in **Sections 3.6.2.1** and **3.6.2.2**.

Many NPDES-issued permits require the development, implementation, and maintenance of a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP details Best Management Practices (BMPs) to prevent stormwater pollution. Activities covered in the SWPPP include the vehicle maintenance facility, hazardous waste accumulation facility (less than 90-day storage), heating and refrigeration plants, shipping and receiving facilities loading/unloading docks, salt domes, landscaping facility, staging/storage areas, fire control system flushing, water distribution lines flushing and sanitizing, hydrostatic testing or flushing of the water tower, erosion and sediment control for small construction activities, sanitary sewer overflow procedures, dry-weather outfall screening areas of exposed soils, and emergency/illicit discharges. The SWPPP is reviewed at least annually. In addition to the GSFC SWPPP, a site-specific erosion and sediment control plan must be developed for construction activities which disturb at least 5,000 square feet or 100 cubic yards of soil. For additional information on construction permits and approvals, see **Section 3.6.2.2.3**, Stormwater Construction Permits and Approvals.

The Chesapeake Bay Total Maximum Daily Load (Bay TMDL) established in December 2010, places more stringent requirements on GSFC and others that discharge to the Bay watershed. The Bay TMDL is a historic and comprehensive plan to restore the Chesapeake Bay by establishing goals for pollutant reductions across the entire footprint of the Bay's watershed. The targeted pollutants are nutrients (nitrogen and phosphorus) and sediments. The Bay TMDL impacts Delaware, the District of Columbia, Maryland,

New York, Pennsylvania, Virginia, and West Virginia and is being implemented for federal/state facilities through Municipal Separate Storm Sewer Systems (MS4) permitting requirements

Figure A-8 (Main Site) and **Figure A-9** (Outlying Areas) show the drainage basin outfalls.

3.6.2.1 Industrial Discharge Permit

GSFC has an NPDES industrial discharge permit (NPDES N0. MD0067482) with MDE that authorizes the discharge of boiler blowdown and non-contact cooling water via Outfall 001 and non-contact cooling water via Outfall 004. Monthly monitoring parameters at Outfalls 001 and 004 consist of flow (including effluent and stormwater), total copper, dissolved copper, total residual chlorine, hardness, temperature, and pH. Quarterly monitoring is required total phosphorous and total nitrogen. **Table B-2** details the NPDES permit limits. Discharge monitoring reports are submitted to MDE electronically on a quarterly basis as part of permit compliance.

For Outfall 001, sampling for pH is conducted at the inlet of the sediment pond, south of Cobe Road, adjacent to the Main Pond. GSFC requested this change in monitoring point location on March 2, 2015 (approved July 2, 2015), in order to avoid impacts from natural events, such as rain or algae growth, from affecting pH in the large pond that discharges to Outfall 001. The monitoring point location for pH at the sediment pond inlet captures process wastewater from the building 24 cooling towers and boiler blowdown as close to the source as possible, thus allowing GSFC to pinpoint pH issues originating from building 24. All other sampling is conducted at Outfall 001. For Outfall 004, all sampling is conducted at the exit of the EOSDIS (building 32) pond. A modification requesting a new pH sampling location at the top of the inlet to the EOSDIS pond was requested on March 27, 2018.

3.6.2.2 Stormwater General Permits

3.6.2.2.1 General Permit for Discharges from Small Municipal Separate Storm Sewer Systems

GSFC maintains an NPDES Municipal Separate Storm Sewer Systems (MS4) general permit, which takes a holistic approach to reducing stormwater pollution. As required under the MS4 permit, GSFC has established measurable goals for each of the following minimum control measures: illicit discharge detection and elimination program, public education and outreach, public involvement and participation, construction site stormwater management, post construction management, pollution prevention, and good housekeeping practices. GSFC is required to report annually to MDE on the status of program implementation and progress towards meeting the goals. The MS4 permit was first issued to GSFC in November 2004. The new permit, issued on April 27, 2018 (General Discharge Permit No. 13-SF-5501, General NPDES No. MDR055501), becomes effective on October 31, 2018 upon submission of the notice of intent for coverage. The new general permit includes a more quantitative approach to improving stormwater quality through practices that have proven to reduce stormwater pollutants. Under the new permit, GSFC will be required to commence restoration efforts for twenty percent of existing developed lands that have little or no stormwater management by2025.

3.6.2.2.2 General Permit for Discharges from Tanks, Pipes, and Other Liquid Containment Structures at Facilities Other than Oil Terminals

GSFC maintains an NPDES general permit for discharges from tanks, pipes, and other liquid containment structures, including fire control systems flushing, water distribution lines flushing and sanitizing, hydrostatic testing or flushing of the GSFC Water Tower, and petroleum storage tank containment structures. This permit was first acquired in April 2009, reissued in March 2012, and modified in 2015. The primary pollutants resulting from fire control systems and potable water distribution systems are chlorine and sediments. The pollutant of concern from petroleum tank containment structures is petroleum from potential leaks or spills. The monitoring requirements vary depending on the type and volume of discharge, as well as the time of year the discharge occurs. GSFC activities that involve discharges covered

under this permit are identified in the GSFC SWPPP. These activities must adhere to BMPs and are subject to an annual inspection/evaluation by the GSFC Environmental Team. The current permit expired in February 2017 and is administratively extended until the new permit is issued. The tentative determination for the new permit, 17-HT, was released April 17, 2018.

3.6.2.2.3 Stormwater Construction Permits and Approvals

GSFC is required to obtain a stormwater construction permit for each construction activity that disturbs more than one acre of land. For construction projects that disturb 5,000 square feet or 100 cubic yards of land or more, GSFC must submit an erosion and sediment control/stormwater management plan to the State. Plans must be approved prior to breaking ground.

3.6.3 Washington Suburban Sanitary Commission (WSSC) Wastewater Discharge Authorization Permit

GSFC was issued a discharge authorization permit (DAP) from the Washington Suburban Sanitary Commission (WSSC) due to the Center's industrial wastewater discharges into the sanitary system. WSSC classifies GSFC as a Significant Industrial User in accordance with Section 801.2.41 of the WSSC Plumbing and Fuel Gas Code. In November 2015, WSSC issued a modification to the GSFC DAP deeming GSFC a Categorical Industrial User due to metal finishing processes conducted in the electro-plating facility located in building 5. This classification dictates that GSFC is subject to the Federal requirements of 40 CFR, Part 433. The modification required quarterly monitoring at Monitoring Point 001, effective the first Quarter of 2016. The current WSSC DAP Permit expires May 29, 2020.

Under WSSC Permit 00449, GSFC monitors industrial wastewater effluent on a quarterly basis at the Industrial Waste Monitoring Point (IWMP) behind building 9 (Monitoring Point FAC) and at the water pretreatment facility within the electro-plating facility located in building 5 (Monitoring Point 001). GSFC submits quarterly reports for both IWMPs to WSSC, as required by the permit. The parameters monitored each quarter at Monitoring Point FAC are total metals (cadmium, chromium, copper, lead, nickel, silver, and zinc), cyanide, biological oxygen demand (BOD), total suspended solids (TSS), flow, and pH; WSSC monitors fats, oils, and grease (FOG), beryllium, total dissolved solids (TDS), and mercury at their own discretion. The parameters monitored each quarter at Monitoring Point 001 are total metals, cyanide, flow, and pH. Because GSFC has a WSSC-approved Toxic Organic Management Plan (TOMP) in place, GSFC is not required to monitor for total toxic organics at Monitoring Point FAC and Monitoring Point 001. **Table B-** further details the WSSC Discharge Authorization Permit limits.

GSFC was issued its first WSSC DAP in June 1989. Since then, several new buildings have been added. Each building conducting research and development is evaluated individually to determine if its operations require monitoring through routine sampling. Some of these buildings discharge via the east wastewater discharge point and are not captured with routine sampling at the Monitoring Point FAC. The buildings have been evaluated individually by WSSC and to date, all discharges have been considered insignificant.

A general condition of the permit is the requirement to properly operate and maintain all treatment systems. There are several treatment systems throughout the main site to include an oil/water separator at the Vehicle Maintenance Facility. In addition, there are grease abatement systems installed in building 1 and 21 cafeterias as well as the building 33 café. GSFC reports quarterly on the service and maintenance of oil/water separators and grease abatement systems. In addition to these treatment facilities, GSFC has various laboratory treatment systems in place. These systems include: two pH neutralization systems in the basement of building 30 (these two systems are being merged with an estimated completion date of January 2019, which will result in only one pH neutralization system in building 30)); individual sink drain neutralization systems in building 11 labs; and a single system supporting the lab block in building 34. In addition, a wastewater pretreatment system is located in the building 5 electroplating facility. This system is comprised of an ion exchange system that removes wastewater contaminants, and a pH neutralization system.

3.6.4 Oil Operations Permit

GSFC holds an Oil Operations Permit from MDE (2014-OPR-3356) since the oil storage capacity of the Center exceeds 10,000 gallons. The permit was authorized in 2014 and is due for renewal in January 2019. The inventory of bulk storage containers subject to Spill Prevention, Control, and Countermeasure (SPCC) regulations is included in GSFC's Integrated Contingency Plan (ICP). The ICP also includes procedures that help prevent oil spills and aid in spill notification and cleanup.

3.6.5 Depredation Permit

Under the Migratory Bird Treaty Act, it is illegal to destroy the nests, eggs, habitats, and birds without a permit. GSFC maintains a depredation permit issued by the USFWS that authorizes GSFC to "take" 50 Canada Geese annually as needed. This permit is renewed annually.

Through the Resident Canada Goose Nest and Egg Depredation Order, GSFC is authorized by USFWS to perform egg addling on GSFC property from March through June of each year. Although no permit is required under the Order, GSFC must properly register in advance each year on the USFWS's Resident Canada Goose website. GSFC is also required to report the number of Canada geese eggs addled to the USFWS by October 31 of each year.

3.6.6 Water Appropriation and Use Permit

GSFC maintains a Water Appropriation and Use Permit (PG1998G023 (04)), issued by MDE, allowing the center to extract groundwater from two wells in the Patuxent aquifer for use in industrial processes. One groundwater well is located on both the eastern side and the western side of the Greenbelt site. Generally, the permit covers a twelve-year period and establishes daily average withdrawal limits to ensure adequate protection of groundwater resources. The current permit allows GSFC to withdraw a daily average of 257,000 gallons per day (gpd) on a yearly basis, and a daily average of 375,000 gpd for the month of maximum use. MDE maintains the authority to alter withdrawal amounts. GSFC provides a semi-annual withdrawal report to MDE as a requirement of the permit. Further discussion regarding the use of groundwater may be found in **Section 4.2.4**.

3.6.7 Scrap Tire Storage and

Maryland Secondary Scrap Tire Collection Facility License No. 2015-RSC-10362 authorizes the accumulation of up to 1,500 scrap tires at any one time at 8800 Greenbelt Road in Greenbelt, Prince George's County, as specified in this facility's application of December 1, 2015. Scrap tires are collected and transported by a licensed scrap tire hauler to a licensed scrap tire recycler. Semi-annual reports are submitted to the state of Maryland detailing number of scrap tires generated and removed from GSFC.

4.0 Environmental Baseline

4.1 Natural Resources

4.1.1 Land Resources

4.1.1.1 Geology

The Greenbelt site is located in Prince George's County, which lies within the Western Shores Upland Region of the Coastal Plain Province (**Figure A-10**). Prince George's County is underlain by a mass of unconsolidated sedimentary deposits that form an enormous wedge overlaying older, crystalline bedrock of Precambrian or Early Paleozoic Age. The generalized geology of Maryland is depicted in **Figure A-11**. The arkosic or sandstone crystalline rock outcrops just to the west of the Prince George's/Montgomery County line. The top surface dips or slopes downward in a southeasterly direction across the County at 60 to 110 feet per mile, reaching a depth of 1,400 to 1,500 feet below sea level at Brandywine, and 2,000 to 3,000 feet below sea level at Chalk Point, at the southeast corners of the County (Mack and Achmad, 1986).

The Greenbelt site is located on unconsolidated fluvial sediments of the Coastal Plain. Fluvial is a term used to refer to the processes associated with rivers and streams and the deposits and landforms created by them. These sediments, which overlay crystalline bedrock, are approximately 500 ft. to 800 ft. thick underlying the Greenbelt site (Hansen and Edwards, 1986). These sediments consist of alluvium from the Pleistocene Epoch (10,000 to 1.6 million years old), and the Potomac Group from the Cretaceous Period (66 to 144 million years old). The Coastal Plain sediments begin at the Fall Line and follow a regional dip to the southeast at approximately 110 ft. per mile (Hansen and Edwards, 1986). The Fall Line is the division between the Piedmont and Atlantic Coastal physiographic provinces. The term "Fall Line" refers to an imaginary line connecting waterfalls or changes in stream flow between the hard rock upland areas of the Piedmont and the soft sediment lowland areas of the Coastal Plain. A brief description of the major sedimentary units, from youngest to oldest, is presented below.

The Pleistocene alluvial sediments consist of upland terraces and paleochannel deposits that are not horizontally continuous throughout the region. The Potomac Group consists of alternating sand and clay lithofacies, which tend to form discrete aquifers, perched aquifers and confining units. The Potomac Group in Prince George's County is subdivided (from youngest to oldest) into the Patapsco, Arundel, and Patuxent Formations. The Potomac Group was mainly deposited in fluvial-deltaic environments (Mixon, 1989) in the early-to-late Cretaceous Period. Sand layers in the Potomac Group above the basal layer are difficult to map between boreholes because of the high variability of the fluvial-deltaic system. The Patapsco Formation has been further subdivided into two separate aquifers, the Lower and the Upper Patapsco aquifers, which are separated by an unnamed confining unit of varying thickness (Mack and Achmad, 1986). Conditions in these formations are illustrated schematically in **Figure A-12**.

Patapsco Formation. This formation ranges in thickness from 200 ft. to 500 ft. (approximately between 200 ft. and 500 ft. below ground surface (bgs) and is comprised of sand, sandy clay, clay, silt, and trace gravel. Sand grains are typically fine-grained and rounded. Clays range in color from tan, buff, and white to mottled pink, and are derived primarily from residual rocks (Mack and Achmad, 1986). Boreholes confirmed that the Patapsco Aquifer extends below the Greenbelt site to a minimum depth of 250 ft. bgs or an approximate elevation of 40 ft. above mean sea level (msl). The Upper and Lower Patapsco aquifers are of similar lithologic character, and the number and thickness of the clay layers increase to the southeast and downdip (Andreasen, 2007).

Arundel Clays. This confining unit is up to 200 ft. thick in locations (approximately between 400 ft. and 700 ft. bgs) and is comprised of dark grey to nearly black lignitic clays (Mack and Achmad, 1986).

Patuxent Formation. This formation ranges from 150 ft. to 300 ft. (approximately between 550 ft. bgs and 1,000 ft. bgs) in thickness and is comprised of sand, clay, silt, and gravel. Sands are typically white, yellow, or brown, fine-grained to coarse-grained, rounded, micaceous, and arkosic. (Arkosic sands are derived from sandstones though erosional processes.) Clays range in color from white, grey, and yellow to pink to red (Mack and Achmad, 1986).

The Patuxent Formation extends from Laurel, Maryland to Georgetown in Washington, DC and bedrock outcrops along an irregular 3- to 4-mile-wide band. The western outcrop boundary roughly follows the Prince George's County line, while the eastern boundary runs closely parallel to US Route 1. The total outcrop area in Prince George's County is approximately 40 square miles. The formation dates to the early or lower Cretaceous Age and is the oldest sedimentary deposit in the Maryland geological coastal region (Mack and Achmad, 1986). It ranges from 150 to 300 feet in total thickness overlying bedrock. Top surface elevations of the Patuxent Formation (**Figure A-13**) are based on the first high-yielding groundwater bearing sand encountered in a zone approximately 250 feet thick lying above the crystalline bedrock as indicated by boring logs. The Patuxent Formation top surface is about 180 to 200 feet below sea level in the vicinity of the Greenbelt site. **Figure A-13** shows hydrogeologic features proximal to the Greenbelt site.

4.1.1.2 Soils

Information about the types of soils in and around GSFC is provided in **Figure A-14** for the Greenbelt site and **Figure A-15** for the Outlying Areas. **Table B-4** provides a key to the figures and provides detailed information about each soil type. The boundaries shown for soil series areas were mapped prior to development. Excavation, fill, and mixing of soils generated by construction in the developed areas of GSFC are likely to have created local conditions different than shown.

Multiple symbols for a given soil series indicate that minor differences in soil type occur within the series (e.g. (Be) Beltsville fine sandy loam and (Bl) Beltsville silt loam), but the data in Table B- is applicable to each type. Locations refer to the occurrence or presence of a soil series within the boundaries of each side of the Greenbelt site or Outlying Area. Other soils series may be present outside the boundaries.

Hydric soils are generally saturated with the water table at or near the ground surface. They are one of three indicators for potential wetlands. Hydric soils may be disturbed and intermixed with other soils in developed areas, reducing or eliminating its value as a wetland indicator in these areas. Soil group data refers to the hydrologic soil grouping, which is used in hydrological, storm drainage, and stormwater management studies. When two hydrologic group designations are listed for a soil series, (e.g., C/D), they apply to drained/undrained conditions, respectively.

A soil association is a landscape that has a distinctive proportional pattern of soil types. All of the GFSC property lies in the Christiana-Sunnyside-Beltsville Association zone. Soils in this association are generally deep, well drained and compacted. Red clays predominate. All soils in the vicinity of GSFC are mildly acidic with a pH ranging from 4 to 5.5.

4.1.1.3 Land Use

Prince George's County, Maryland contains about 488 square miles or 312,300 acres of land area. The County lies within the Washington-Arlington-Alexandria Metropolitan Statistical Area and the larger Washington-Baltimore-Arlington Combined Statistical Area.

Prince George's County is divided into 36 planning areas. Each planning area has an approved County Master Plan. The majority of GSFC is located within planning areas 64 (Greenbelt and Vicinity) and 67 (Agricultural Research Center Planning Area) (**Figure A-16**). Area 64 extends northward from the eastern side of the Greenbelt site for more than 5 miles to the Patuxent River. Within the vicinity of GSFC, Cipriano Road separates Area 67 to the west and Area 70 to the east.

The County General Plan establishes a hierarchal system concept of ideal development that recognizes the advantages of concentrating certain types of commercial and related activities. These points of concentration are defined as activity centers and are a means for preventing haphazard and inefficient development along major roads or at crossroads. There are four levels of activity centers defined in ascending order as: (1) Neighborhood, (2) Village, (3) Community, and (4) Major Community Activity Centers.

In the vicinity of GSFC, existing land use closely matches master plan zoning in each area. Commercial development is concentrated along Greenbelt Road. The Roosevelt Center and the Cipriano Square Shopping Center are classified as Village Activity Centers by the County. Village Activity Centers have a generalized defined overall size of 5 to 10 acres of commercial leasable space and serve an estimated population of 12,000 to 20,000 within an area of 2 to 4 miles radius. Cipriano Square, located on Greenbelt Road opposite the Main gate entrance to GSFC has 14 stores, multiple restaurants, and a bank. Aerospace Place Mall, anchored by a Merchant Tire Center, is a strip mall that opened in 2001.

The Greenway Center and East Gate Shopping World are classified as Community Activity Centers with 10 to 15 acres of leasable space. They serve a population of 20,000 to 30,000 and are within 10 minutes of GSFC. Greenway Center is the largest shopping center in the study area occupying 85,390 square feet of leasable space on a 23-acre site.

In the Greenbelt Planning Area, residential zoning west of the Baltimore-Washington Parkway in the study area is predominantly residential-townhouses. To the east of the Parkway, within the City of Greenbelt limits, all residences are garden apartments and townhouses. The 3-story Greenbriar III and Glen Oaks multifamily units abut the west side of GSFC. Continuing eastward to Cipriano Road, multi-family and townhouse developments (Chelsea Wood Condominiums, Brittany Place Apartments, and Green Oak Towers) occupy the area on the south side of Greenbelt Road, opposite the western side of the Greenbelt site.

In Planning Area 70, the Yorkberry and Greenbelt Woods subdivisions are single family detached housing residential areas between the Cipriano Square Shopping Center and a Prince George's County School complex. A County regional stormwater management dry pond separates the subdivisions. The low-rise Countryside Apartments complex is located in the northeast quadrant of the Greenbelt/Good Luck Road intersection, while the similar Woodland Landing development is found on the east side of the town-office Greenbelt Executive Office Center. Individual older residences, set well back from Greenbelt Road, collectively occupy about 40 acres between Woodland Landing and the East Gate Shopping Center in a rural-residential zone.

NASA has its own Master Plan and is not subject to the County's land use regulations. As a result of the LUCs discussed in **Section 3.5**, the land comprising DFA A1, DFA A2, DFA B, and DFA C cannot be used for residential purposes or daycare facilities.

4.1.2 Air Quality

4.1.2.1 Climatic Conditions

Prince George's County is the geographic center of Maryland; it lies at the western edge of the middle Atlantic coastal plain, east of the Blue Ridge Mountains, and west of the Chesapeake Bay. The Patuxent River, a tributary of the Chesapeake Bay, lines the County's eastern border. The County is part of the Baltimore-Washington metropolitan area and is susceptible to variations in climatic conditions such as extreme heat, thunderstorms, tornadoes, and winter weather (snow and ice).

Since this region is near the average path of the low-pressure systems which move across the country, changes in wind direction are frequent and contribute to the changeable character of the weather. The net effect of the mountains to the west and the bay and ocean to the east produces a more equable climate compared with other continental locations farther inland at the same latitude.

Rainfall distribution throughout the year is rather uniform; however, the greatest intensities are confined to the summer and early fall months, the seasons for hurricanes and severe thunderstorms. The average annual precipitation is 42.1 inches and annual snowfall is 14.5 inches.

January is the coldest month, while July is the hottest. Snowfall occurs on an average of eleven days per year; however, only six of these days produce snowfalls of 1 inch or greater. Snow is frequently mixed with rain and sleet, and seldom remains on the ground for more than a few days.

Glaze or freezing rain occurs on an average of two to three times per year, generally in January or February. Some years pass without the occurrence of freezing rain, while in other years, it occurs on as many as eight to ten days. Sleet is observed about five days annually with the greatest frequency of occurrence in January.

Winter and spring months have the highest average wind speed. The annual prevailing wind direction is from the west. Destructive velocities are rare but usually occur during severe thunderstorms in the summer.

During the summer, the area is under the influence of a large semi-permanent high-pressure system commonly known as the Bermuda High. This high-pressure system is centered in the western North Atlantic, near Bermuda and brings warm humid air to the area. The air quality impacts of the Bermuda High are twofold. The relatively cloud-free skies enhance daytime heating and nocturnal cooling, the latter causing strong nocturnal temperature inversion. The daytime sunlight also drives the photochemical reactions that generate certain air pollutants (primarily ozone) and air pollutant precursors. The second impact of the Bermuda High is the clockwise flow of wind around the high-pressure system, transporting air pollutants and pollutant precursors from the heavily industrialized Ohio Valley into the Baltimore-Washington metropolitan area.

4.1.2.2 Air Quality Standards and Ambient Air Quality

The Clean Air Act (CAA) requires the U.S. Environmental Protection Agency (USEPA) to set National Ambient Air Quality Standards (NAAQS) for six common air pollutants known as "criteria" pollutants. These criteria pollutants include carbon monoxide (CO), lead, nitrogen dioxide (NO_2), ozone, particulate matter ([PM], further classified as PM with aerodynamic diameter less than or equal to 2.5 microns [$PM_{2.5}$] and PM with aerodynamic diameter less than or equal to 10 microns [PM_{10}]), and sulfur dioxide (SO_2). The current NAAQS for each criteria pollutant are provided in **Table B-5.**

In addition to the NAAQS, USEPA is required to designate Air Quality Control Areas (AQCAs) for meeting (attainment), not meeting (nonattainment), or maintaining criteria pollutant standards. Where there are insufficient ambient air data for a criteria pollutant, the AQCA is designated as unclassifiable. Nonattainment areas are further classified as marginal, moderate, serious, severe, or extreme. For nonattainment designations, states and local governments are required to develop State Implementation Plans (SIPs) outlining how areas would attain and maintain the standards via air pollutant emission reductions.

GSFC is part of the Washington, DC-MD-VA AQCA. Currently, the Washington, DC-MD-VA AQCA is a nonattainment area for ground-level ozone, a maintenance area for CO, and an attainment area for PM_{10}, $PM_{2.5}$, NO_2, SO_2 and lead (https://www.epa.gov/green-book). **Table B-5** shows the current NAAQS attainment status for Prince George's County. The County is currently classified as marginal nonattainment for ground-level ozone

Air quality data is recorded at multiple state monitoring stations throughout the AQCA. The closest ozone monitoring station to GSFC is located at Howard University-Beltsville. **Table B-6** shows the 8-hour ozone exceedances (based on the 2015 standards) recorded by the Howard University-Beltsville ozone monitoring station during the 2017 ozone season (May-September).

Ground-level ozone is not produced or emitted directly. It is generated when NO_X combine with volatile organic compounds (VOCs) in a photochemical reaction. The reaction is catalyzed by high temperatures,

abundant sunshine, and prolonged periods of air stagnation. Ground-level ozone concentrations are therefore controlled indirectly by controlling NO_X and VOC emissions.

4.1.2.3 Emissions Sources

All GSFC fossil fuel-driven stationary sources are regulated under a Title V Operating Permit. Stationary sources at GSFC include the five boilers in the Central Heating and Refrigeration Plant, space heating boilers, and fixed and portable emergency power generators.

The Title V permit authorizes GSFC to use natural gas and landfill gas as the primary fuels and No. 2 fuel oil as a backup fuel for firing the boilers in the Central Heating and Refrigeration Plant. The space heating boilers use natural gas only and the generators use No. 2 fuel oil only.

Other permitted emissions sources at GSFC include electrochemical plating, surface coating operations, fuel storage and dispensing facility, vapor degreasing, clean-room semiconductor development and fabrication, and char-broilers. These emission sources are monitored for PM, hazardous air pollutants (HAPs), toxic air pollutants (TAPs), and VOCs.

The GSFC Air Emissions Inventory Database contains all emissions data from 2001 to the present. Emissions data provided in this ERD represent information from 2017.

The principal criteria pollutant emission sources at GSFC are the five boilers in the Central Heating and Refrigeration Plant. Each boiler has a heat rating of 49.5 million British Thermal Units per hour (MMBtu/hr) and they all have identical physical parameters (e.g., stack dimensions). Two of the boilers have dual oil and natural gas feed burners, while the other three boilers have dual oil and natural gas/landfill gas feed burners. The NO_X emissions from all five boilers shall not exceed 0.1 pounds (lb)/MMBtu based on a calendar monthly average when burning a combination of any of the following fuels: natural gas, No. 2 fuel oil, and/or landfill gas (**Table B-7**). Washington Gas supplies natural gas averaging 1,024 British thermal units (Btus) per standard cubic foot (Scf) with a range of 1,022 to 1,028 Btu per Scf. Landfill gas has a heating value of 500 Btus per Scf, with a range of 476 to 558.2 Btu per Scf. The composition of the landfill gas is 50% methane, 40% carbon dioxide (CO_2), 8% nitrogen, and small quantities of other hydrocarbons (less than 2% total). In 2017, landfill gas and natural gas accounts for approximately 99% of the total boiler heat input and fuel oil accounts for approximately 1%.

The 2017 ozone-season emissions and calendar year (CY) emissions of criteria pollutants are shown in **Table B-8** and **Table B-9**, respectively. NO_X emission factors were determined during the 2012 stack testing. The PM, CO and VOC emission factors were obtained from the USEPA AP42, Compilation of Air Pollutant Emission Factors, 5th edition (U.S. Environmental Protection Agency. (1995)). The sulfur oxides (SO_X) emission factor was computed assuming a fuel-sulfur concentration of 0.3%. GSFC may only burn fuel oil during a declared emergency. Since natural and landfill gases have significantly lower concentrations of sulfur than fuel oil, the SO_X emissions are greatly reduced.

The primary operating standard for the boilers is based on heat input to the boilers. Under the Title V permit, the total 12-month rolling heat input consumed by the five boilers must not exceed 750,000 MMBtu. A 12-month rolling sum is calculated each month to demonstrate compliance with the operating standard. **Table B-10** presents the 12-month rolling heat input consumed by the five boilers from January to December 2017. Based on these values, the 12-month rolling sum throughout 2017 was well below the operating permit standard.

GSFC also has emergency power generators located throughout the Center. The generators assume mission critical electric power loads when the public utility service is lost or interrupted. GSFC also operates two portable emergency power generators, to meet temporary increases in power demands at individual buildings. All generators operate on No. 2 fuel oil exclusively. NO_X emissions produced by the emergency diesel generators were assessed using the emission factors obtained from the USEPA AP-42 and manufacturer specifications. **Table B-11** presents NO_X emissions from the generators in 2017.

4.1.2.4 Ozone Depleting Substances

Chlorofluorocarbons (CFC) and hydrochlorofluorocarbons (HCFC) have been used universally for decades as the refrigerant of choice in large capacity industrial, commercial, and institutional air conditioning equipment. They possess excellent heat transfer properties; do not break down physically or chemically when used as a refrigerant; and are nontoxic, nonflammable, and safe to handle and use. In refrigeration and air conditioning units, they are contained within sealed chambers and piping. Releases only occur from occasional leaks or when material is not captured during unit repair or discard.

However, CFCs were found to be one of the primary contributors to ozone depletion in the upper atmosphere, particularly around the Earth's poles. USEPA has defined the Ozone Depletion Potential (ODP) as the ratio of the impact on ozone that a chemical has when compared to the impact of a similar mass of CFC-11 (refrigerant trichlorofluoromethane [R-11]). Similar to R-11, dichlorodifluoromethane (R-12) also has an ODP of 1.0. Refrigerant chlorodifluoromethane (R-22 or HCFC-22), an HCFC, has an ODP of 0.05.

The CAA Amendments of 1990 and the International Montreal Protocol of 1992 called for the gradual phase out of ozone depleting substances (ODS). Subsequent USEPA regulations have accelerated phase out. Production of R-11 and R-12 refrigerants ceased on December 31, 1995, and foreign importing is prohibited. Units using these refrigerants may continue to do so, pending availability of existing stock and reclamation or recycling.

Since R-22 has a much lower ODP than R-11 or R-12, it is acceptable for continued use. Phase out of R-22 began in 2010. R-22 is only being made available for equipment that was installed prior to January 1, 2010 and was designed for the use of R-22. Production of R-22 will cease in 2020.

The ten chiller units located in buildings 24 and 31 of the Central Heating and Refrigeration Plant use R-22 and R-134A (1,1,1,2-tetrafluoroethane). The two chiller units located in building 35 use R-134A and R-410A (a mixture of R-32 [difluoromethane] and R-125 [pentafluoroethane]). R-134A and R-410A are HFCs (hydrofluorocarbons) ODS substitute refrigerants.

On September 26, 2016, USEPA issued a new rule that updates the existing ODS refrigerant regulations and extends these regulations to non-exempt non-ODS substitute refrigerants, such as HFCs.

4.1.2.5 Air Conformity Analysis

SIPs outline programs and policies for achieving and maintaining attainment status. Attainment status is achieved when the NAAQS are satisfied.

Transportation conformity is determined regionally by the Metropolitan Washington Council of Governments through computer modeling of emissions from vehicles on the regional road network within the Washington, DC-MD-VA ozone nonattainment area. Transportation conformity is further demonstrated at the project level. General conformity is considered on a more local scale.

The USEPA issued general conformity regulations (40 CFR Part 93, Subpart B) containing procedures and criteria for determining whether a proposed federal action would conform to CAA implementation plans. The regulations ensure that federal facilities and federal actions do not adversely affect a pertinent state or local agencies' plan for improving air quality.

As stated earlier, ground level ozone is not emitted directly, but is created in the atmosphere through a photochemical reaction involving NO_X and VOC. Control of ground level ozone is achieved through control of NO_X and VOC emissions. General conformity analysis review is performed for GSFC projects as part of the NEPA process.

4.1.2.6 Greenhouse Gases

4.1.2.6.1 Introduction

Greenhouse gases (GHGs) are gases that trap heat in the lower atmosphere, warming the earth's surface temperature in a natural process known as the "greenhouse effect." GHGs include CO_2, methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), HFCs, and sulfur hexafluoride (SF_6). Human activities have caused a rapid increase in GHG concentrations. This rising level contributes to global climate change, which in turn can contribute to environmental and public health concerns

4.1.2.6.2 Mandatory Reporting of GHG

On October 30, 2009, USEPA published a regulation (40 CFR Part 98) that requires large GHG emissions sources in the U.S. to report their GHG emissions. The regulation is referred to as the Greenhouse Gas Reporting Program and applies to direct GHG emitters such as GSFC. The threshold for reporting is 25,000 or more metric tons of CO_2 equivalent ($MTCO_2e$) per CY. CO_2 emissions from biogenic fuels such as landfill gas are not counted toward the 25,000 $MTCO_2e$ threshold. Facilities are required to report GHG emissions annually (for the previous CY) and must self-certify the data. USEPA verifies the data submitted but does not require third party verification.

Since 2008, GSFC GHG emissions have been less than the 25,000 $MTCO_2e$ threshold. Therefore, GSFC is currently not subject to the GHG reporting requirements. The use of landfill gas, a biogenic fuel, in GSFC boilers has reduced GSFC's reportable GHG emissions because emissions from biogenic fuels are exempt from the requirements of 40 CFR Part 98. Using the methodologies contained in 40 CFR Part 98, GSFC's stationary source GHG emissions in CY 2017 were calculated to be 11,431 $MTCO_2e$, well below the reporting threshold of 25,000 $MTCO_2e$.

4.1.2.6.3 Other Federal Requirements to Reduce GHG Emissions

- On May 17, 2018, President Trump issued Executive Order (EO) 13834: Efficient Federal Operations. Under E.O. 13834, federal agencies must meet statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment. E.O. 13834 also revokes E.O. 13693 signed by President Obama on March 19, 2015; Planning for Federal Sustainability in the Next Decade. E.O. 13834 only directs federal facilities to continue tracking and reporting on energy GHG emissions.

4.1.2.6.4 MDE Requirements

In 2009, Maryland Governor O'Malley and the Maryland General Assembly passed the Greenhouse Gas Emissions Reduction Act (GGRA). The GGRA requires implementation of a statewide GHG reduction plan to achieve a 25 percent reduction of GHGs from 2006 levels by 2020.

MDE requires facilities and installations to certify and submit an emissions statement for the prior calendar year (CY) (Code of Maryland Regulations [COMAR] 26.11.01.05-1 and COMAR 26.11.02.19D). The emissions statement is used by MDE for inventory and planning purposes. At a minimum, the emissions statement must:

- Identify VOC or NOx sources and the actual daily and annual emissions from each source
- Explain the method used to determine emissions from each source and operating schedules and production data that were used to determine emissions
- Explain any increases or decreases in emissions for each source, if reported emissions differ from the previous year's emissions statement

As required by COMAR regulations, GSFC submits a certified emissions statement to MDE by April 1 of each year. GSFC estimates GHG emissions for all permitted fuel burning equipment.

In CY 2017, GSFC's GHG emissions reported to MDE (permitted emission sources only) were calculated to be:

- CO_2: 29,094 tons (includes biogenic landfill gas)
- CH_4: 0.6 ton
- N_2O: 0.2 ton

4.1.3 Water Resources

4.1.3.1 Storm and Surface Water

Drainage is unusually complex at GSFC because the site is located in the Anacostia-Patuxent river drainage divide at the apex of four separate tributary stream basins (**Figure A-8** and **Figure A-9** for GSFC drainage basins.) Local water resources around GSFC, including floodplains and wetlands, are shown in **Figure A-18** and **Figure A-19**.

On the Greenbelt site, storm drains are confined to the developed areas. There are nine separate networks (sub-basins). The storm water conveyance systems as well as topographical variations influence the drainage boundaries. Building roof drains also impact the drainage divides. Storm drains on the western side of the Greenbelt site are extensively networked to the conveyance system with few instances of disconnection. Conveyance on the eastern side of the Greenbelt site is more localized and directed to nearby storm water structures. Once collected, most runoff is conveyed to stormwater management structures such as wet and dry ponds, swales, ditches, etc. In the Outlying Areas, the drainage basin is influenced by topography.

Discharge points on the northern and western perimeter of the Greenbelt site as well as Outlying Areas 100, 200, 300, and 400 drain to two tributaries of the Anacostia River—the Beck Branch and Beaverdam Creek. Discharge points on the south and east perimeter of the Greenbelt site drain to two tributaries of the Western Branch of the Patuxent River—the Bald Hill Branch and Folly Branch). See **Table B-12 f**or details on tributaries associated with drainage sub-basins. Drainage sub-basins DB-1, DB-2, DB-3, and Outlying Area 200 discharge to several intertwined, unnamed tributaries that lead into Beaverdam Creek. The 150-acre SCS Lake is located on Beck Branch downstream from drainage sub-basin DB-4 and Outlying Areas 100, 300, and 400. DB-5 and DB-6 drain to Folly Branch. Stormwater runoff from sub-basin DB-7 passes under Greenbelt Road to the Prince George's County Stormwater Management Facility on the opposite side of the road, near Copernicus Lane. Sub-basins DB-8 and DB-9 drains under Greenbelt Road in the vicinity of the main gate, joining an unnamed tributary to Bald Hill Branch.

Structural stormwater management at GSFC is comprised of 28 stormwater retention and detention structures and bioretention basins (**Table B-13**). Some of these "structures" pre-date stormwater permits and, therefore, structural stormwater management. Some of these structures are abandoned sediment basins. All stream outfalls receiving runoff from developed areas have large stormwater management structures, except for DB-8. DB-8 has a small detention structure that enables infiltration; this structure does not capture any runoff south of Explorer Road. With the development of stormwater regulations such as the Maryland Stormwater Act of 2007, the strategy for stormwater management has changed from containment of large storm events to implementing localized infiltration techniques known as Low Impact Development (LID) techniques, or Environmental Site Design (ESD) to the maximum extent practicable (MEP). The strategy of LID is to create local features that do not convey water but instead promote groundwater infiltration through vegetative features or engineered control devices. The goal of LID is to maintain pre-development hydrology by capturing normal rain events (about two inches of rainfall). Of the 28 structures at GSFC, four are LID rain gardens and bioretention cells, which are located in the vicinity of building 32, five are micro-bioretention cells which were installed in conjunction with the construction of the new FPB (building 36).

Built in 1966, the Main Pond, located on the western side of the Greenbelt site, is the largest stormwater management structure at GSFC. Together with the Sediment Pond located south of Cobe Road and parallel to the Main Pond, the ponds form a two-tier stormwater quantity control system. The Main Pond is capable of handling the 100-year storm. The high-water elevation design is 131.0 feet; the 100-year flood elevation is 130.28 feet. The crest of the Sediment Pond is at 136.0 feet, and the 100-year flood elevation is 135.5 feet. The Sediment Pond has been observed overflowing Cobe Road. The Main Pond still has 4.10 acre-feet of excess capacity under Sediment Pond overflow conditions.

The ponds at buildings 28 and 29 were designed to physically handle the peak discharges of the 100-year storm. Under 100-year conditions, the crest of the building 29 dam is at 176 feet. Water reaches 175.75 feet, while peak discharges are still 70 cubic feet per second less than pre-development rates. The pond at building 28 is a dry detention pond capturing runoff from an approximately 5-acre area around the building, the majority of which is impervious. The pond was designed with approximately 0.6 acre-feet of excess capacity, above the capacity required for the associated construction.

The EOSDIS Pond was originally designed and constructed to handle the increased stormwater runoff that would be generated by three large development projects in the southeast portion of the Greenbelt site. Currently, the EOSDIS Pond receives drainage from building 32, approximately half of building 33 and the associated parking lot and blowdown from B31. The EOSDIS Pond has considerable excess capacity. It is estimated that this pond could accommodate up to 12 acres of additional impervious area, while still maintaining release discharges below 1980 hydrologic conditions. The Pond is classified as a quantitative detention and qualitative retention facility.

The ESSB Pond was also designed as a quantitative detention and qualitative infiltration facility. If necessary, this pond could be modified to accommodate runoff from more impervious areas. Currently, the water elevation under 100-year storage conditions is 184.76 feet, corresponding to approximately 3.0 acre-feet of detention storage. About 5.6 acre-feet of runoff can be stored with one foot of freeboard.

DB-4 is the largest drainage area on the eastern side of the Greenbelt site. In the 1960's, a low earth dam was constructed across the small stream coursing northward forming Beaver Pond. There is a small pool of open water behind the dam, but the remainder is covered by a few centimeters of water with a dense growth of hydrophilic plants from shore to shore. Facility design and operating characteristics are unknown. There are no storm drain systems or stormwater management structures in Areas 100, 200, 300, and 400. Impervious surfaces, including buildings, roads, and parking, occupy less than two percent of the total area. Only one building (building 305) in the Outlying Areas has a footprint larger than 5,000 square feet. Roads are generally only one lane wide. Swales and channels in the immediate vicinity of buildings handle drainage. In general, it is 700 feet or more between developed areas and the nearest continuous all-weather flow stream.

Stormwater management can be achieved on a site-wide or subarea basis by constructing facilities for each project as it is implemented or by a combination of these methods. In general, stormwater management facilities serving larger areas are technically and economically preferable but may be more difficult to place and fund. Despite its size, GSFC has relatively few potential large stormwater management sites due to the density of development, topography, presence of existing wetlands, or adjacency to sensitive natural habitats.

The State of Maryland adopted rules and regulations establishing criteria and procedures for stormwater management (as provided in COMAR 26.17.02). MDE has issued a design manual which is incorporated by reference into COMAR stormwater requirements. The design manual was amended in 2011 to include provisions of the Maryland Stormwater Act of 2007. ESD to the MEP was required for all stormwater management plans approved after May 4, 2010.

GSFC uses 1980 site conditions as a reference or baseline for hydrologic analysis. Prior to 1980, containment and management of stormwater onsite was limited. The design and approval system was not

in place as it is today. On the eastern side of the Greenbelt site and the Outlying Areas, 1980 hydrologic conditions were essentially natural (i.e., nearly 100 percent wooded). Prior to 1980, the eastern side of GSFC development was limited to areas around buildings 25 and 27. Impervious coverage in the Outlying Areas has minimally changed since 1980, amounting to less than two percent of the total area.

Stormwater quality is achieved through the implementation of pollution prevention best management during various practices. GSFC's NPDES stormwater permits explicitly control stormwater quality. These permits and the SWPPP are discussed in **Section3.6.2**.

4.1.3.2 Surface Water Quality

Industrial wastewater is discharged into two ponds—the small Sediment Pond (which feeds into the Main Pond) on the western side of the Greenbelt site, and the EOSDIS Pond (building 32) on the eastern side. Industrial effluent entering these two locations includes boiler and cooling tower blowdown to the Main Pond (Outfall 001) and cooling tower blowdown to the EOSDIS Pond (Outfall 004). The outfalls to these two ponds are monitored monthly via GSFC's NPDES permit. A summary of the NPDES Limits for GSFC Permitted Outfalls is provided in **Table B-2.** This table presents the average results of each parameter measured during the monthly NPDES sampling. To further evaluate water quality, additional special studies have been conducted over the years to attain baseline data and assess impacts on these water resources from various contributions.

GSFC has had recurring problems with copper levels in both the Main Pond and EOSDIS Pond. This recurring problem resulted in numerous non-compliance events with GSFC's NPDES permit limits for total copper from 2006 through 2018. An extensive study was conducted from 2007 through 2008 (Proxtronics, Inc. (2008)) to pinpoint the source of these copper exceedances. The results of this study indicated that cooling tower discharge was the highest contributing source. In 2009 through 2010, Facilities Management Division (FMD) conducted a study to determine the best solutions to control copper. This study yielded several institutional controls to assist in controlling copper excursions. Currently, corrective actions have included improved water chemistry management to inhibit corrosion and the installation of filtration devices at the building 31 chiller plant. GSFC continues to pursue additional institutional and management controls to achieve absolute compliance.

In 2006, boiler blowdown was added to the NPDES permit. Due to the higher pH in boilers, GSFC monitored the small Sediment Pond and the Main Pond for pH levels. The pH levels at both ponds experience natural shifts over time, with pH values as high as 11. This trend is more consistent during summer months when algae blooms peak. With the issuance of the 2012 permit, GSFC received stricter limits on pH. Prior to the permit issued in 2012, the pH limits at Outfalls 001 and 004 were 6.0 to 9.0. The new permit required GSFC to achieve compliance with the newly established pH limits of 6.5 to 8.5 by June 1, 2015. GSFC installed a pH neutralization unit for the boiler blowdown associated with Outfall 001 in order to meet the new pH limits on the permit. Chemical reactions due to algal respiration during blooms have been attributed to warm weather peaks in pH. In an effort to minimize the possibility of seasonal pH peaks, GSFC performed a one-time alum treatment followed by installation of aeration pumps and diffusers in the storm water management ponds associated with Outfalls 001 and 004.

Beginning with the issuance of the 2012 permit, GSFC must monitor quarterly for nutrients at Outfalls 001 and 004. Prior to 2012, GSFC only monitored nutrients annually to establish eligibility for exemption from Bay Restoration Fund fees. To establish an exemption, the annual average of nutrients must meet the following criteria: total nitrogen must be less than 3.0 milligrams per liter (mg/L) and total phosphorus must be less than 0.3 mg/L. Nutrient data from Outfalls 001 and 004 are included in **Table B-2.** In a letter from the Department, received March 4, 2016, MDE determined that GSFC was no longer subject to the Bay Restoration Fund Fee.

No study has been conducted to specifically evaluate the quality of surface water at GSFC.; however, GSFC did conduct a study between 2006-2011 to monitor surface water runoff from various parking lots around

the Greenbelt site to assess the quality of the runoff. Data from parking lot studies are averaged over the duration of the study and include ten locations around the Greenbelt site. Similarly, GSFC conducted a study to measure the efficiency of bioretention at the building 32 bioretention area. The bioretention study was inconclusive.

Water quality is a primary concern at GSFC. Through the auspice of GSFC's SWPPP, activities that present a risk of pollution are routinely inspected and evaluated, and new activities are added as needed. The primary goal of the SWPPP is to ensure that facilities implement good housekeeping practices to prevent pollution of water resources. The SWPPP also includes water quality data that is updated frequently.

4.1.3.3 Groundwater

There are several aquifer systems underlying GSFC. These include the Upper Patapsco, the Lower Patapsco, the Patuxent, and a system of shallow perched groundwater. A detailed discussion of each groundwater system and their geological properties is provided in the sections that follow.

The Upper Patapsco has been involved in a long-term monitoring program to track the fate and transport of a TCE contamination plume.

In accordance with the LUCs discussed in **Section 3.5**, use of groundwater from the unconfined Upper Patapsco Aquifer at GSFC is restricted to investigative and monitoring purposes.

4.1.3.4 Shallow Perched Groundwater

There appears to be at least two separate shallow perched water-bearing zones overlying the Patapsco aquifer. The shallow, perched groundwater layers identified occur in the Patapsco Formation. The upper unconfined aquifer system in the alluvium overburden (Pleistocene terrace unit) receives direct recharge and discharges to small surface streams and other surface water bodies, Beaverdam Creek and Greenbelt Lake. Shallow perched groundwater flow is influenced by local topography, moving from areas of high elevation to areas of lower elevation. Typically, groundwater present in perched groundwater layers either flows vertically to the next lower aquifer, is lost to evapotranspiration, or discharges to streams via seepage. There is inadequate information available to fully understand the vertical and horizontal components of the perched water-bearing zones. Based on an evaluation of the existing data, it is assumed that perched water-bearing zones exist across the Greenbelt site and are from surface grade to depths of at least 40 feet bgs.

Perched groundwater elevation data collected from the shallow, perched groundwater-bearing zone during the Phase II BARC Investigation indicates that due to the complex heterogeneous stratigraphy of the Atlantic Coastal Plain, hydraulic permeability varies significantly in both the vertical and horizontal planes across the Greenbelt site and BARC properties (ERT, 2012a). Groundwater has been detected at shallow depths in permanent groundwater monitoring wells (MWs) across the northern portion of the Greenbelt site, and temporary MWs on BARC property. Clay lenses within the vadose zone are intercepting groundwater and creating shallow, perched groundwater layers and localized northerly groundwater migration above or in the upper portions of the Upper Patapsco Aquifer (**Figure A-20**). Hydraulic mounding, damming or other hydraulic mechanisms may also be occurring, and appears to be localized near the boundary between BARC and the Greenbelt site. Mounding as a result of seasonal increased flow from elevated land surfaces south of the concrete pad of unknown origin and infiltration from storm water drainage could also be a possibility within the Greenbelt site; however, MW placement across the Greenbelt site is not as vertically or horizontally focused, and not as effective in distinguishing localized hydraulic differences as was the temporary MW field on BARC property. Additionally, the inferred groundwater flow direction with the shallow, perched groundwater layers in the northernmost Greenbelt site MWs and the temporary BARC MWs appears to be from south to north. Groundwater movement within the underlying Upper Patapsco Aquifer, on the other hand, has been historically assumed and inferred to flow from the northwest to the southeast (ERT, 2012b).

4.1.3.5 Patapsco Aquifer

The Patapsco aquifer system beneath the Greenbelt site and BARC properties consists of surficial Pleistocene deposits and the underlying Potomac Group. The Patapsco aquifer system is unconfined beneath the Greenbelt site. Recharge is supplied to the Patapsco Aquifer from its outcrop area located on a northeast trending fall line. The Patapsco Aquifer has been further subdivided into the Lower and Upper Patapsco Aquifers (Mack and Achmad, 1986).

Based on MDE established standards for groundwater quality (COMAR 26.08.02.09) and site-specific aquifer data, the Upper Patapsco aquifer system beneath the GSFC and BARC properties is considered a Type IIb aquifer by the State of Maryland. Type IIb aquifers have a transmissivity between 1,000 and 10,000 gallons/day/foot, permeability greater than 100 gallons/day/square foot, and natural water with a total dissolved solids concentrations between 500 and 1,500 milligrams/liter. Groundwater from a Type IIb aquifer that is treated by commercially available home water treatment systems shall not exceed primary or secondary standards for drinking water.

The Upper Patapsco aquifer system occurs throughout the Maryland Coastal Plain. The Upper Patapsco aquifer system consists of the sandy portions of the upper part of the Lower Cretaceous-age Patapsco Formation (part of the Potomac Group in Maryland). The Upper Patapsco aquifer system typically consists of medium- to coarse-grained feldspathic and quartzose sands and gravels, interbedded with layers of red, gray, and mottled clay. The altitude of the top of the aquifer system ranges from 100 ft above sea level near its outcrop to more than 2,400 ft below sea level near Ocean City. Data collected in 2010 (ERT Inc. (ERT). (2011a)) suggests that groundwater within the Upper Patapsco Aquifer across the Greenbelt site is between approximately 124 ft and 138 ft above msl and flows from north-northwest to south-southeast across the Greenbelt site. Transmissivity of the Upper Patapsco aquifer system ranges from 20 ft2/d in Charles County to 9,990 ft2/d in Anne Arundel County. The highest values typically occur in Anne Arundel County and decrease both to the north and to the south. Storage coefficient ranges from 8.4 x 10-5 to 0.0096 (Andreasen, D.C., Staley, A.W., and Achmad, G.J. (2013)). The confining units between the Pleistocene terrace deposits and the Upper Patapsco Aquifer are likely not ubiquitous throughout the Greenbelt site, allowing for the migration of groundwater from the shallow perched water-bearing zones into the Upper Patapsco Aquifer.

Based on MDE established standards for groundwater quality (COMAR 26.08.02.09) the Lower Patapsco aquifer system beneath the GSFC and BARC properties is considered a Type IIa aquifer by the State of Maryland. Type IIa aquifers have a transmissivity greater than 10,000 gallons/day/foot, permeability greater than 100 gallons/day/square foot, or natural water with a total dissolved solids concentrations between 500 and 6,000 milligrams/liter.

The Lower Patapsco aquifer system is also present throughout the Maryland Coastal Plain and is separated from the Upper Patapsco by the Middle Patapsco Confining unit. The Lower Patapsco aquifer system is confined beneath the Greenbelt site. The Lower Patapsco aquifer system consists of the sandy portions of the lower part of the Lower Cretaceous-age Patapsco Formation. The aquifer system is composed of white to yellow, fine- to medium-grained feldspathic and quartzose sands and gravels interbedded with layers of red, gray, and mottled silty clay. The altitude of the top of the aquifer system ranges from about 100 ft. above sea level near its outcrop to more than 2,900 ft. below sea level near Ocean City. The total thickness of the Lower Patapsco aquifer system along a line trending approximately parallel to strike from southern Maryland to the upper Eastern Shore ranges from about 250 to 350 ft. Transmissivity of the Lower Patapsco aquifer system ranges from 40 ft2/d in Prince Georges County to 11,900 ft2/d in Anne Arundel County. The highest values typically occur in Anne Arundel County and decrease both to the north and to the south. Storage coefficient ranges from 8.6 x 10^{-5} to 0.025 (Andreasen, D.C., Staley, A.W., and Achmad, G.J. (2013)). Potentiometric levels in the Patapsco Aquifer in Prince George's County indicate that groundwater flows in predominantly southeasterly direction from the recharge area near the fall line (Fleck and Vroblesky, 1996). Additional investigation activities, explained further in this report, indicate that a

shallow perched groundwater unit overlying the Patapsco Aquifer may flow both in a northerly direction discharging into north-flowing surface water streams and vertically discharging to the Upper Patapsco Aquifer that flows in a southeasterly direction.

4.1.3.6 Patuxent Aquifer

Based on MDE established standards for groundwater quality (COMAR 26.08.02.09) the Patuxent aquifer system beneath the GSFC and BARC properties is considered a Type IIa aquifer by the State of Maryland. Type IIa aquifers have a transmissivity greater than 10,000 gallons/day/foot, permeability greater than 100 gallons/day/square foot, or natural water with a total dissolved solids concentrations between 500 and 6,000 milligrams/liter.

The Patuxent aquifer system beneath the Greenbelt site and BARC properties extends throughout the Maryland Coastal Plain and is separated from the Lower Patapsco by the Arundel Clay Confining Unit. The Patuxent aquifer system is confined beneath the Greenbelt site. The Patuxent Aquifer consists of the sandy portions of the Lower Cretaceous-age Patuxent Formation (next to lowest member of the Potomac Group). The aquifer system is typically composed of medium- to coarse-grained, feldspathic and quartzose sands and gravels interbedded with layers of red, mottled, and gray clay. Patuxent sands are white or light gray to orange brown, angular and moderately sorted, and commonly contain significant amounts of interstitial clay. Gravels, often containing angular to rounded clasts of gray clay, and coarse ferruginous conglomerates occur commonly in the lowest portions of the unit. The altitude of the top of the aquifer system ranges from about 170 ft. above sea level near its outcrop to as much as 4,200 ft. below sea level near Ocean City. The total thickness of the Patuxent aquifer system along a line trending approximately parallel to strike from southern Maryland to the upper Eastern Shore ranges from about 125 to 525 ft. Transmissivity of the Patuxent aquifer system ranges from 20 ft^2/d in Charles and Harford Counties to 21,950 ft^2/d in Baltimore County. Values are typically highest northeast of Washington, D.C. and decrease significantly in Charles and southern Prince George's Counties. Storage coefficient ranges from 3.4×10^{-5} to 0.0012 (Andreasen, D.C., Staley, A.W., and Achmad, G.J. (2013)). Production wells constructed in the Patuxent Formation in the vicinity of the Greenbelt site serve as the source for make-up water for the cooling towers and boilers.

4.1.3.7 Wetlands and Floodplains

Wetlands and waterways at and in the vicinity of GSFC are shown in **Figure A-18** and **Figure A-19. Figure A-18** includes National Wetland Inventory (NWI) mapping (USFW, 1992), which delineates the areal extent of wetlands and surface waters as defined by Cowardin's system (Cowardin, 1979). These digital data files are records of wetlands location and classification as defined by the U.S. Fish & Wildlife Service's NWI program. These wetlands were photo interpreted by Maryland Department of Natural Resources (MD DNR) using Maryland's Digital Orthophoto Quarter Quads photography. **Figure A-19** includes surveyed wetlands within GSFC property (GSFC GIS Portal) and a Maryland-National Capital Park and Planning Commission (M-NCPPC) stream data file (M-NCPPC, 2009). The file shows all waterways and storm water features greater than 20-feet in width. This waterway data was developed for M-NCPPC as a planning resource. Wetland areas on GSFC property were field surveyed over a four-day period in June 1992 (Metcalf & Eddy, 1993). The survey determined the character and approximate extent of these wetlands. Formal delineations were not made, although delineation forms were completed to standardized data collection and the wetland boundaries were sketched on large scale site mapping. The wetlands identified during this field survey were classified according to Cowardin's system. Wetlands south of Explorer Road, on the eastern side of the Greenbelt site, were determined by separate wetland delineation which was completed as part of the buildings 32 and 33 development in this area (Parsons Facilities Services Company, 1997). With the exception of two riverine wetlands on the eastern side of the Greenbelt site, all identified wetlands within GSFC are classified as non-tidal, palustrine wetlands, differing only by class and subclass.

Maryland Wetlands of Special State Concern (**Figure A-18**) are defined as those with habitat or ecologically important buffers for animal or plant species listed as threatened or endangered by the USFWS or the Maryland Department of Natural Resources (DNR), or as wetlands that contain ecologically unique or unusual areas. Any construction disturbance within 25 feet of a non-tidal wetland, or within 100 feet of wetlands of Special State Concern, may require a State wetland permit in addition to a federal permit from the U.S. Army Corps of Engineers (COMAR 26.23.02.01). Maryland DNR GIS Data indicates that a listed Wetland of Special State Concern, referred to as Soil Conservation Service (SCS) Lake, occurs on GSFC property, at the property line north of Soil Conservation Road. The presence or extent of this wetland's occurrence on GSFC's property has not been field verified. Beck Branch, which flows from east to west, parallel to the GSFC property line, is also bordered Wetlands of Special State Concern. Discharge from GSFC's Beaver Pond drains to SCS Lake and Beck Branch.

Wetland Area A (**Figure A-19**) is located on the eastern side of the Greenbelt site. This wetland occurs at the point where two branches of an unnamed tributary to Beck Branch converge near the GSFC property line. Branch 1 (**Figure A-19**) runs northward from the building 31 stormwater management pond. Branch 2 (**Figure A-19**) runs westward, parallel to the property boundary**.** Both stream branches are underlain by hydric soils, Bibb and Elkton silt loams, for most of their lengths. A palustrine, forested, broad-leaved deciduous, temporarily flooded (PFO1A) wetland, larger than that indicated on NWI mapping, was surveyed in the area where the two branches merge at the property line.

Wetland Area B (**Figure A-19**) is located where Branch 1 flows north and reaches a weir approximately 2,900 feet south of the GSFC property boundary. The weir marks the northern boundary of Beaver Pond which contains hydrophytic vegetation and hydrologic features indicative of various classes of wetlands (open water, emergent, and forested wetlands). The extent of Beaver Pond has been digitized and incorporated into GSFC's GIS Portal.

No wetland areas were observed along Branch 1, south of Beaver Pond until reaching the building 31 stormwater management pond. No wetlands were observed along Branch 2 upstream from where Branch 1 and Branch 2 converge at Wetland Area A.

Wetland Area C (**Figure A-19**) is a wetland mitigation site which abuts Beaver Pond, immediately to the west. This site was created as a result of the Soil Conservation Road relocation (GSFC Nontidal Wetland Permit #03-NT-0444, 2005). Mitigation for this project resulted in the creation of approximately 43,678 square feet of forested, nontidal wetlands. It was determined by the Maryland Department of the Environment's (MDE) Mitigation and Technical Assistance Section of the Nontidal Wetlands and Waterways Program that approximately 9,396 square feet of the mitigation project site had failed (GSFC Nontidal Wetland Compensation Fund Permit #03-NT-0444, September 2011). GSFC was directed to pay into the MDE Wetland Compensation Fund in lieu of remediating the failed portion. MDE determined that the mitigation conditions were met in letter dated October 28, 2011 (GSFC Nontidal Wetland Compensation Fund Permit #03-NT-0444, October 2011). The extent of the wetland mitigation area has been digitized and incorporated into GSFC's GIS Portal.

Wetland Area D (**Figure A-19**) is in the northern, undeveloped section of the east side of the Greenbelt site. Wetland vegetation and hydrology, indicative of a PFO1A wetland was observed south of Wetland Area A and north of Wetland Area B (Beaver Pond), at the northern end of a minor intermittent tributary stream. Wetland Area E (**Figure A-19**) is a shallow depression on the west side of the access road to the west of building 25 that contains wetland vegetation and hydrology indicative of an emergent, narrow-leaved persistent, semi-permanent (PEM5F) wetland. The observed wetland features have not been formally evaluated.

Wetland Area F (**Figure A-19**) in Area 100 extends across the western sector in a narrow band that broadens along the southern boundary. NWI mapping classifies these wetlands as palustrine and emergent wetlands (**Figure A-18**). Wetland vegetation and hydrology observed in this area were indicative of a PFO1A wetland with a segment of palustrine, scrub-shrub, broad-leaved deciduous, temporarily flooded (PSS1A)

wetland in the central area near the radar tower**.** The observed wetland features have not been formally evaluated.

Wetland Area G (**Figure A-19**) is located in the wooded area in the northwest quadrant of Area 200. This small wetland conveys flow from a large culvert stream and into a low-lying marshy floodplain area with an intermittent stream network. Vegetation in this floodplain area consists of obligate wetland species, including various grasses, sedges, rushes, ferns, and skunk cabbage. The observed wetland features have not been formally evaluated.

Wetland vegetation and hydrology were observed within and immediately outside of the GSFC fence line at Area 300, across Good Luck Road. Wetland Area H (**Figure A-19**), identified as a PFO1A wetland, occurs at the northernmost fence line, east of building 306. Wetland Area I (**Figure A-19**) was observed directly opposite of Building 302, across Good Luck Road, and contains vegetation and hydrology, indicative of a palustrine, open water, intermittently exposed/permanent, diked/impounded (POWZh) wetland. Wetland Area H is not on GSFC property. The observed wetland features have not been formally evaluated.

Area 400 contains a large swath of forested canopy that is currently undeveloped. No wetland features have been identified in Area 400 to date. No formal wetland investigation of this area has been performed.

Flooding is rare at GSFC, occurring as a result of clogged or damaged stormwater structures. Routine maintenance of stormwater structures has minimized flooding at the Greenbelt site. **Figure A-19** includes the Federal Emergency Management Agency (FEMA) 100-year floodplain as it occurs north of the GSFC property. The GSFC property does not fall within the 100-year or 500-year floodplains.

4.1.3.8 Coastal Zone Management

The Federal Coastal Zone Management Act (CZMA) of 1972 (16 USC § 1451, et seq., as amended) requires that "federal actions which are reasonably likely to affect any land or water use, or natural resource of a state's coastal zone be conducted in a manner that is consistent with a state's federally approved Coastal Zone Management Program (CZMP)" (Ghigiarelli, Elder. (2004)). Through the CZMP, specific goals, objectives, and policies were established for the management of uses and activities which have a direct, and potentially significant, effect on coastal resources. On March 18, 2011, the National Oceanic and Atmospheric Administration (NOAA) announced its approval of a Routine Program Change (RPC) to Maryland's Enforceable Coastal Policies. The RPC was submitted to NOAA on November 19, 2010. Federal consistency applies to the updated policies as of April 8, 2011. Maryland's Coastal Zone is made up of sixteen counties and the City of Baltimore. This includes Prince George's County. The GSFC is more than ten miles from the Chesapeake Bay. It is not located in close proximity to any beaches, estuaries, barrier islands, or coral reefs. In addition, the campus lies outside the 100-year floodplain.

4.1.4 Biological Resources

GSFC encompasses approximately 1,270 acres of land which includes several tracts of forests, maintained lawns and a large forested wetland.

The northern boundary of GSFC and its Outlying Areas are contiguous to a large tract that has no commercial or residential development. The tract extends to the north and northeast across northern Prince George's County, the Anacostia River Watershed, and into Anne Arundel County to Fort Meade. Amtrak northeast corridor railroad tracks and the Baltimore-Washington Parkway roughly define the eastern and western tract limits, respectively. The entire tract is almost exclusively owned and occupied by federal agencies. The natural environment in this tract extends into the northern sector of the eastern side of the Greenbelt site and Outlying Areas and is part of the Maryland Coastal Plain Ecosystem Province. The topography can be characterized as gently undulating or rolling, and the divides formed by the dendritic stream pattern can be difficult to discern in the field. Physical infrastructure such as buildings and roads occupy less than two percent of the tract. The USDA properties within the tract have a roughly equal mix

of agricultural and forested land cover. These woodlands can be characterized as a Pine-Oak Association Forest (Hotchkiss and Stewart, 1979).

4.1.4.1 Vegetation

According to a plant survey conducted in 2002 (Jones, 2002), there are 404 different plant species on the Greenbelt site, 261 species occur on the western side and 307 occur on the eastern side. Sites survey locations are depicted on **Figure A-Figure** A-21**.** No plant survey has been conducted at the Outlying Areas. There are no known rare or endangered species on the Greenbelt site or the Outlying Areas.

The canopy at the Greenbelt site primarily consists of oak (*Quercus* spp), scrub pine (*Pinus virginiana*), and red maple (*Acer rubrum*). The understory contains black gum (*Nyssa sylvatica*), sweet gum (*Liquidambar styraciflua*), and red maple. Shrubs and small trees include mountain laurel (*Kalmia latifolia*), blueberry/huckleberry (*Vaccinium/Gaylussacia* spp), and some American holly (*Ilex opaca*).

Three habitats at the Greenbelt site contain unusual plants. One habitat on the eastern side of the Greenbelt site contains widespread skunk cabbage (*Symplocarpus foetidus*). Skunk cabbage, normally found in wooded, marshy areas, was not found anywhere else at the Greenbelt site. Fourteen different types of Carex, a type of sedge, were found here, out of a total of 26 types found on the entire Greenbelt site. Another habitat on the eastern side of the Greenbelt site is a sandy area west of the former collimating tower is another sandy area. Longbranch frostweed (*Helianthemum canadense*), orangegrass (*Hypericum gentianoides*), wild ipecac (*Euphorbia ipecacuanhae*), and foxglove beardtongue (*Penstemon digitalis*) grow here. Longspike tridens (*Tridens strictus*), a unique type of grass normally only found in areas of south and west Maryland, grows on the western side of the Greenbelt site, along the Main Pond. The Greenbelt site also has three cypress trees located on the north end of the main pond. The base roots of these trees are submerged in water year round. Cypress trees are rare this far north and are an unusual find in a man-made pond. Little is known about these trees and their history, but they are protected by a chain link fence surrounding the base of the small tree stand.

Several exotic and invasive species grow at the Greenbelt site, including Japanese stiltgrass (*Microstegium vimineum*), mile-a-minute weed (*Polygonum perfoliatum*), bull thistle (*Cirsium vulgare*), callery/bradford pear (*Pyrus calleryana* 'Bradford'), Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), and phragmites or common reed (*Phragmites australis*). Also, a single specimen of purple loosestrife (*Lythrum salicaria*) was discovered at GSFC, and immediately eradicated in August 2009. A Purple Loosestrife Reporting Form was filed with DNR following the discovery.

There are numerous forest conservation areas on the Greenbelt site, created because of construction projects. See **Figure A-7** for a depiction of these areas. **Figure A-21, Figure A-22,** and **Figure A-23** demonstrate the current land cover on the Greenbelt site and in the Outlying Areas; forest conservation areas and forest and grassland types are also included within the figures.

In June of 2016 a report was submitted for a Forest Stewardship Plan (Arseneault, Justin. (2016)). The plan submitted was in consultation with the Maryland Department of Natural Resources Forest Service. This gives some possible actions to undertake to give GSFC main center forest areas more viability, and to consider on a fund availability basis. There are no state or federal requirements to carry out the plan.

4.1.4.2 Terrestrial Wildlife

A Biodiversity Survey was conducted in 2004 to survey terrestrial vertebrates and habitats at GSFC (University of Maryland, 2004). The survey focused on frogs and toads, woodland salamanders, breeding birds, small mammals, medium sized carnivores and omnivores, and large mammals. **Figure A-24** displays the survey sites.

Nine species of frogs and toads were recorded in the study (University of Maryland, 2004). The most widely distributed species were the southern leopard frog *(Rana sphenocephalus utricularius)*, the eastern American toad *(Bufo americanus americanus)*, the gray treefrog *(Hyla chrysoscelis, H. versicolor)*, the northern spring peeper *(Pseudacris crucifer),* and the northern green frog *(Rana clamitans melanota)*. These widely distributed species are regarded as common and abundant in the area (**Table B-14**).

No woodland salamanders were found at GSFC. The eastern red-backed salamander *(Plethodon cinereus)* is widespread and abundant in eastern North America and would be expected at GSFC; however, the area was experiencing drought conditions and this species remains below the surface during dry periods.

Seventy species of birds were recorded during the survey. Significant differences were noted in the number of species in different sized forest fragments (**Table B-15**), with the smallest fragments containing roughly half the number of species in large and medium sized fragments. Along with a fewer number of species in the smaller fragments, there was a change in the species composition, with "area sensitive" species replaced by "suburban residential" species.

Three species of owls were found during the study. The barred owl *(Strix varia)* was the most abundant species, with one great horned owl *(Bubo virginianus)* and one eastern screech owl *(Otus asio)* also seen. The owls were restricted to the large forested tracts at the north ends of both sides of the Greenbelt site.

GSFC is home to a resident Canada goose *(Branta canadensis)* population. The number of resident geese that nest at GSFC has increased sharply, as the geese have adapted to the mild winters and do not migrate. During the nesting season of 1998 and 1999 (March – May), significant impacts to humans occurred. As the geese adapted and became complacent to human presence, physical attacks on employees occurred around nesting areas. Population counts during May and June of 1999 recorded over 100 at the Greenbelt site. Particular areas of concern include the shrub areas around buildings and parking lots, and locations of significant pedestrian traffic. Although predators, such as fox, are present and have been observed at GSFC, their presence has not made an impact on the abundant geese population. Geese excrement is scattered across the Greenbelt site during the summer molting period (when the geese are flightless) and in the Main Pond areas at Cobe and Explorer Roads. Control measures, such as egg addling and dog handling to reduce breeding, have been introduced and appear successful at the present time.

Small mammals observed at GSFC include the white-footed mouse *(Peromyscus leucopus)*, house mouse *(Mus musculus)*, southern short-tailed shrew *(Blarina carolinensis)*, eastern chipmunk *(Tamias tamias striatus)*, eastern gray squirrel *(Sciurus carolinensis)*, and eastern cottontail *(Sylvilagus floridanus)*. Bats and flying squirrels *(Glaucomys spp.)*, although common in the area, have not been noted due to their nocturnal nature and the fact that no GSFC study has included nocturnal mammals. An eastern red bat (*Lasiurus borealis*) has been observed during daylight hours around the constructed wetland behind building 25. Medium sized carnivores-omnivores observed on GSFC include raccoons *(Procyon lotor)*, red fox *(Vulpes vulpes)*, gray fox *(Urocyon cinereoargenteus)*, Virginia opossum *(Didelphis virginiana)*, long-tailed weasel *(Mustela frenata)*, striped skunk *(Mephitis mephitis)*, and domestic cat *(Felis catus)*. Raccoons, red fox, and long-tailed weasel were more commonly found in the large forest fragments while gray fox, Virginia opossum, and domestic cat were found most frequently in the medium and small forest fragments.

The primary large mammal found on GSFC is the white-tailed deer *(Odocoileus virginianus)*. Physical counts were taken on the western side of the Greenbelt site between the years 1994 and 2009. The population of white-tailed deer gradually increased from approximately 50 animals in 1994 to more than 70 animals on the western side of the Greenbelt site in 1998. Control measures undertaken beginning in 2002, which include sharp shooting in the late evening hours, reduced the population to approximately 15 animals annually. The Eastern side of the campus was not measured through a physical count although reduction activities took place there as well. Counts between 2003 and 2009 showed less than 20 animals on the western side. In October 2006, the population was 16 deer, followed by a population of 10 deer in October of 2010. These numbers are much closer to that which the habitat could optimally sustain without

impacting natural vegetation regeneration and habitat for other species. Because historical counts proved that the control methods were effective, physical population counts were discontinued in 2010 and replaced with Forward Looking Infrared Radiometer (FLIR) surveys and additional data to determine population counts. FLIR equipment surveys are conducted each winter before a culling event to estimate population and movement of animals. Meat from deer shooting events is donated to soup kitchens.

In addition to habitat impacts, the white-tailed deer have been associated with occurrences of zoonotic and vector-borne diseases (e.g., Lyme disease) on GSFC. Deer feeding stations, 4-Poster Deer Treatment Bait Stations, have been established on the Greenbelt site to interrupt the tick life-cycle. Permethrin, a derivative of pyrethrum (a naturally occurring insecticide derived from the chrysanthemum), rubs off the station onto the deer as they feed on the bait (corn), thus killing any ticks the deer is infested with. The stations are mobile and can be moved depending on the use of the station (i.e., if deer do not use a particular station, it will be moved to another location). This program was established as a research program under the USDA. The program has been highly successful to date and will be continued.

4.1.4.3 Aquatic Environment

GSFC is located in the Coastal Plain physiographic province of Maryland. The facility is located on a drainage divide with surface runoff from the north and central portions of the site flowing to Beaverdam Creek and Beck Branch, tributaries of the Anacostia River. The southern portion of the property drains to the Western Branch of the Patuxent River via the Bald Hill Branch tributary. The eastern points of discharge drain to the Western Branch of the Patuxent River via the Folly Branch tributary (**Figure A-28**).

A study was conducted in partnership with George Mason University to provide baseline information on the aquatic resources of GSFC (George Mason University, 2002). Seven stream sites, each located on small first order tributaries, were monitored on a monthly basis for water quality; watershed areas ranged from 21 to 201 acres. All major stream reaches on the Center were sampled; individual sample sites were selected to be representative and accessible.

Sampling of streams at GSFC was restricted to base flow conditions and 2002 was an exceptionally dry year. The water quality of GSFC streams was generally consistent with expectations for Maryland coastal plain streams and was in compliance with state water quality standards and general guidelines. The phytoplankton in all ponds was characterized as typical freshwater species. The ponds at GSFC exhibited generally eutrophic, or highly enriched, conditions. The two larger ponds on the eastern side of the Greenbelt site both underwent seasonal stratification which, together with the eutrophic status, resulted in severe oxygen depletion in the lower layers of both ponds for most of the year. This resulted in elevated values of ammonia nitrogen. Over the past 5 years GSFC has installed aeration pumps in the ponds to increase the levels of oxygen. In addition, periodic chemical treatments are performed to reduce the amount of phosphorus keeping values within parameters set in the Center's NPDES permit.

In partnership with representatives from the Maryland DNR, a study of the fish at the Main Pond was conducted in 2002 (MDNR. (2002)). The study was commissioned to investigate reports of grass carp (*Ctenopharyngodon idella*) in the Main Pond. It is illegal to possess or to stock grass carp, a fish native to China, in Maryland waters. The concern was that the fish could migrate from the pond entering the Anacostia watershed and inflict serious ecological damage to the aquatic ecosystem. Electrofishing and gillnetting were used to survey the pond. No grass carp were found during the survey; however, the presence of grass carp cannot be ruled out. The most abundant fish found were bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*), and pumpkinseed (*Lepomis gibbosus*) were also common. Black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), and channel catfish (*Ictalurus punctatus*) were identified as scarce.

4.1.4.4 Threatened and Endangered Species

No federal threatened, endangered, or rare species are known to be established as resident species on GSFC properties. The northern long-eared bats (Myotis septentrionalis) are found in Maryland. Suitable habitat for this species could include a broad range of tree species having cracks, crevices, or shag bark, and trunks measuring 7.6 centimeters (3 inches) in diameter. However, this species prefers old-growth forests and relies on interior forest habitat with lower amounts of edge habitat for foraging, roosting, and pup rearing (NatureServe 2014). No old growth or interior forest habitat occurs on the installation. There has been a reported case of a visiting bald eagle on GSFC property. No known critical habitat is located on GSFC. **Appendix C** provides a current listing of federally- and state-listed threatened and endangered species.

4.2 Utilities and Infrastructure

4.2.1 Heating and Cooling

When there is a sufficient density of buildings, central heating and cooling systems are more economical, energy efficient, and reliable than individual building systems. Larger equipment units are more energy efficient as fewer operators are needed, and a single reserve unit can serve as backup for several buildings when other units are out of service for maintenance or repair.

A high degree of reliability in controlling building temperatures and humidity is essential in computer, laboratory, and satellite assembly areas at GSFC. The central heating and cooling systems were installed to increase the level of reliability. Both steam and chilled water are circulated to most of the major buildings. Small ancillary buildings and those in outlying areas have individual building heating and air conditioning units serviced by gas, oil, or electricity. A geothermal system was completed and operational as of September 2012, providing service to building 25.

4.2.2 Steam Production

Steam is used throughout the year for hot water, laboratory and cleaning processes, building temperature and humidity control, and for use in the cafeteria in building 21. **Table B-16.** shows the monthly steam produced in 2017. About 12 percent of the steam produced is used to operate steam driven equipment within the steam plant. In the winter months (January, February, and March) of 2017 when use was the highest, GSFC used 51,000 to 54,000 lbs of steam per hour for heating and humidification.

GSFC operates the steam plant under the provisions in the Title V operating permit issued by the MDE. The permit covers boiler operations for natural gas, landfill gas, and fuel oil firing and boiler stack emissions. To maximize operating efficiency, an additional boiler is fired up only when demands reach about 90 percent of the nominal capacity of on-line operating units. Production is monitored by a computerized Energy Management Control System. Plant equipment was overhauled in 1994 and 1995, during which all boilers were retrofitted with low nitrogen oxide emission fuel burners.

Generated steam is sent to a common header and pumped into the distribution system that supplies steam to many of the major buildings on the Greenbelt site. This distribution system is composed of high-pressure steam lines and low-pressure condensate return lines between manholes. In 2005, the steam plant was converted to use well water for boiler makeup. Boiler blowdown is now discharged to GSFC storm drains and is subject to a NPDES industrial discharge permit. Well water contains significantly fewer contaminants than city water, which results in less use of treatment chemicals and less corrosion of condensate return lines.

4.2.3 Chilled Water

GSFC uses central refrigeration to cool buildings and in its industrial processes. Water is cooled by chillers and cooling towers, then pumped and circulated to buildings through a distribution system. After capturing heat from the buildings in air handling units, the water is returned to the plant through parallel piping. At

the plants, chillers cool the water and transfer the heat to cooling towers, which release the heat to the atmosphere.

Cooling towers require makeup water to replace evaporative losses. Makeup water demand accounts for more than half the average annual site water consumption, and as much as 70 percent of the demand on hot summer days when building cooling requirements are high. In 2006 the cooling towers were converted to allow for the use of well water for makeup water.

4.2.4 Water and Wastewater

4.2.4.1 Water

GSFC utilizes water provided by WSSC and from groundwater wells to meet facility needs. Potable water is supplied by WSSC to all buildings at the Greenbelt site and Outlying Areas 200, 300, and 400. Potable water is supplied by BARC through groundwater wells to Area 100. GSFC's water distribution system is sized for fire protection flows, which are much greater than normal peak usage.

The amount of water consumed at GSFC varies with season. The average potable water rate usage is approximately 271,500 gpd. Annual potable water consumption is provided in **Table B-17. Table B-18** shows the average daily well water consumption.

4.2.4.2 Wastewater

Sanitary sewage collection at GSFC is handled by a combination of three separate sewer pipe networks that discharge to the WSSC sanitary sewer system. The Outlying Areas are serviced by septic tanks or fields. **Table B-19** details the septic tanks at GSFC. The first collection system covers the entire western portion of GSFC and building 25, Area 600, and building 35 on the eastern portion of the center. It is the largest system on center, collecting wastes from all but four GSFC buildings. Since GSFC is located on the crest of the drainage divide between the Anacostia and Patuxent Rivers, this system has both gravity flow and forced pressure mains. All buildings northwest of Goddard and Explorer Roads on the western side of GSFC that have sanitary service require pumping of sewage over the drainage divide to the south side of GSFC. The eastern sanitary system collects waste from buildings 31, 32, 33, 34, 79, and 95, 92 the GEWA Recreation Center. Both collection systems discharge by gravity flow to the WSSC sanitary sewer system. GSFC maintains two WSSC permitted discharge points. The first and oldest is a manhole located behind Building 9. The second is the point at which the waste treatment facility in the Building 5 Plating Shop discharges to the WSSC sanitary system.

GSFC maintains several wastewater treatment systems. These systems were put in place to meet conditions of GSFC's wastewater discharge authorization permit. See **Section 3.6.3** for additional information about these treatment systems.

Septic tanks are located on the eastern side of GSFC for building 83 and in Areas 100, 200, 300, and 400 (**Table B-19**). All buildings with restrooms in Areas 100, 200, 300, and 400 are connected to septic tanks; there is no sanitary service provided by WSSC in the Outlying Areas. It is estimated that about 200 gallons of domestic sewage is processed through the septic tanks each day. This number can fluctuate greatly from day to day.

4.2.4.3 Natural and Landfill Gas

The Washington Gas Company–Maryland Division distribution system delivers natural gas to GSFC. GSFC purchases natural gas from Washington Gas, or when economic savings can be realized, from the Defense Energy Supply Center. The Defense Energy Supply Center is a Department of Defense agency, which makes natural gas purchased at fixed rates available to other federal agencies around the country.

Since January 2003, GSFC has been burning landfill gas in three of the five boilers in the Central Heating and Refrigeration Plant. TORO Energy of Dallas, Texas signed an agreement with Prince George's County

to capture, process, and deliver gas produced at the County-owned Sandy Hill Landfill. The landfill is located on Old Laurel-Bowie Road about 1.5 miles to the east of the Area 400. Through a contract with TORO Energy, landfill gas is delivered to GSFC and used as an alternative fuel supply for the Central Heating and Refrigeration Plant boilers.

About 98 percent of all the natural gas delivered to GSFC is used as a fuel supply for the boilers in the Central Heating and Refrigeration Plant to produce steam for Center heating and research processes. **Table B-20** shows natural and landfill gas use by the Central Heating and Refrigeration Plant boilers in 2017. The peak recorded natural gas usage month at the Central Heating and Refrigeration Plant was February 2017, with a total natural gas consumption of 32,809,998 Scf.

Natural gas use fluctuates with the season as heating demands are superimposed on the relatively constant base demand needed to generate steam for scientific, technical, and space humidity control purposes. Washington Gas classifies GSFC gas service as interruptible. Supply can be cut or reduced during periods of shortages, or when user demands approach or exceed Washington Gas distribution system capacity. At such times, GSFC switches to No. 2 fuel oil to produce steam.

Analysis of the landfill gas indicates that it is composed of 50 percent CH_4, 45 percent CO_2, and 5 percent higher hydrocarbons such as ethane and propane. Natural gas composition varies by well source, but typically has 90-percent CH_4, 5 percent ethane, and 2 percent propane as the hydrocarbon constituents. Nitrogen occurs as an impurity in natural gas. Landfill gas burns cooler but has the advantages of lower cost and NO_X emissions. The landfill gas is carried between the landfill and GSFC in a pipeline located primarily on government property.

4.2.4.4 Oil

GSFC manages and stores approximately 288,000 gallons of oil. The facility operates under GSFC's Oil Operations Permit from MDE. The permit and the SPCC regulations require bulk oil storage containers equal to or greater than 55 gallons in capacity to have engineering controls, regular inspections, and emergency spill procedures. For oil regulated under SPCC requirements, only containers that are 55 gallons or greater are counted in the storage capacity. Elevators and other miscellaneous equipment that require oil in order to operate do not meet the definition of bulk oil storage (as defined by 40 CFR 112) and as such are not counted in total oil storage capacity. However, elevators and other miscellaneous equipment containing oil must be managed in a manner to prevent release to the environment. GSFC's ICP outlines all the requirements and preventive measures for oil operations at GSFC.

There are approximately 50 tanks that store oil at GSFC. Oil is used for the vehicle fleet, generators, and boilers. **Table B-21** details the annual fuel oil use at GSFC.

Other tanks on the Greenbelt site are used to store new motor oil for equipment and vehicle use while others are used to store used oil.

4.2.4.5 Electricity

GSFC receives utility service from the Potomac Electric Power Company (Pepco) to serve all its power requirements, including buildings, exterior lighting, and fixed equipment around the site. System components include Pepco primary feeders, on-site substations, power distribution via underground duct banks, and building equipment.

Recent FY electric power consumption is shown in **Table B-30**. A maximum demand of 27.0 megawatts for the entire GSFC facility was recorded in June 1998. The GSFC facility used 160 megawatts in 2017.

4.3 Cultural Environment

4.3.1 Historic Resources Adjacent to GSFC

Five historic resources have been identified in the area outside of the NASA boundaries (Maryland-National Capital Park Planning Commission, 1992). They are:

- Baltimore-Washington Parkway Historic District (Site 69/26)
- City of Greenbelt Historic District (67-4)
- Perkins Chapel and Cemetery (Site 64-5) – 8500 Springfield Road
- Hayden Farm (Site 64-4) – Beaverdam Road
- Dorsey Chapel (Site 70-28) – 10704 Brookland Road

The Baltimore-Washington Parkway Historic District is listed on the National Register of Historic Places (NRHP). It covers 1,353 acres consisting of right-of-way in a 19-mile long section between the city limits of the District of Columbia and Baltimore. It was promoted as early as 1920 to alleviate traffic congestion on US Highway 1 between the two cities. Authorization was given in 1930 to the National Capital Park and Planning Commission to acquire land for right-of-way. Funding for design and construction was not made available until 1950. It opened to traffic in 1954.

GSFC abuts the Baltimore-Washington Parkway at the far northwest corner of the Greenbelt site, where an interchange provides access to Gate 3 via Explorer Road. Parkway right-of-way is relatively narrow at this point and is forested on both sides in the vicinity of the interchange. Except for Explorer Road, all of the GSFC property in this area is forested so that GSFC facilities are screened from the Parkway. Bridges, culverts, and walls at the interchange are not contributing elements within the Historic District.

The City of Greenbelt Historic District is also listed in the NRHP. It is located on the west side of the Baltimore-Washington Parkway sharing a common boundary with the Parkway between Greenbelt Road and the BARC to the north of the GSFC interchange. The district encompasses the area covered by the original "greentown" plan as developed by the U.S. Resettlement Administration and was designed and built between 1935 and 1941. Greenbelt is considered to be the most successful and intact example of the "greentown" concept in the U.S.

GSFC is separated from the Greenbelt Historic District by the Washington-Baltimore Parkway and by intervening residential development within the city. The point of closest approach between GSFC and the District occurs in the vicinity of the GSFC/Parkway interchange. The sector of Greenbelt in this area is forested, remaining lightly developed as in the original plan.

The Perkins Chapel and Cemetery are of local historical significance, because the chapel is one of only a few rural chapels surviving from the mid-nineteenth century. Hayden Farm is of local significance because it is a fine example of a large early twentieth century dairy farm, which is somewhat unusual in a county oriented toward tobacco and grass crops. Dorsey Chapel (Brookland M.E. Church) was a focal point for the rural Black community of Brookland.

4.3.2 Historic Resources on GSFC

The Spacecraft Magnetic Testing Facility is listed in the NRHP and is designated as a National Historic Landmark as part of the "Man in Space" theme program undertaken by the National Park Service, applied to military and NASA facilities. GSFC continues to actively use the facility. Management and operation of the facility are performed in accordance with a Programmatic Agreement executed in 1989 between GSFC, the National Conference of State Historic Preservation Officers, and the Advisory Council on Historic Preservation (ACHP) (Dixon, 1996).

Constructed in September 1960, building 2 was GSFC's second building. Although the building was modified many times, it was beyond restoration and reached the end of its useful life. Due to its design, configuration, age, and condition, building 2 no longer efficiently and effectively served GSFC's current and future mission requirements.

Building 2 was eligible for the National Register in the areas of science and exploration as part of a historic district. The building represented the important achievements of a body of scientists and technicians that occupied the office and laboratory spaces. As the building did not operate independently but was largely supported by other facilities located at GSFC, it was also eligible as part of a historic district. In accordance with the requirements of a Memorandum of Agreement among NASA GSFC, the Maryland State Preservation Office, and the ACHP, building 2 was deconstructed in 2012 following a Cultural Resources Survey (Goodwin, 2012) The site of the former building was seeded with grasses for erosion and sediment control. Building 34, the Exploration Sciences Building, was constructed in 2010 to renew GSFC science capabilities for the 21st century. The vast majority of science activities and operations formerly housed in building 2 were relocated to building 34.

Another structure at GSFC that predates 1961 is building 101 (Site 64-9) which is found in Area 100, the Antenna Test Range, on Beaverdam Road. It is a farmhouse dating from the late 19th or early 20th century. It has been determined to be ineligible for listing in the National Register because it does not possess integrity or historic significance (Dixon, 1996).

4.3.2.1 2012 Cultural Resource Survey (Goodwin, 2012)

In 2012 GSFC commissioned a Center-wide historic properties survey (The Survey) to document and evaluate all potentially-eligible buildings and landscapes at GSFC. The Survey was required to include an historic context covering mission and historic themes and to identify associated historic real property at the GSFC Greenbelt campus. The Survey was intended to document GSFC Greenbelt campus history and development from 1959 to 2012, with a special focus on the first 20 years.

4.3.2.2 Historical Context and Architectural Reports for the Cultural Resource Survey

The Historical Context Report presents the results of a comprehensive study of the history of GSFC, which developed an historical overview of GSFC and identified associated historic themes and property types (Goodwin, 2012).

The report concluded that NASA had taken the opportunity to create an architectural identity for the Goddard campus when planning the design of the new research facility. This architectural identity resulted in the establishment of a corporate campus representative of similar facilities constructed during the 1950s and 1960s.

GSFC resources were evaluated to identify contributing and non-contributing resources to a potential NRHP historic district or districts. Data analysis applying the NRHP Criteria for Evaluation identified a collection of buildings, structures, and landscapes that represented a recognizable entity necessary for a GSFC historic district. The period of significance for the historic district is 1960 – 1969 and represents the first decade of development at GSFC.

4.3.3 Archaeological Resources on GSFC

GSFC lies within Maryland Archaeological Research Unit 11, Riverine Potomac Drainage. GSFC has completed a number of investigations to determine the cultural resources at the site. A preliminary study, intended as a tool for prioritizing further work and consultations with review agencies, defines the research area, provides historic and cultural overviews to establish a context for encountered resources, and inventories known or identified resources within and around GSFC (Miller et al., 1992). No field work was completed, but GSFC real property records, including plans for alterations and remodeling of facilities, the general literature, and archival records at the Maryland Historical Trust and other pertinent organizations were reviewed.

The most important outcome of this preliminary study was the development of a predictive archaeological model for the GSFC site. Field investigations have determined that the predictive model is a good one. Kassner investigated about 105 acres of area with low potential for prehistoric sites, as indicated by Miller,

in the southern portion of the east side of the Greenbelt site and encountered no evidence of prehistoric or historic activity (Kassner, et al., 1991).

A Phase I reconnaissance survey (KCI, 1999) revealed the presence of two prehistoric and two historic period sites on GSFC property. Phase II investigations of three of the sites were conducted in the summer of 2002 and prepared by John Milner Associates, Inc (2004). Of the four sites only one was identified as eligible for inclusion in the NRHP.

GSFC maintains an Integrated Cultural Resources Management Plan (ICRMP) as a planning and management tool to support cultural resource activities, including compliance with the National Historic Preservation Act (NHPA).

4.3.4 Paleontological Resources

4.3.4.1 Fossilized Dinosaur Footprints

Dinosaur footprints belonging to a mother, and possibly her baby, were discovered on the GSFC campus in August 2012 by an amateur paleontologist. The footprint has been authenticated by an outside expert in fossilized footprints. The 12-inch wide footprint has been identified as a nodosaur (armored dinosaur), a large herbivore. The footprints suggest that the mother and baby were likely fleeing to avoid becoming prey to a larger animal.

4.4 Waste Management

4.4.1 Solid Waste Generation and Disposal

Solid waste is generally composed of trash, garbage, and refuse, including paper, glass, ashes, plastics, and newspapers. In the 1990s, the USEPA introduced an integrated solid waste management concept, aiming to expand on outdated solid waste management initiatives. To that end, GSFC strives to maximize existing landfill life through the implementation of an integrated waste management system, while protecting the natural environment and quality of life. Measures within the management system include minimizing waste generation through source reduction; separating, recovering, and recycling materials; incinerating when appropriate; and using landfills more effectively.

Solid waste at GSFC consists of office waste, plastics, glass, wood, trash, and cafeteria waste. Waste is collected by custodial staff and placed in dumpsters located around the facility. A private contractor then picks up the waste and hauls it to a sanitary landfill.

The quantity of waste generated at GSFC varies from year to year (**Table B-22**), depending on active GSFC missions.

4.4.2 Recycling Programs

Recycling consists of activities during which materials no longer considered useful to the generator are collected, sorted, processed, and produced or converted into new products. GSFC initiated its recycling program in the 1990's. This was due in part to Presidential EO 12873, designed to encourage response by federal agencies to work with existing laws to reduce solid waste, develop markets for recycled products, foster new technologies and increase the purchase of recycled products. GSFC implemented a Single Stream Recycling Program in 2011 through which recyclable materials are collected in a single container.

GSFC recycles items such as white and mixed paper, newspapers, light cardboard, aluminum soda cans, ferrous and nonferrous metals, and glass and plastic containers, rinsed plastic utensils, glass bottles and jars, food boxes, milk and juice boxes, paper bags and non-foil wrap, phone books, and soft and hard cover books. GSFC has also included rechargeable battery recycling stations in buildings throughout campus. Materials are collected by several contractors. Since 1990, efforts have been concentrated through several programs to reduce generation and disposal volumes through increased recycling.

Recent totals at GSFC for non-construction and non-demolition recyclables were 495 tons and construction and demolition totals of 182 tons in FY 2017. Additionally, the online Freecycle@NASA program allows employees to exchange under-utilized office items. This program is available to all NASA centers.

4.4.3 Hazardous Waste

MEMD is responsible for documenting and managing hazardous wastes generated at GSFC. Waste is generated at various points at GSFC, referred to as satellite accumulation areas (SAAs), and is transferred to the less-than-90-day waste facility when the accumulation of a hazardous waste reaches 55 gallons and/or when the accumulation of an acute hazardous waste reaches 1 quart. Each SAA has a point-of-contact that is required to attend annual Hazardous Waste Management Training. Detailed hazardous waste management procedures can be found in Goddard Procedural Requirements (GPR) 8500.3, Waste Management.

The Greenbelt site maintains Large Quantity Generator status in Maryland. The USEPA Identification Number associated with the Greenbelt site is MD9800013865. GSFC also has three other sites that maintain Very Small Quantity Generator Status--Area 200 (USEPA Identification Number MDR000001925), Area 300 (USEPA Identification Number MDR000527469) and Area 400 (USEPA Identification Number MDR000527468).

Waste data collecting and management activities such as characterizing waste, waste generator training and inspection areas where waste generation occurs, are formally documented in an official GSFC document (e.g., Work Instructions, GPRs). This enables GSFC to predict trends and track waste streams at the organizational level. It also provides direction for those working in the program, helps ensure data consistency, identifies responsible parties for waste generation, and establishes responsibilities for waste management activities.

In January 2010 GSFC began to use the Hazardous Materials Management System (HMMS) replacing the previous access database. GSFC uses HMMS for managing hazardous materials and for reporting waste compliance. HMMS is the only system of its type that was created and developed in close cooperation with the federal user community.

HMMS is supported by the GSFC Hazardous Materials Office staffed by Code 270, Information and Logistics Management Division. The GSFC Hazardous Materials Office captures all data points that are significant and critical for managing and reporting the Center's storage and use of hazardous materials. This same database is also used to manage the data related to the Center's Hazardous Waste Management Program. Using the system as designed creates a "closed-loop" system that tracks material storage, usage, and individual users. All waste related information is kept in the database creating a 'one-stop shop' for all hazardous material and waste management data.

The annual User's Conference empowers members of the HMMS community to provide critical input on the continued development of HMMS. Since user input is ongoing, HMMS continues to be the most current and comprehensive solution available to manage hazardous materials.

Establishing a baseline for waste generation at GSFC is difficult due to the nature of the operations. Over the past five years GSFC has been in the process of streamlining operations and facilities. This causes an unpredictable spike in waste generation due to the deconstruction of older facilities and operations and starting of new ones. It has become more efficient to have some work performed by an outside vendor than in-house. Construction and consolidation of operations has led to end users reducing their inventory and purging old, expired and unwanted chemicals. For these reasons, it is difficult to perform a trend analysis and establish baselines for waste generation at GSFC.

Table B-23 provides the amount of hazardous waste generated at GSFC by reporting year, and **Table B-24** presents the total amount of wastes (hazardous, universal, and non-Resource Conservation and Recovery Act [RCRA] wastes) generated by organization. Toxic and Hazardous Substances

4.4.4 Toxic and Hazardous Substances Regulatory Summary

Consumer demands for new products post World War II were fueled by the introduction of synthetic materials such as nylon, coated paper products, and plastics. Production to meet these demands was accompanied by a corresponding increase in the generation of chemical wastes. The first federal law dealing with this issue was the Solid Waste Act of 1965. This law was relatively ineffectual and was amended by the RCRA in 1970. RCRA focused on the protection of human health and the environment from the potential hazards of waste disposal. The Act also took actions to reduce the amount of waste generated and to conserve energy and natural resources. RCRA was amended in 1980 and later in 1984. The 1984 amendments, referred to as the Hazardous and Solid Waste Amendments, significantly extended the scope of RCRA. Of particular importance, Hazardous and Solid Waste Amendments established the extensive land disposal restrictions that exist for many hazardous wastes.

Problems associated with past mismanagement of hazardous wastes were addressed by RCRA's companion law, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, which addressed the cleanup of inactive and abandoned hazardous waste sites. CERCLA was amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA). In addition to updating the core requirements of CERCLA, SARA contains requirements for federal and state governments, and industry related to hazardous materials emergency preparedness and community right-to-know. Title III of SARA, known as the Emergency Planning and Community Right-to-Know Act (EPCRA), requires the Governor of each state to establish a State Emergency Response Commission (SERC). Each SERC, in turn, is required to designate Emergency Planning Districts within the State to facilitate preparation and implementation of an Emergency Planning Committee for each planning district. Today there are more than 3,800 Local Emergency Planning Commission (LEPCs) across the country. Facilities such as GSFC which use hazardous materials must prepare annual reports to the LEPCs regarding hazardous materials stored on the facility.

4.4.5 Emergency Planning and Community Right-to-Know (EPCRA)

The EPCRA establishes requirements for federal, state and local governments, Indian Tribes, and industry regarding emergency planning and "Community Right-to-Know" reporting on hazardous and toxic chemicals.

The Community Right-to-Know provisions help increase the public's knowledge and access to information on chemicals at individual facilities, their uses, and releases into the environment. States and communities, working with the facilities, can use the information to improve chemical safety and protect public health and the environment. EPCRA has four major provisions:

- Emergency planning (Section 301-303)
- Emergency release notification (Section 304)
- Hazardous chemical storage reporting requirements (Sections 311-312)
- Toxic chemical release inventory (Section 313)

Emergency planning provisions include requirements that are satisfied with the preparation of GSFC's ICP. Also included in the ICP is a list of extremely hazardous substances with designated threshold planning quantities (TPQ). Any facility that has any of the listed chemicals at or above its TPQ must notify the SERC and LEPC within 60 days after they first receive a shipment or produce the substance on site. GSFC utilizes several Tier II chemicals in quantities greater than the TPQ (**Table B-25**).

Facilities must immediately notify the LEPC and the SERC if there is a release into the environment of a hazardous substance that is equal to or exceeds the minimum reportable quantity set in the regulations. This requirement covers the 356 extremely hazardous substances as well as the more than 700 hazardous substances subject to the emergency notification requirements under CERCLA Section 103 (40 CFR 302.4).

Section 311 requires facilities that have Safety Data Sheets (SDSs) for chemicals held above certain quantities to submit either copies of their SDSs or a list of SDS chemicals to the SERC, LEPC, and local fire department. Facilities covered by Section 311 must, under Section 312, submit annually an emergency and hazardous chemical inventory form to the LEPC, the SERC, and the local fire department.

The toxic chemical release inventory (Section 313) is discussed in **Section 4.4.6** below.

4.4.6 Toxic/Hazardous Substances Inventory

EPCRA Section 313, commonly referred to as the Toxic Release Inventory (TRI), requires certain facilities to complete a Toxic Chemical Release Inventory Form annually for specified chemicals. The form must be submitted to the USEPA and the State on July 1 and must cover releases and other waste management of toxic chemicals that occurred during the preceding CY. One purpose of this reporting requirement is to inform the public and government officials about releases and other waste management of toxic chemicals. In addition, the Pollution Prevention Act of 1990 requires collection of information on source reduction, recycling, and treatment. The USEPA maintains a national TRI database on the Internet.

GFSC's chemical use generally falls under the "otherwise use" category. The release reporting threshold in this category is 10,000 pounds for most chemicals unless otherwise specified in USEPA regulations (40 CFR 372).

In June of 2012, GSFC filed an EPCRA TRI report Form R for exceeding the "Otherwise Used" category for R-22. It was determined that GSFC had exceeded the threshold for reporting in the "otherwise use" category. GSFC completed a mass balance making reasonable assumptions. It was assumed that each chiller was at full capacity at the start of 2011 and that recovery tanks remain empty unless a chiller is evacuated for repairs. The total amount of HCFC-22 used during 2011 was calculated; the amount of HCFC-22 recovered and reused on-site during the same year was subtracted to determine the amount of new HCFC-22 used. This calculation is the most conservative. GSFC "otherwise used" 13,011 pounds of HCFC-22.

Under normal operating conditions, GSFC would expect to use no more than 500 pounds of HCFC-22 to recharge each chiller resulting in an annual usage of approximately 3,000 pounds per year. When a leak is discovered that cannot be quickly repaired, the chiller is evacuated to a recovery tank and the recovered HCFC-22 is reused on-site. During 2011, GSFC had two abnormal events that caused an activity exceedance for the HCFC-22. The abnormal events are not expected to reoccur.

4.4.6.1 GSFC Polychlorinated biphenyl (PCB) and Asbestos Activities

GSFC maintains a list of all oil-filled equipment, as required by the ICP, which is summarized in the following section. The results of a GSFC-wide study of all oil filled operating equipment confirmed that the equipment on campus does not contain PCB oil.

GSFC conducted a center wide Asbestos Survey. The results of this survey are kept with the FMD asbestos coordinator and are available for review upon request.

4.5 Spill Control and Prevention Measures

GSFC implements an ICP to prevent, respond to, and report spills onsite. The GSFC ICP is a consolidated plan that addresses requirements for the following applicable emergency response plans:

- USEPA's Oil Pollution Prevention Regulation (SPCC and Facility Response Plan Requirements) – 40 CFR 112.7 and 112.8
- Oil Spill Contingency Plan – 40 CFR 109
- USEPA's Resource Conservation and Recovery Act (RCRA) Contingency Plan and Emergency Procedures – 40 CFR Part 262, Subpart M and COMAR 26.13.05.04

- Occupational Safety and Health Administration Hazardous Waste Operations and Emergency Response Regulations – 29 FR 1910.120(a)(iv) and (v)

The current ICP was finalized in January 2013 and recertified in April 2017. The recertification reflected the addition of a new building, its associated infrastructure and a new electrical transformer. The ICP is reviewed annually and updated as necessary and is applicable for the following potential chemical emergencies:

- Release from bulk oil storage containers as defined by 40 CFR 112.7 on GSFC property
- Oil release on GSFC property which threatens waters of the state
- Emergency response to hazardous substance spills/releases on GSFC property, with specific provisions for the < 90-day waste accumulation facility

To comply with the USEPA's Oil Pollution Prevention regulations (40 CFR 112.7 & 112.8), the ICP includes the following information:

- Procedures established to prevent the occurrence of oil spills
- Descriptions of engineering controls installed to prevent spills
- Clear outlines of the plan of action to be taken in response to spills (i.e., spill control and countermeasures)
- Facility maps, descriptions, and diagrams
- Discussion of the facility's SPCC conformance and reasons for nonconformance
- Type of oil in each container and storage capacity of the container
- Emergency contact list and phone/radio numbers
- Disposal methods for recovered materials
- Prediction of the direction, flow rate and total quantity of oil that will be released
- Organized discharge response procedures that are readily useable in an emergency
- Rationale for non-practicable containment and/or diversionary structures
- Inspections, test and records
- Employee training and discharge prevention procedures
- Security of oil containers
- Loading/unloading of oil
- Structural analysis of oil tanks
- Compliance with state requirements

The ICP also addresses activities associated with the handling, transferring, removal, storage, disposal, and use of oil at various facilities throughout GSFC. The Plan details spill reporting requirements and outlines actions necessary for GSFC to comply with the MDE-issued Oil Operations Permit. Oil program management procedures are described in the GPR for water management (GPR 8500.3).

To comply with the Oil Spill Contingency Plan requirements (40 CFR 109), the ICP:

- Assigns responsibilities and duties of all parties involved in spill prevention planning and oil spill clean-up operations
- Establishes notification procedures for early detection and timely notification of an oil discharge
- Establishes an oil discharge response team
- Pre-designates a qualified oil discharge response coordinator who can direct operations and request assistance from federal authorities
- Identifies a preplanned location for an oil discharge response operations center and a reliable communications system for directing the response operations
- Includes provisions for varying degrees of response depending on the severity of the discharge
- Specifies the order in which various waterways will be protected when more than one waterway may be affected from an oil discharge

- Identifies where response operations may not be adequate to protect all waterways
- Defines procedures for recovery of damages and enforcement actions, as provided by state and local statutes

To comply with USEPA's Hazardous Substance Contingency Plan regulations (40 CFR Part 262, Subpart M and COMAR Section 26.13.05.04), the ICP:

- Establishes emergency response contacts and an emergency response coordinator
- Includes a description of emergency response equipment on site and an evacuation plan specific to each building
- Establishes procedures for identifying the hazard and the health/environmental risks associated with the hazard
- Establishes procedures for containment, clean up, disposal/treatment, reporting, and monitoring of the spill site

Hazardous waste management procedures are described in GPR 8500.3, Waste Management.

4.6 Restoration Program

Restoration sites are currently managed under the auspices of the State Superfund Program. The NASA Restoration Program Manager coordinates with MDE regarding site investigations and closures. This summary only addresses the Greenbelt location and does not include off-site locations such as tracking stations or sites where GSFC is a Potentially Responsible Party.

Multiple sites have been investigated on GSFC for environmental contamination. Four sites have received remedial field actions: the Pistol Range, building 94, building 24 Mercury Release Site, and the Biodiesel AST. Five sites are subject to LUCs, as described in **Land Use Controls (LUCs)**. **Figure A-25** shows sites currently subject to the LUCs. **Figure A-26** and **Figure A-27** show remediation areas/investigated sites at the Greenbelt site.

4.6.1 Environmental Sites Subject to LUCs

In April 2014 GSFC began the LUC Implementation Plan (LUCIP) for TCE Groundwater and DFAs. The LUCIP was put into place as part of the State's No Further Requirements Determination (NFRD). The LUCIP implemented controls that would minimize human exposure to potential contamination associated with the environmental sites at GSFC. Four of the environmental sites subject to LUCs are DFAs (DFA A1, DFA A2, DFA B, and/or DFA C). The areas were never used as municipal landfills. Investigations are complete for the DFAs (No Further Action required by MDE). The fifth environmental site subject to LUCs is the TCE groundwater plume. The LUCs are discussed in **Section 3.5**.

See **Figure A-25** for a geographic location of the DFAs, the TCE plume source area, and the most current outline of the TCE groundwater plume.

4.6.1.1 DFA A1 (aka Nimbus Road Landfill)

DFA A1 was used for the disposal of construction rubble, dirt, asphalt, and concrete between approximately 1963 and 1969. DFA A1 formerly encompassed approximately 0.75 acres of land near the intersection of Nimbus and Minitrack Roads. The area encompassed by DFA A1 is bounded to the north by an unnamed creek and woods, to the west by the building 28 parking lot, and to the east by a wooded area on GSFC; a road exists to the south. The topography of the land in the vicinity of DFA A1 gradually decreases from the southwest to the northeast with a sharp slope at the northwestern edge of DFA A1.

The area is now covered with soil and gravel. A GSFC cloud networking station, consisting of a series of electrical and communication units, as well as a large intermodal container box, has since been erected on the DFA A1 site. The site is enclosed by a chain link fence placed for the purpose of providing secondary security of the cloud networking operations.

4.6.1.2 DFA A2 (aka Cobe Road Landfill)

DFA A2 was used for the disposal of construction rubble, dirt, asphalt, and concrete between approximately 1963 and 1977. The area occupied by DFA A2 is located approximately 400 feet to the north of the DFA A1 location, and this area encompasses approximately 0.47 acres of land, centered on Cobe Road, near the border of the USDA BARC. Grassy vegetation forms the eastern and western boundaries of DFA A2; a road forms the north and south boundaries. The topography of the land in the vicinity of DFA A2 gradually decreases from the southwest to the northeast with a sharp slope at the northern edge. DFA A2 was discovered, excavated, and partially removed in 1991 and 1992 while constructing the Cobe Road right-of-way. All debris encountered was removed, including construction debris, dirt, and several empty drums. DFA A2 is overlain by Cobe Road, which is within the secured facility and used for local travel only.

4.6.1.3 DFA B (aka Metro Landfill)

DFA B was used for the disposal of excavated soils during the construction of the New Carrolton Metro Station between approximately 1977 and 1983. The area occupied by DFA B encompasses approximately 8.6 acres of land centered along Explorer Road. This area is bounded to the north and east by a wooded area, to the west by a parking area, and to the south by building 34. The topography of the land in the vicinity of the former DFA B gradually decreases from the southwest to the northeast.

Excavation activities associated with the building 34 construction uncovered construction debris within the DFA B footprint. During the construction of Loop Road, building 34, and the associated parking lot, the majority of DFA B was excavated, removed, and replaced with material that would meet the necessary load-bearing requirements for construction. Soil and non-soil items (such as tires, concrete, etc.) were appropriately managed (either removed from the site or repurposed). Much of the concrete was segregated, crushed and screened for reuse as base materials for the road and parking lot. The remainder of the area was then backfilled with soil that had the necessary load-bearing characteristics for construction. There is no accurate estimate of what percentage of the landfill was excavated. DFA B is now almost entirely covered with asphalt and a small portion of building 34 (the majority of the building 34 footprint exists south and west of DFA B), which was constructed circa 2009.

4.6.1.4 DFA C

DFA C area was used for the disposal of construction rubble, dirt, asphalt, and concrete between 1969 and 1977. The timing of when DFA C ceased accepting waste is not precisely documented. A review of available aerial photos confirmed that DFA C had ceased accepting waste by early 1988. Most of the disposal activity occurred at DFA C prior to 1974, and a 1977 aerial photo shows recent vegetation debris disposal. Aerial photographs from 1983 and 1987 depict DFA C as an inactive fill area (i.e., no new piles or scarring, etc.). An April 21, 1988 aerial photograph shows the DFA C site area is completely graded with a new soil cover. There are no indications that any closure activities are on-going at the time of the 1988 aerial photograph (i.e., there are no construction equipment or other activities present).

The area occupied by DFA C encompasses approximately 0.7 acres of land in the northeast section of GSFC. This area is bounded to the north by an unnamed perimeter road, to the south by a former shooting range, to the west by the tracking and communication area, and to the east by a service road. The topography of the land in the vicinity of the former DFA C gradually decreases from the south to the north.

The area in the vicinity of DFA C is a former handheld fire extinguisher training area and disposal area for dirt and construction rubble (concrete and asphalt). Fire extinguisher training occurred in this area starting in 1987 after usage of DFA C had ceased; fire extinguisher training was subsequently terminated in 2007. DFA C remains heavily vegetated and undisturbed.

4.6.1.5 TCE Groundwater Plume

The TCE groundwater plume has been fully delineated, vertically and horizontally. It has been determined that the TCE groundwater plume is confined to the shallow unconfined Upper Patapsco Aquifer underlying GSFC. The horizontal extent of contamination extends north to south from beyond the northern boundary of GSFC (onto the BARC property) to the southern boundary of GSFC, and from east to west from approximately Goddard Road to Hubble Road on GSFC. Characterization and long-term monitoring of the shallow Upper Patapsco Aquifer TCE groundwater plume has determined a substantial reduction in contaminant mass since TCE in groundwater was first identified in 1989.

The DFAs were once suspected to be the source of the TCE groundwater plume. Subsequent investigations have indicated that the DFAs are not the source. The most probable source of the TCE groundwater plume was identified to be located within an area north of DFA A2, near the northern boundary of GSFC. A concrete pad was located within the probable source area. The concrete pad was presumed to be associated with historical operations that resulted in the TCE in groundwater. Analytical data and historical aerial photographic analysis confirm this as the probable source area (ERT. (2012a)). The concrete pad has been removed and the area has been leveled and seeded.

In 2004, a risk assessment was performed in accordance with applicable USEPA guidance utilizing concentrations of TCE in groundwater. The results of this risk assessment indicated no potential excess risk from dermal and inhalation exposure to the most likely human receptors at GSFC (workers). The vapor intrusion pathway has also been assessed, and it has been determined that no complete pathway exists for worker exposure (ERT. (2012b)).

As of the most recent sampling conducted at GSFC in 2014 (ERT. (2014)), concentrations of TCE in the shallow Upper Patapsco Aquifer remain at concentrations above the MDE Cleanup Standard for Type I and Type II Aquifers and the USEPA Maximum Contaminant Level (MCL) (5 micrograms per liter [µg/L]). The calculated risk falls within the USEPA acceptable non-carcinogenic and carcinogenic risk range that does not require action but requires environmental management decisions per the LUCs.

4.6.2 Other Sites

4.6.2.1 Building 94: Farmhouse and Underground Storage Tanks (UST)

The Farmhouse was located on the eastern side of the Greenbelt site, near building 25 (**Figure A-26**). The Farmhouse was built in the 1940s and acquired by GSFC thorough the purchase of the east side of the Greenbelt site from BARC. From about 1968 until 1996, the Farmhouse was used by the Art and Photography Club at GSFC. The Farmhouse was condemned in 1996 due to lead-based paint and structural and health issues that arose after a pipe leak. Waste from the Farmhouse was disposed of in a sink on the second floor which flowed to the ground. The septic tank associated with the Farmhouse emptied into a dry well with no drain field. Also, on site was an underground storage tank (UST) that was used to store heating oil.

Samples collected at the site revealed that there was no significant contamination from past activities. Surface soil samples revealed lead-contamination levels of 24,700 to 58,700 milligrams per kilogram (mg/kg). Because of the health threat posed by the lead, flood, and structural integrity, the building was demolished, and lead remediation activities were conducted.

4.6.2.2 Building 81: Former Pesticide Storage Area

Building 81 is located on the eastern side of the Greenbelt site and was used by FMD's grounds maintenance contractor for horticultural support (**Figure A-26**). A sink, located on the site, drained to surface soils in the wooded area behind the site. During an environmental inspection, it was noticed that plants appeared stressed and/or dead. It was thought that maybe some pesticides had been disposed of in the sink, which

exited on the soil behind the site. GSFC conducted an investigation in 1997 and it was found that there were no significant contamination levels. A letter was sent to MDE in 1997 detailing the findings.

4.6.2.3 Former Transformer Storage Area

A review of potential sources of contamination identified a former equipment storage yard, the location of which now includes the footprint of the Child Care Center. Initial investigations conducted in the late 1990s and in 2005 did not indicate the presence of contamination. Additional sampling was conducted in 2007. Results of this sampling event also did not indicate the presence of any contamination. Based on the results of these investigations, it has been concluded that there is no evidence of a release of contaminants from the former storage that has impacted subsurface soils on GSFC.

4.6.2.4 Pistol and Rifle Range

The Pistol and Rifle Range is located on the eastern side of the Greenbelt site and was used from the 1960s until about 1991 as a practice area for Gun Club members and the Security force (**Figure A-26)**. The Pistol Range is approximately 181 ft. by 41 ft. and the rifle range is approximately 600 ft. by 95 ft. A site investigation was conducted in 1997 to characterize the lead contamination in surface soil, subsurface soil, and sediment. The backstops, which are the earthen mounds that the bullets are fired into, exceeded the regulatory levels for lead contamination. Lead concentrations as high as 5,055 mg/kg and 447 mg/L were observed in the backstops. A decision to clean up the Pistol and Rifle Ranges was driven by a need to reduce worker exposure, facilitate future expansion, and minimize contaminant migration.

The remediation for the Pistol and Rifle Ranges was completed at the same time as the lead removal from the Farmhouse (**Section 4.6.2.1**). Stabilized soil at the Pistol and Rifle Ranges was screened to separate and recycle approximately 25 tons of material consisting of lead slugs/fragments and ballistic sand. Approximately 700 tons of stabilized soil was disposed of at an off-site landfill. Use of in-situ inactivation methodology eliminated the need for lengthy regulatory approvals and facilitated completion of the cleanup in approximately six months.

4.6.2.5 Area 400 Research Facility

A chemical leachfield at the Propulsion Research Facility, Area 400 (**Figure A-27**), was used since 1964 to drain laboratory sinks. A site investigation was conducted in 1997/1998 to determine the impacts from past activities at the site. Chemicals used at the site included isopropyl alcohol, hydrazine, and chloroform. Soil and groundwater samples revealed no contamination and no further action has been taken at this area.

4.6.2.6 Area 600 Backup Generator Release

A release of fuel oil from a former backup generator and day tank was discovered during a sitewide deconstruction in April 2016. An investigation began in September 2017 when samples were taken in accordance with applicable Federal and Maryland law, including the Maryland Environmental Assessment Technology program (MEAT); GSFC Construction Specifications; and Occupational Safety and Health Administration standards. In August 2018, GSFC implemented the Corrective Actions Plan Dated November 2017. The objectives of the plan were met, and the final closure report was submitted to the State in Septemebr 2018.

4.6.2.7 Building 24 Mercury Release Site

A temporary trailer was being set up near the northwest corner of building 24. On December 12, 2006, while preparing a footer for stairs into the trailer, what appeared to be elemental mercury was discovered on an exposed concrete footing of the building. The source of the mercury was believed to be mercury gauges associated with No. 6 fuel oil USTs which were situated on the west side of building 24, immediately south of where the stairs to an office trailer were being built. The mercury gauges associated with the tanks were connected to the control room of building 24. The tanks were removed in the late 1980s. It is believed

that the mercury observed was released from the gauges during the excavation of the tanks or is residue from re-fill procedures performed in the past.

Following detection of the released mercury, emergency response procedures were initiated. A mercury vacuum was used to capture the mercury and surrounding mercury impacted soil. A two foot by two-foot area was excavated to remove the mercury impacted soil and determine if additional mercury impacts were present. Field screening of excavated soils, using a mercury vapor analyzer, indicated readings ranging from 89 to 136 micrograms per cubic meter ($\mu g/m^3$). Soil was removed until field screening results indicated that the lower detection limit (0.003 $\mu g/m^3$) of the mercury vapor meter had been achieved. Subsequent to the emergency response procedures, confirmatory soil samples were collected from soil cores from the excavation area and submitted for fixed laboratory analysis of total mercury via USEPA Method 6020. Results indicated concentrations in excess the MDE Cleanup Standards for Residential and Non-Residential Soil (0.10 mg/kg and 0.12 mg/kg, respectively). It is also noteworthy that soil, excavated during the emergency response procedures exhibited a petroleum (fuel oil) odor.

Seven soil borings were made on September 21, 2007, in and surrounding the former mercury release area and former UST excavation area. One surface soil sample was collected, using a hand shovel, from the immediate area of the former release under the existing wooden stairs. No detectable concentrations of mercury were reported in soil samples from the borings. A concentration of 3.1 mg/kg mercury was reported in the surface soil sample collected from under the stairs. This concentration exceeds the current MDE Cleanup Standards for non-residential soil and groundwater.

Removal of the contaminated soil took place on September 28, 2008. Soil was removed until analysis indicated that the mercury contamination was below MDE Cleanup Standards for Non-Residential Soil. One location at the north end of the excavation area close to the building 24 foundation had mercury levels slightly higher than the MDE Cleanup Standards for Non-Residential Soil (0.155 mg/kg versus 0.120 mg/kg). This was at a depth of 43 inches and excavation was not considered safe beyond this point. There is a very small, estimated to be less than 5 cubic feet, amount of soil with contamination levels slightly above the MDE Cleanup Standards for Non-Residential Soil. This area presents minimal risk given the small volume of contaminated soil.

4.6.2.8 Building 27A Leachfield

On June 11, 1987, two GSFC employees from Code 205 (now known as the Code 250, MEMD) emptied maybe 10 or 15, 55-gallon barrels of water, possibly contaminated with oil, through oil absorbents. There was no smell from the drums. The absorbents were placed on a gravel area in the grass next to the edge of the asphalt parking area, north of the original section of building 27A. While the exact location of the gravel is not known, it was closer to building 27A than to the Explosives Storage Facility (building 27B) across the parking area to the north. This location where the drums were emptied is now under the eastern portion of the paved area immediately north of building 27A. This gravel area was known as the leachfield or leach pit. A Site Investigation was performed by Occu-Health, Incorporated in August 2001; no sampling was conducted as part of the effort.

Confirmatory sampling was conducted in August 2008 to document the presence or absence of contamination. A 20 by 40-foot grid was created at the location where the drums were emptied. The grid was broken down into 16 equal areas and the center of each area was designated as the sampling point for that area. Two samples were collected from each sample point, the first at the soil horizon (beneath approximately 8 inches of asphalt and 6 inches of aggregate base) and the second at a depth of 24 inches below the soil horizon. Visible contamination was noted at one sampling point. Sample analysis confirmed the presence of petroleum hydrocarbons at a concentration of between 5,700 and 14,000 mg/kg. The MDE has established residential and non-residential cleanup standards for Petroleum Hydrocarbons ((MDE). (2001)). These standards establish cleanup levels in non-residential areas of 620 mg/kg for both gasoline and diesel range organics (DRO).

On December 16, 2009, a removal action was conducted that excavated a 10- by 12-foot area to a depth of 3.5 feet centered over the sample location where the high level of petroleum hydrocarbons was found. Soil samples were collected from the excavated area. The excavated area was backfilled with clean fill and repaved. One of the soil samples collected did demonstrate DRO at levels greater than the MDE cleanup standards. However, a risk assessment concluded that no risk was present because exposure to workers or residents is unlikely because the area is covered with an asphalt cover and several feet of clean fill and the site is located in a fenced, secured, federal research facility. Furthermore, diesel-range organics have a propensity to adhere to organic matter and fine material (i.e., clay and silt) in the soil; therefore, total petroleum hydrocarbon TPH-DRO is not considered to be highly mobile in the subsurface. Groundwater is not expected to be impacted due to the generally immobile characteristics of TPH-DRO and the depth to groundwater (25-30 ft.) expected at the site.

4.6.2.9 Sitewide Arsenic Study

Soil sampling of the small sediment pond and sandbar was conducted in July 2007 prior to a planned dredging project. The purpose of this sampling was to determine whether the soil would need to be transported as waste or fill upon dredging. Sampling analysis revealed arsenic levels above the MDE cleanup standards for residential and non-residential soil. According to MDE cleanup guidelines; the residential cleanup standard is 4.3 mg/kg, and the non-residential cleanup standard is 1.9 mg/kg. A review of the literature suggested that the arsenic levels found were consistent with expected background for this area. A project was undertaken to determine if the background levels of arsenic are consistent with background levels historically documented in surrounding geographical areas and that the arsenic levels found in the sediment pond were within the expected range.

GSFC was divided into 30 grid points. Grid points were classified into two groups; developed, and undeveloped. Developed grid points refer to locations where the ground has been disturbed due to construction activities, and areas that had been converted to turf grass. Undeveloped grid points refer to locations where natural vegetation occurs. Undeveloped grid points lie in forested areas with natural leaf litter and deciduous tree cover. Samples were taken as close as possible to the center of each grid.

Results were higher than average background levels of arsenic in the surrounding soils of Prince George's County, Maryland. However, results were not higher than expected considering increases in arsenic concentrations near outcrop areas. According to MDE's Facts on Arsenic, the higher levels at GSFC can be attributed to the Patuxent Formation outcropping near GSFC. As previously noted, arsenic concentrations near outcrop areas in Prince George's County have been recorded between 10-25 mg/kg. Based on these results and surrounding Prince George's County geology, there is no perceived increased risk to human or environmental health because the total arsenic is not at concentrations above adjacent Prince George's County background levels.

4.6.2.10 Biodiesel AST

A release of biodiesel fuel oil from the former AST was discovered during its removal in September 2011. The release occurred in the underground feed line running from the AST to the fueling pump. In accordance with MDE guidance and the GSFC MEMD, four soil samples were collected, and laboratory analyzed to identify potential contamination. Based on the sample analysis and visual observations of soil staining and oil odor, soil was excavated from the affected area and disposed of at a permitted offsite disposal facility.

Additional investigation activities were conducted in April 2012 in accordance with applicable Federal and Maryland law, including the MEAT; GSFC Construction Specifications; and Occupational Safety and Health Administration standards. The purpose of the additional investigation was to verify that there was no contamination remaining at levels greater than the MDE non-residential cleanup standards for soil of 230 mg/kg. No concentrations of TPH-DRO were detected above the applicable Cleanup Standard for Residential Soil.

4.7 Radioactive Materials and Non-Ionizing Radiation

Radiation is energy and can take the form of waves or particles. Depending on the amount of energy present, radiation can penetrate many materials. Radiation, in the form of waves, is referred to as electromagnetic radiation. Electromagnetic radiation consists of individual packets of energy, called photons, whose wavelength is inversely related to the amount of energy in the photon. The electromagnetic spectrum can be classified into the categories of ionizing and non-ionizing depending upon the amount of energy present. In order to be classified as ionizing radiation, the radiation must have sufficient energy to affect the structure of atoms, usually by knocking electrons out of the orbital cloud thus "ionizing" the atom. X-rays and higher energy portions of the electromagnetic spectrum fall into the ionizing radiation category because the individual photons have sufficient energy to cause ionization. Non-ionizing radiation encompasses the rest of the electromagnetic spectrum. This includes radio waves, infrared, visible light, and ultraviolet light. Ionizing radiation also includes particulate forms of radiation such as beta particles (fast moving free electrons), alpha particles (relatively energetic helium nuclei), and neutrons (energetic particles with a neutral electrical charge with a weight similar to that of a proton).

4.7.1 Ionizing Radiation

Sources of ionizing radiation include naturally-occurring and manmade radioactive materials and various manmade devices. The major source of radioactive materials is byproducts of fission reactors. Activities involving byproduct radioactive material are strictly controlled by the Nuclear Regulatory Commission (NRC) through regulations that are in 10 CFR Parts 19, 20, 30 and 35, the U.S. Department of Transportation (49 CFR Part 171), and the USEPA (40 CFR Part 60).

GSFC uses radioactive sources for the testing and calibration of instrumentation used on space missions. Due to the nature of the instrumentation, radioactive sources used for testing and calibration are typically very low in activity.

GSFC is permitted by the NRC to use and store radioactive and radioactive contaminated materials under NRC license 19-05748-02. This is a Type A Broadscope License. NRC issues these licenses to facilities that have comprehensive radiological protection programs. The license sets limits on the overall quantity of radioactive material, and the quantity of individual radionuclides that may be held at any one time. Possessors of Type A Broadscope licenses are required to have a strong, systematic management program including a Radiation Safety Officer and a Ionizing Radiation Safety Committee to ensure that day-to-day operations are conducted in a safe and sound manner. The current license expires in 2021. GSFC has a second NRC license (19-05748-03), which authorizes GSFC to store and operate two irradiator units. The units are used for studies of radiation effects on spacecraft and spacecraft components.

In addition to possessing a number of generally licensed radioactive materials that are naturally occurring or accelerator generated, GSFC has several electric power-driven ionizing radiation devices that are licensed. They are used for testing and integration of spacecraft hardware. Several pieces of equipment generating X-ray are housed in various buildings around the west portion of the Greenbelt site. These machines are used for research purposes and for testing or examination of spacecraft components for internal hidden flaws.

GSFC generally possesses only a small fraction of the quantity of radioactive material allowed by the Type A Broadscope License at any one time. A small amount of low-level radioactive waste is generated every five years. This waste is shipped off site for disposal.

4.7.2 Non-Ionizing Radiation

The sources of non-ionizing radiation of concern, from an environmental and human health standpoint, are manmade sources such as radio transmitters, radars, microwave transmitters, and lasers. GSFC has several radio/microwave frequency devices which emit sufficient power to present a potential environmental or human health hazard. Procedures have been established that require all devices capable of transmitting

radio frequencies be evaluated, using American National Standards Institute (ANSI) Standard C95.2 and Institute of Electrical and Electronics Engineers C95.1, to ensure that they do not present a hazard. The majority of the devices that fall into the hazard category are satellite uplinks capable of transmitting high powered radio/microwave frequency beams. The evaluation process includes a determination of the distance at which the beam is considered to be no longer hazardous. All such devices are operated with strict controls to ensure that risks are managed to acceptable levels.

Lasers are another category of devices that emit non-ionizing radiation. Lasers are categorized into hazard classes using the ANSI Z-136.1 standard. The ANSI standard is a consensus standard adopted by U.S. regulatory agencies. GSFC has more than 300 lasers that fall into Classes 3B and 4. The lasers are used for a variety of research and other purposes including satellite tracking, illumination, and the precise measurement of distances. The use of lasers in Classes 3B and 4 is controlled and must follow strict safety procedures. Some of the lasers are used outdoors, such as when used to track or illuminate a satellite. Safety procedures include practices, as defined in ANSI Z-136.6, to ensure that aircraft illumination does not take place and that there is no generation of specular or diffuse reflections which could endanger the public.

4.8 Noise

Maryland has established standards as goals for noise levels as measured at property lines abutting the property with the noise source. **Table B-26** summarizes Maryland noise standards and maximum allowable noise levels for industrial, commercial, and residential zoning districts (land uses). The Maryland maximum allowable noise levels for construction and demolition activities are 90 A-weighted decibel (dBA) during daytime hours. Development at GSFC is surrounded by a perimeter buffer, which is primarily forested. GSFC operations are conducted indoors and produce negligible exterior noise levels.

Because many laboratory, testing, and communications functions are extremely sensitive to noise and vibrations, GSFC ensures that all activities which may generate noise and vibration are properly controlled. The shortest distance between any GSFC building (building 33) and an outside residence is about 300 feet. The most significant noise generators on GSFC are the generators located in the Central Heating and Refrigeration Plant and the East Heating and Refrigeration Plant. Both buildings are more than 1,400 feet from the nearest outside residence. Additionally, these buildings were designed to control noise transmission outside of the buildings, because of their proximity to laboratories and offices. Furthermore, GSFC is separated from the residential area by Maryland Highway 193, a major thoroughfare, with its accompanying traffic noise.

4.9 Transportation

4.9.1 GSFC Access

GSFC is a security-controlled facility, and with the exception of two tracts on the eastern portion of the Greenbelt site, it has fencing around the perimeter of each subarea. Interior site fencing further isolates some comparatively small areas. Areas 100 through 400 each have one or more unnumbered access gates on their perimeters.

There are multiple gates along the boundaries of the Greenbelt site, but only four are open for normal workday access. Employees may enter and leave the site through the Main Gate on Greenbelt Road, the Parkway Gate from the Baltimore-Washington Parkway, the South Gate (on IceSat Road) or the North Gate (on Hubble Road across from building 27). All of these gates provide general site egress and have individual security checkpoints. The Main Gate is open at all times; the Parkway and North Gates open at 6:00 am and close at 7:00 pm on work days, and the South Gate has modified working hours during morning and afternoon peak hours. All other gates are normally locked and used for emergencies only.

All visitors to secure areas must obtain passes in building 9 at the Main Gate before site entry. The Visitor Center which is in the southeast corner of the western side of the Greenbelt site is outside the security perimeter and accessible to the general public during operating hours. Visitors reach the Visitor Center via ICESat Road off of Greenbelt Road.

4.9.2 Parking

GSFC currently has an estimated 8,000 spaces on the Greenbelt site as determined from an aerial survey included in the NASA Goddard Transportation Management Plan (GSFC. (2016)). Parking for the employees in Areas 100 through 400 is generally informal and there are none or few delineated spaces. Assignment of space type was determined by ground level verification or by deducting non-employee spaces from a lot where dual parking functions occur (e.g., Visitor Center spaces).

Although GSFC does not have a general employee parking sticker or permit program, many of the site spaces are available to employees. There are approximately 8,000 general employee spaces with the remaining 900 set aside for special or site visitor use. Employees may be ticketed if they park in these latter two areas. Many of the employee spaces are now covered by trailers housing personnel that cannot be accommodated in adjacent buildings. Handicapped (approximately 200) and reserved (approximately 150) parking spaces are included in the general employee total. Rear view mirror tags are issued for handicapped spaces or those reserved for persons with disabilities. Reserved spaces are those set aside for high ranking administrative and technical personnel whose jobs require immediate space availability throughout the work day.

The current GSFC employee parking space per employee ratio is estimated to be 8,000/8,740 or 0.90. About 80 percent of the site facilities and parking, which include all but a few facilities on the west side of the Greenbelt site, was built in the 1960's. The area was rural at that time, except for the City of Greenbelt and the crossroad community of Glenn Dale. Transportation demand management was unneeded, and parking was installed at a one to one space per employee ratio. More recent projects such as building 33, 34, and 35 on the east side of the Greenbelt site have been constructed with lower ratios. As a result, the west side of the Greenbelt site has a one to one space per employee ratio, while the east side ratio is nearer 0.9.

The general standard for parking at federal facilities in the Washington suburbs where no Metro subway stations are present is two spaces for every three employees, which is equivalent to a 0.67 ratio ((NCP) (1989)). Parking for agency visitors, government vehicles, loading, security, and emergency vehicles, and other special uses is not included in the computation.

GSFC recognizes the 0.67 standard as a long-term goal. Practical constraints beyond GSFC's control preclude achieving this goal in the short term and will make it difficult to do so in the future. Taking all the factors into consideration, GSFC believes that a 0.70 parking space per employee ratio is an achievable long-term goal..

4.9.3 Mass Transit

GSFC is on the extreme periphery of the regional transit system. Transit service at GSFC is limited to two general bus routes, the Greenbelt line (Routes G13, G14, G16) operated by the Washington Metropolitan Area Transit Authority ([WMATA]; http://www.wmata.com/bus/timetables/MD/G12-16.pdf), and the Prince George's County "The Bus" Route No. 15 Express (http://www.princegeorgescountymd.gov/Government/AgencyIndex/DPW&T/Transit/wRt15X.pdf).

The Greenbelt line shuttles between the Greenbelt and New Carrollton WMATA Metro stations, which are located about 3 miles to the west and south of GSFC respectively. The Greenbelt station is the terminus for the Metro Green line and is a station on the MARC Camden line between Baltimore and Washington. New Carrollton is the terminal station for the Metro Orange line and a stop on the MARC Penn railroad line.

The WMATA Greenbelt bus line (Routes G13, G14, and G16) operates from 5:30 am to 10:30 pm on weekdays. Service intervals are every half hour from 5:30 am to 9:00 am and from 4:00 pm to 7:00 pm and one hour at other times. Routing is not direct to either metro station. Because GSFC is a controlled facility, the bus routes do not transit the Greenbelt site. One stop at the Main Gate services GSFC.

The County bus ("*TheBus*" Route 15X) provides exclusive service to GSFC to and from both the New Carrollton and Greenbelt Stations. This route operates seven times from each station during the morning and seven times to each station during the evening rush hours. Transit time on the express bus ranges from 15 to 20 minutes. Two stops, at the Visitors Center and at the Main Gate, service GSFC.

4.9.4 Transportation Demand Management

Transportation Demand Management measures that reduce single occupancy vehicle use have limited potential at GSFC. The majority of employees live to the north and east of GSFC beyond the limits of the Washington regional network or in the interstitial areas between major transit corridors. The highest concentrations of GSFC employee residences occur in and around Laurel, Bowie, Crofton, and more closely, Greenbelt and Lanham. Other significant concentrations of 120 employee residences or more per zip code occur around Annapolis, Anne Arundel County, and in the US Route 29 corridor from Silver Spring through Burtonsville to Columbia in Howard County. The number of employees who live in the City of Baltimore and its northern and eastern suburbs is similar to those who live within Washington, D.C.

Transit service and its growth potential are limited by GSFC's location and surroundings. There is no commercial or residential development to the north and northeast of GSFC. These areas are occupied by the research fields and farms of BARC, and the woodlands of the PWRC. The former extends for miles to the Patuxent River and County boundary, the latter beyond into Howard County. The virtual zero development density will remain in the foreseeable future. In effect, these open areas halve the potential overall ridership demand of any transit route in the vicinity of GSFC. Therefore, GSFC will always be on the outer fringe of the Washington regional transit network.

Periodic surveys are conducted on employee commuting patterns, modal choice for trips, and parking utilization. GSFC has been running a free internal site shuttle service since November 2000. GSFC has a Bike Share Program for employee use on Center, and showers are available in several facilities and a fleet of cars, minivans, and vans is maintained for official business travel within the region.

GSFC employee support facilities further reduce the need for off Center travel during the day. These include the Goddard Child Development Center, two cafeterias and snack bars, two small convenience shops, the NASA Federal Credit Union, GSFC fitness center and health unit, and GEWA recreational, cultural, and social club facilities.

GSFC has prepared an enhanced Transportaiton Management Plan (TMP) as a part of the current Facilities Master Plan (2018 FMP) that details conditions, goals, and strategies for further Transportation Demand Management. Measures given in the TMP will apply to both GSFC and Partnering and Outreach Zone employees.

The Transportation Management Plan has set the following goals:

- Minimize the percentage of employees who commute to and from the Center in single occupant vehicles (e.g., by maximizing use of the alternative modes such as high occupancy vehicles, ridesharing, transit, bicycling, and pedestrian)
- Reduce onsite parking to two spaces per three employees or 0.67 ratio as indicated in the National Capitol Planning Commission federal facility guidelines for sites outside the Beltway
- Enhance the quality of work life for employees to help the Center attract and retain a workforce that best meets mission commitments

The 2016 TMP surveyed employees to assess the goals listed above. The results of the survey indicated that 37% of respondents are able to telecommute at least one day per week, however only 0.4% of employees regularly telecommute three or more days per week. Employees indicated that they were very interested in telecommuting but did not have the support or equipment to succeed. Establishing methods to encourage and support telecommuters would decrease the number of trips made to/from the campus, thereby reducing the strain of commuting on campus and local roads. Increasing telecommuting would also decrease the parking demand on campus.

Establishing a variable work schedule for employees by staggering start times would also impact the transportation network. Commute trips for employees would be shifted to cover a period of two or three hours in the mornings/evenings, which would decrease roadway congestion at the campus entrance gates and on surrounding roadways.

- Greenbelt Implementation Goal: Work Remotely
  - 2016 (existing) 0.4%
  - 2018 objective 0.5%
  - 2020 objective 1.0%
  - 2025 objective 2.0%
  - 2032 objective 4.0%

4.10 Socioeconomic Environment

4.10.1 Population, Employment, and Economic Trends

4.10.1.1 Population

Prince George's County is located in the Washington metropolitan region. The estimated population in 2017 was 912,756. This was an increase of 5.7 percent from the 2010 census total of 863,420. It is estimated that by 2020 there will be 916,150 people in Prince George's County. The 2020 population estimate for Maryland is 6,141,900. Prince George's County also has a diverse population. In 2017, the estimated population in Prince George's County was 16 percent White, 63 percent Black or African American, 4 percent Asian, 14 percent some other race, and 3 percent two or more races. Approximately19 percent of the population identified as being of Hispanic. Current population by race and ethnicity is presented in **Table B-27**. Statistics on household composition in the County are presented in **Table B-28**.

The educational attainment for county residents as of 2017 indicates that over 88 percent of county residents are high school graduates and 34 percent have a bachelor's degree or higher.

4.10.1.2 Employment

Prince George County is known for its economic and technical stability. Labor statistics including labor force, employment, and unemployment rates for Prince George's County are presented in **Table B-29**. The county has a labor force of 524,032 individuals and an unemployment rate of 5.3%. The unemployment rate has decreased in each year between 2013 and 2017.

4.10.1.3 GSFC-Greenbelt Site

As of January 2018, there were about 2,840 civil servants at the GSFC Greenbelt campus. The actual number of employees varies each day and is primarily dependent on current contracts and projects. **Table B-31** presents the population counts for GSFC employees at the Greenbelt site. More than 90 percent of Greenbelt site employees work on a Monday through Friday, 8 am to 4:30 pm schedule. The remaining workers operate on a schedule of three 8-hour shifts. Demographic data about contractors is not available. **Figure A-29** provides a snapshot of the GSFC's civil servants skill distribution and the ethnic diversity of civil servants at GSFC.

4.10.1.4 Economic Trends

Trends in income statistics for Prince George's County are detailed in **Table B-32**. Prince George's County Per Capita Income was $35,947 in 2017. Prince George's County median household income at $81,240 in 2017.

The top ten largest employers in the county are the University of Maryland System (18,726 employees), Andrews Air Force Base (17,500 employees), U.S. Internal Revenue Service (5,539 employees), U.S. Census Bureau (4,414 employees), United Parcel Service (4,220 employees), GSFC (3,397 employees), Giant Food (3,000 employees), Prince George's Community College (2,785 employees), Verizon (2,738 employees), and Dimensions Health (2,500 employees).

The largest portion of GSFC's budget is obligated through contracts with commercial firms, nonprofit institutions and other government agencies. These contracts allow GSFC to acquire the goods and services necessary to accomplish its mission parameters and objectives. These dollars are then returned to the local, state and national economy in the form of gross output, sales, the purchase of intermediate goods and services, and employee income. Details of the 2017 GSFC budget are available in **Figure A-29**.

4.10.2 Environmental Justice

GSFC has an Environmental Justice Implementation Plan (EJIP) to comply with EO 12898. The original EJIP was drafted in 1996 and amended to include threshold values using 2000 census data (the thresholds in the EJIP of 1996 used 1990 census data). The EJIP was updated in 2013 based on data from the 2010 census. A determination that no impacts to neighboring minority or low-income populations of EJ impacts is made after an analysis of census tracks around GSFC. The most recent EJ determination was made in the EJIP 2013 that GSFC is not impacting neighboring minority and low-income populations.

4.10.3 Safety and Health

GSFC has an established Safety and Occupation Health Program. Safety and occupational health encompass planning, development, and management of policies and procedures for the protection of personnel, property, and the public from hazards generated by processes and operations at Goddard. The Safety Program addresses institutional safety versus system safety. Elements of the Safety Program include:

- Occupational Safety
- Mishaps Prevention
- Construction Safety
- Contractor/Procurement Safety
- Cryogenic Safety
- Fire Protection
- Safety Training and Awareness

Elements of the Occupational Health Program include:

- Ionizing and non-ionizing radiation safety covering sources and uses of ionizing (source material and x-rays) and non-ionizing radiation (lasers, radio frequency, Ultra-violet/High Intensity Light) are conducted according to policies and procedures
- Industrial Hygiene providing for workplace surveys, indoor air quality reviews, ergonomics evaluations and asbestos program oversight
- Chemical Safety to provide for the safe use of chemicals and assist in Process Hazard Analysis

GSFC relies on medical emergency and fire protection services from the Prince George's County Fire Department. GSFC has its own health unit operating during normal working hours to provide first aid and

immediate assistance to civil servants in emergency situations. The Security force also has trained Emergency Medical Technicians that can provide basic life support functions.

4.10.4 Tourism and Recreational Opportunities

Maryland and Prince George's County enjoy a healthy level of tourism and receive a large amount of money from this industry. According to the Prince George's County Conference and Visitors Bureau, the County had an estimated 7,702,500 visitors in 2017.

The Goddard Visitor Center ranks among the top attractions to see in Prince George's County. In 2016, the Visitor's Center celebrated its 40th Anniversary. The Goddard Visitor Center features special programming, including the annual Goddard Model Rocket Contest and Science on a Sphere (movies projected on a sphere). The visitor center continues to evolve to enhance its services to the public and community. The strategy shifts the facility from serving as a traditional visitor center toward serving as a science exploration and education center, showcasing NASA's work and accomplishments in a Goddard context and better meeting NASA's educational objectives. Almost 40,000 people pass through the Visitor Center each year. Its mission is to inspire, engage, and educate people leveraging on GSFC's endeavors in Earth and Space exploration.

4.11 Goddard Master Plan

Sustainability is an integral part of the GSFC Center Master Plan. The GSFC 2010 Master Plan is in the process of being updated to reflect scheduled projects and future plans. The update (not yet published) ensures that buildings and infrastructure are managed in an environmentally sustainable manner through comprehensive approaches to reducing energy consumption and dependence on non-renewable resources. Initiatives presented in the plan include:

- Enhancing suitability and flexibility of existing buildings to increase usage efficiency
- Consolidation of new development and enhancing existing pedestrian areas and greenspaces, to promote collaboration, walking and bicycling between buildings, and reduce required vehicle fleet size and on-center fuel consumption
- Ensuring new construction and major renovations meet or exceed federal guidelines for sustainable building design
- Prioritizing deconstruction and recycling of associated materials for any removed buildings.

4.12 Sustainability

With its unique perspective as a global leader in Earth and Atmospheric Science, Goddard strives to increase resiliency of our missions through sustainable practices, reaching for continued human progress, productivity, and prosperity, without compromising our natural resources for future generations. GSFC employs a strategic sustainability planning process in its mission support activities to address potential threats to the NASA mission from foreseeable changes in the social, financial and physical environment Goddard operates within. Specifically, Goddard emphasizes planning for a changing climate, the use of life-cycle analysis in procurement, maintenance and construction decision-making, reducing consumption of non-renewable resources, and minimizing the release of harmful waste, pollution and emissions. NASA policy directive 8820.2 requires GSFC to incorporate sustainable design principles and procedure requirements into new facility construction and major renovation projects. These requirements are evident in the current GSFC Master Plan. Additionally, the Facilities Maintenance Division is actively developing sustainable procedures for all of its roles and activities. Furthermore, in accordance with EO 13834, "Efficient Federal Operations," the Center's Sustainability and Energy Management Programs promote stewardship of resources through innovative design, procurement of sustainable, energy-efficient products, and efficient facility management practices.

4.12.1 Sustainability Program

NASA's annual Strategic Sustainability Performance Plan (SSPP), (now to be replaced by the annual Sustainability Report), and the Goddard Sustainability Plan are visionary plans for restoring the center's ecological functions, along with minimizing or eliminating impacts of NASA operations to the environmental systems that support us. The plans strive to reduce energy intensity, increase the use of clean and renewable energy sources and pollution prevention, and consider climate adaptation. Innovative storm water management and sustainable landscaping practices will reduce urban heat islands, maintenance costs and stormwater runoff, demonstrating a culture of environmental stewardship. NASA GSFC's Sustainability Plan recommends locations to install bioretention cells, tree plantations, and meadows.

4.12.1.1 Environmental

Stormwater Management – Goddard applies the use of low impact development techniques and seeks to repair stormwater conveyances and retention ponds, to restore pre-development hydrological function and reduce run-off contaminants entering the Chesapeake Bay watershed. The bioretention area and rain garden at building 32, and swales surrounding building 36 serve to retain, filter and infiltrate storm water, reducing runoff volume and pollution.

Tree Plantings – Plantings at buildings 8, 37 and 23, the Visitor Center and the employee gate area serve to reduce urban heat island effects and increase stormwater infiltration.

Alternative Landscape Management – Goddard promotes "no mow" areas on campus and seeks opportunities to replace actively maintained areas with open meadows. Likewise, trees have been planted in large lawn areas where meadows are not feasible. This can be observed in the lawn area near the parking lot between buildings 37 and 23, as well as to the north and east of building 8. Reduced mowing reduces air emissions and fuel consumption associated with mowing activities, and meadow grasses reduce invasive species and increase storm water infiltration and evaporative site cooling.

As a demonstration of more sustainable, ecological landscapes, a 0.1-acre meadow was added near the entrance of building 33. This project was initiated in 2016 in partnership with the University of Maryland Extension Service to create pollinator habitat by using native grass and wildflower meadow species.

4.12.1.2 Energy and Water Management and Renewable and Clean Energy

Responsible management of energy, water and waste are an essential component of the Center's sustainability goals. The energy program outlines goals for optimizing energy use and management of resources including:

- Reduce energy consumption per square foot of building floor area 2.5% annually through FY2025 compared to FY2015 baseline
- Reduce potable water consumption per square foot of building floor area 2% annually through 2025 compared to FY2007 baseline
- Increase renewable energy use by 30% and clean energy use by 25% by FY2025 compared to the FY2015 baseline

4.12.1.2.1 Energy Intensity Reduction and Conservation

Comprehensive Energy Audit (identifying actionable energy efficiency measures) - An ASHRAE level-2 comprehensive building energy audit was completed for the entire GSFC-Greenbelt facility in FY15. This project identified potential energy conservation measures (ECMs) across the Center. The ECMs that offer the most benefit to the Center will be investigated further with Investment Grade Audits (IGA). Final ECMs selected from that effort will be formulated into energy reduction projects and presented to Center leadership for approval and funding.

Power Plant Optimization Project – This ongoing FY15 Utility Energy Service Contract (UESC) project improves the existing equipment controls, energy performance, and the mechanical infrastructure within the facilities plant.

Combined Heat and Power (CHP) Project–This concept project is being evaluated as a potential option to replace the aging heat and power plant (building 24). It is proposed that a CHP would give GSFC-Greenbelt the ability to generate its own electricity by utilizing landfill gas and heat recovered from boiler operations as a renewable energy source, reducing Goddard's utility costs and increasing energy resiliency.

Energy Management Control System (EMCS) Upgrade Project – This ongoing FY16 funded CoF Energy project will result in the removal of an obsolete control system and replace it with an upgraded more efficient system. This new system will allow the full utilization of the functionality and capabilities of the EMCS. This upgrade will cost $6M and is projected to save roughly $1 million/year.

Energy Savings Performance Contracting (ESPC) and UESC - GSFC uses ESPCs and UESCs to upgrade to more energy efficient equipment Center-wide. ESPCs/UESCs employ a third party to install energy saving technology, which is paid for over time by a portion of the profit gained through energy cost savings that result from the higher efficiency of the equipment installed. ESPC/UESC projects have been performed in approximately 32 buildings at GSFC Greenbelt. ESPC projects include decentralizing boilers, replacing lighting fixtures, improving the efficiency of the heating, ventilation, and air conditioning (HVAC) systems, insulating piping in the heating/refrigeration plant, and installing an energy recovery system in the building 5 plating shop.

4.12.1.2.2 Alternative Energy

Alternative energy systems at Goddard:

Geothermal HVAC System in Network Testing and Training Facility (building 25) – This system takes advantage of near-constant soil temperatures deep in the ground to provide up to 2.6 million BTUH of heating in the winter, and 280 tons (3.4 million BTUH) of cooling in the summer; approximately enough heating and cooling for 90 homes.

Burning Landfill Gas in Boilers – GSFC uses methane gas that is naturally generated by a nearby landfill to heat 33 of the buildings on Center. Doing so reduces annual CO_2 emissions equivalent to 35,000 cars. By using landfill gas instead of traditional natural gas, GSFC has saved the taxpayers more than $20 million since 2003 in fuel costs.

4.12.1.2.3 Potable Water Conservation

Over the past 5 years, FMD replaced approximately 700 3-gallon-per-minute faucets with 1.5- gpm sensor-operated faucets. Each faucet saves approximately $105/year. Toilets and urinals on Center were retrofitted with low-flow devices, which result in similar savings.

Additionally, GSFC uses on-site well water to replace water lost to evaporation in HVAC boilers and cooling towers. The benefit of using locally sourced water for industrial purposes is the reduction in energy and municipal drinking water usage: it eliminates the need for power to pump water through a municipal drinking water system; the need of treating water to a potable standard; and eliminates the municipal water cost. In 2017, the Center used an average of 223,228 gallons per day of well-sourced water, saving the equivalent of municipal potable water used in the HVAC equipment.

4.12.1.3 Employee Nutrition and Food System Sustainability

GSFC has fully implemented the General Services Administration Food Service Sustainability Guidelines at all center cafeterias. These guidelines serve to enhance the nutritional value of food served to NASA employees. They support food production systems that protect natural resources, are socially just and accessible, and support the development of local communities and economies.

4.12.1.4 Waste Management

To encourage reuse of surplus office supplies, GSFC implemented Freecycle@NASA, an online community that allows employees across the Agency to exchange under-utilized office items. This program allows employees to both offer or request items, saving NASA money on purchases and reducing waste sent to the landfill.

GSFC has instituted a HMMS that promotes the redistribution of surplus chemicals from projects with extra supplies to projects needing the same chemicals. This initiative reduces waste and storage of hazardous materials used at GSFC. In addition to the waste diversion benefits of the HMMS, the system enables the MEMD to identify environmentally benign alternatives for hazardous materials commonly used on Center. For example, solvent-based parts washers across GSFC were substituted with an aqueous based cleaner.

GSFC has also implemented single-stream recycling to increase recycling of waste generated on Center. A single-stream system increases participation by individual waste generators due to reduced sorting requirements and decreases on site management costs associated with collecting multiple streams of recyclables.

The Procurement Operations Division at GSFC is actively promoting preferential purchases of energy-efficient, water-efficient, bio-based, environmentally preferable, non-ozone depleting, recycled content containing, and non-toxic or less toxic products where available to meet mission and facilities operation needs. Purchase of such environmentally preferable products is promoted through standards governing direct product or service procurement by GSFC, delivery under contract, or product and service use by a contractor.

4.12.1.5 Employee Education

MEMD promotes education through outreach to Center employees using a verity of platforms. Quarterly Environmental Bulletins are available on the MEMD website, through links found on the Center's internal news webpage and are distributed via e-mail quarterly. MEMD also hosts several "Lunch and Learn" sessions on a verity of environmental topics ranging from storm water pollution prevention to conservation and sustainability. The goals for outreach are to improve awareness and make employees more conscious of their actions and how they impact the environment at work and home.

4.12.1.6 Regional Outreach

As a significant landholder in the Baltimore-Washington Region, GSFC is a dominant player in regional ecosystems. To participate in regional ecosystem management, GSFC participates in the Baltimore Washington Partners for Forest Stewardship.

Additionally, GSFC demonstrates its participation in regional environmental initiatives through the Maryland Green Registry, an association of facility managers in Maryland committed to enhancing the environmental sustainability of their facilities.

4.12.1.7 Climate Change Adaptation

Science teams aligned with the Goddard-led Mid-Atlantic Coastal Resilience Institute are providing scientific analysis and tools to understand and mitigate future storm and sea-level rise impacts in the greater Mid-Atlantic region. Goddard has partnered with the Naval Research Lab, Virginia Institute of Marine Science, University of Delaware, and Randolph-Macon College to deploy a host of technologies to study the eastern coastline from air, land, and sea. The results of these studies will foster a better understanding of the physical processes occurring in the region, therefore informing future resilience planning.

4.12.1.8 Sustainable Buildings

GSFC's newest building, the FPB (building 36), is LEED Gold Accredited demonstrating the facility's high performance in sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality. The 120,000-square-foot building includes space for approximately 330 research scientists, engineers, and administrative personnel.

The accreditation of this building marks the continuing commitment by NASA to pursue LEED certification in all new construction and substantial renovation projects.

4.12.1.9 Alternative Fuel Vehicles

GSFC currently operates an ethanol vehicle fuel pump (E-85) for NASA fleet use. Additionally, GSFC fleet management preferentially purchases alternative fuel and hybrid vehicles where applicable for government vehicles and use of low emissions vehicles are specified in service contracts on Center. Goddard also uses two electric cars and is planning to construct additional electric vehicle charging stations to support more electric vehicles throughout the campus.

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Appendices

Appendix A **– Figures**

Appendix B **– Tables**

Appendix C **– Rare, Threatened, and Endangered Species**

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Appendix A
Figures

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Figure A-1. GSFC Location Map – Metro Area

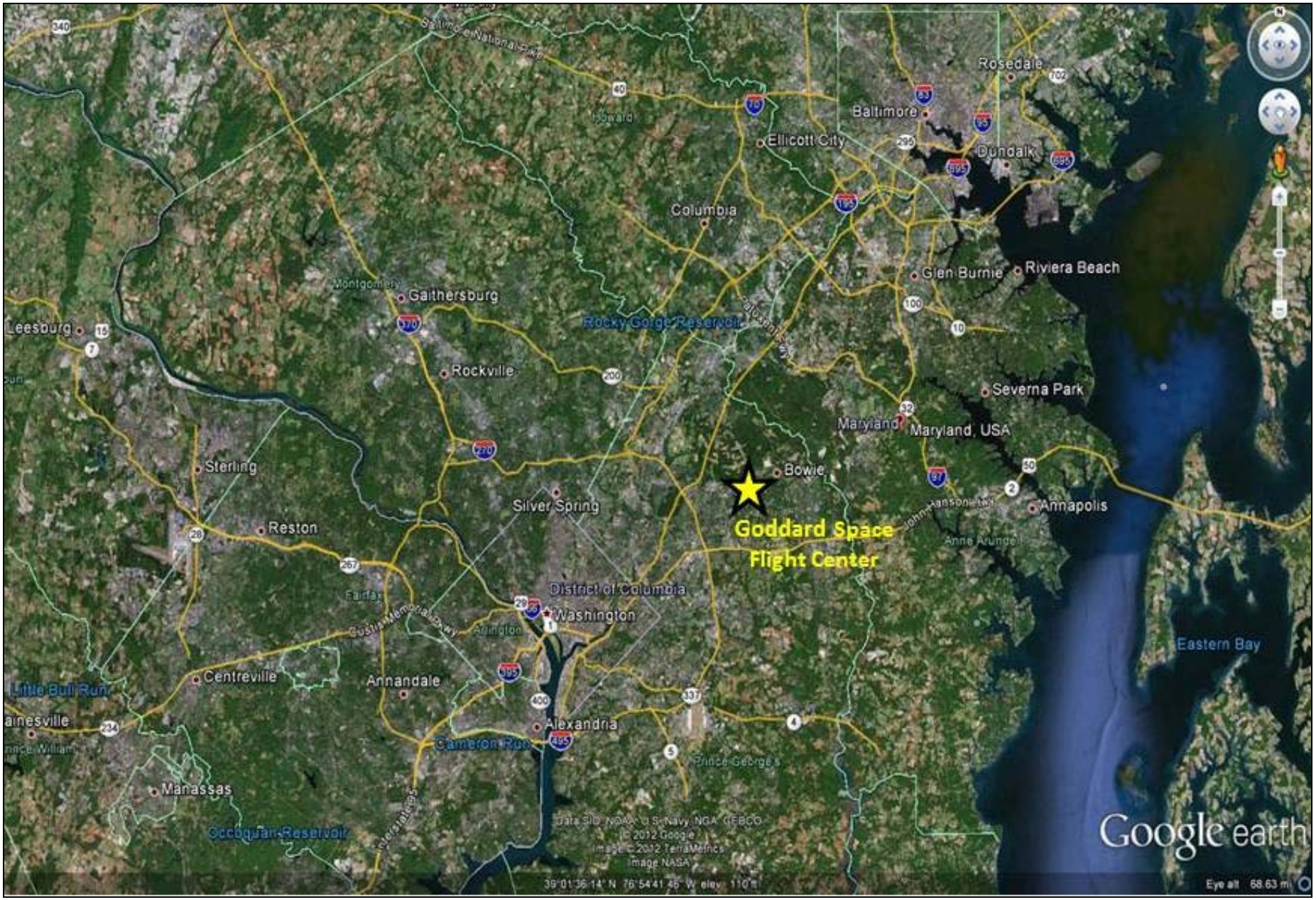


Figure A-2. GSFC Location Map – Local Area

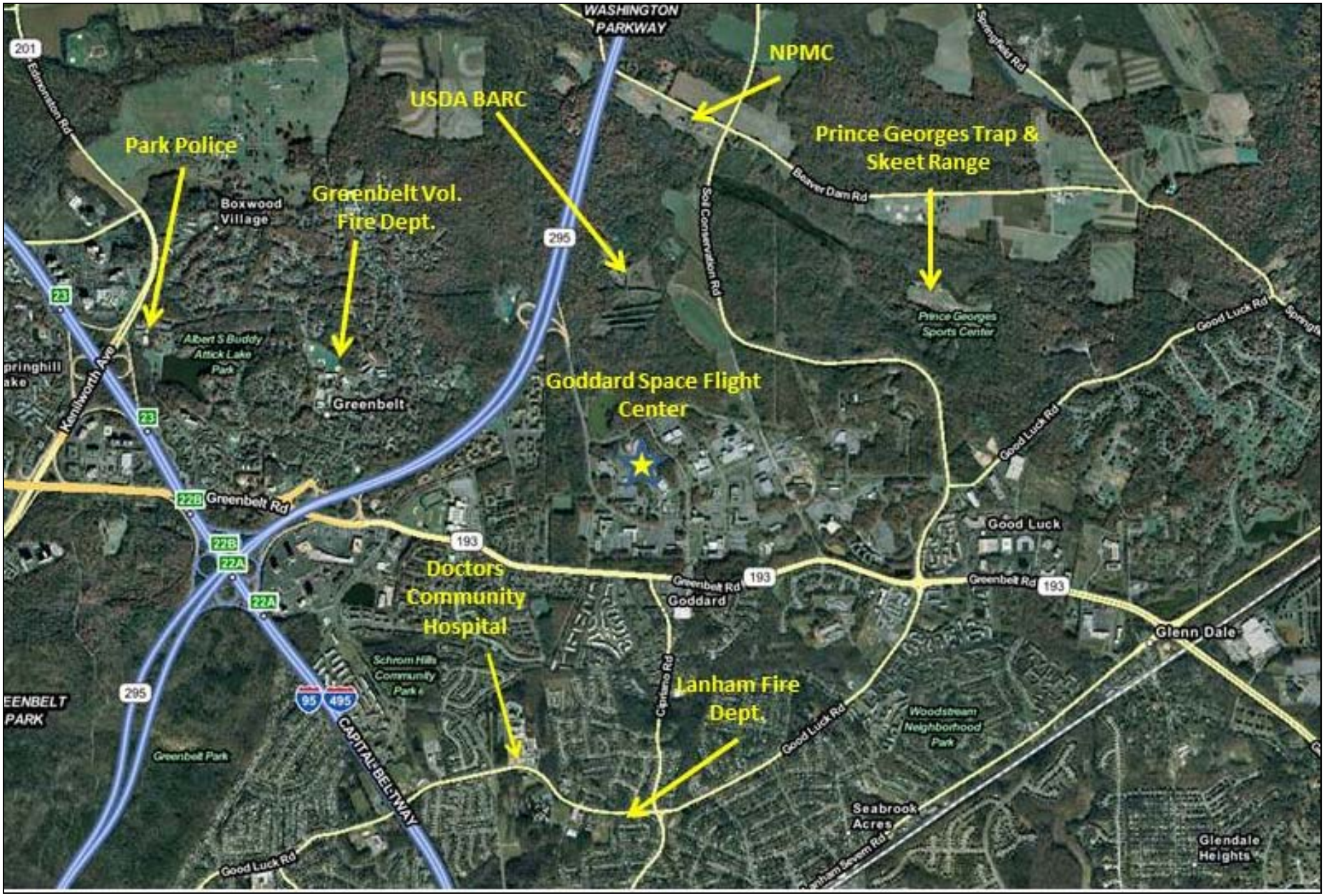


Figure A-3. GSFC Greenbelt Site

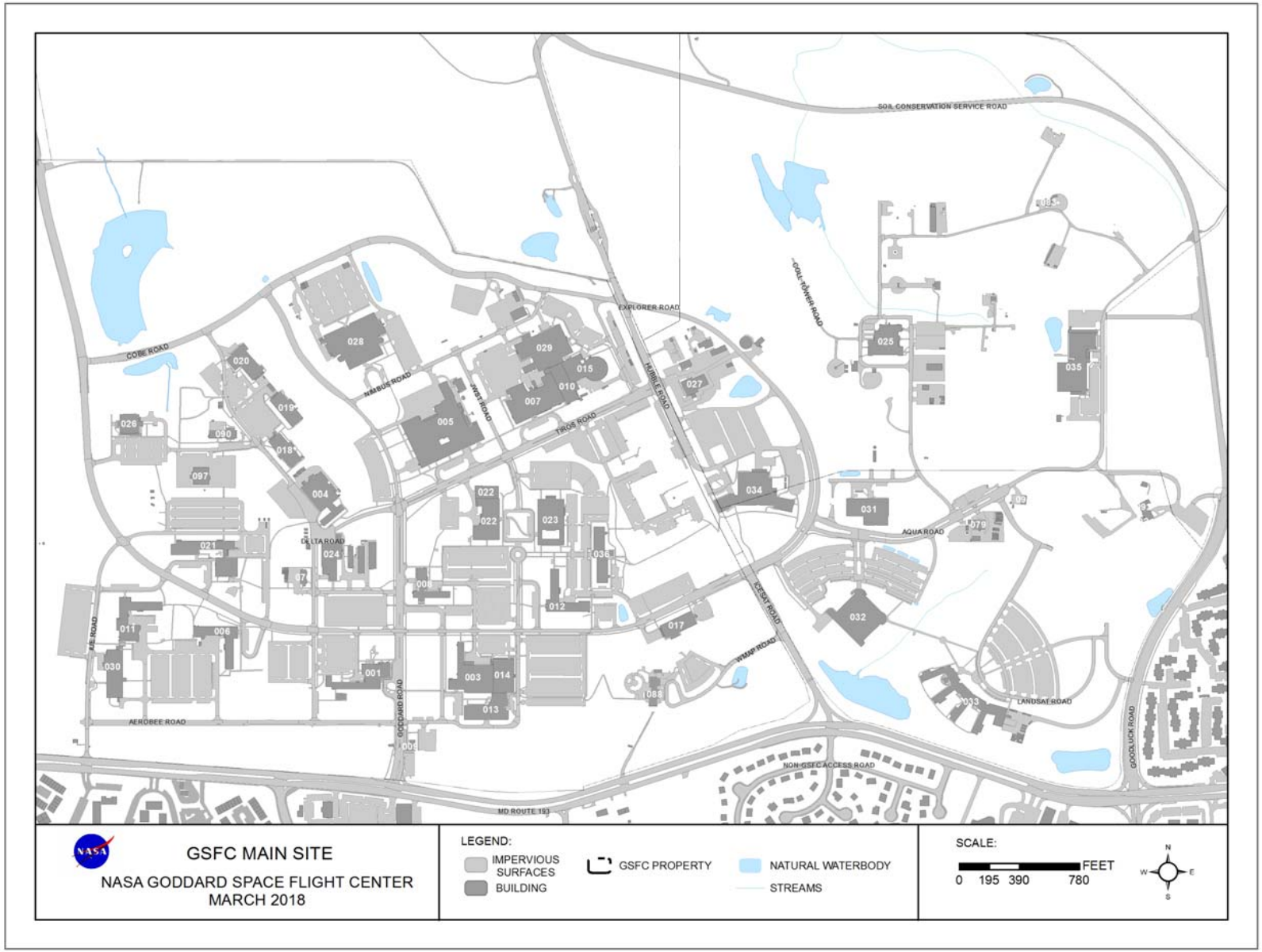


Figure A-4. GSFC – Outlying Areas

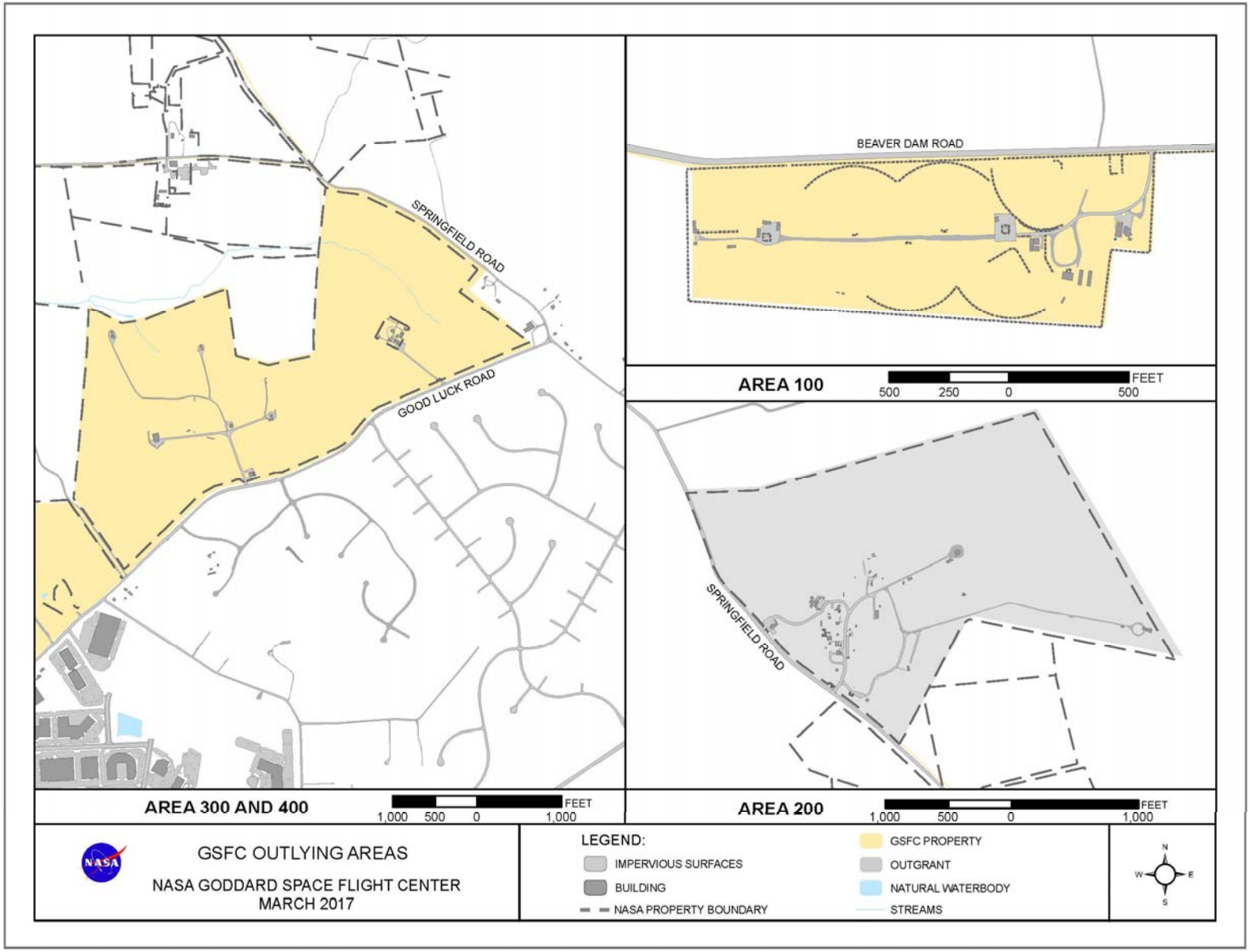


Figure A-5. GSFC Aerial Map

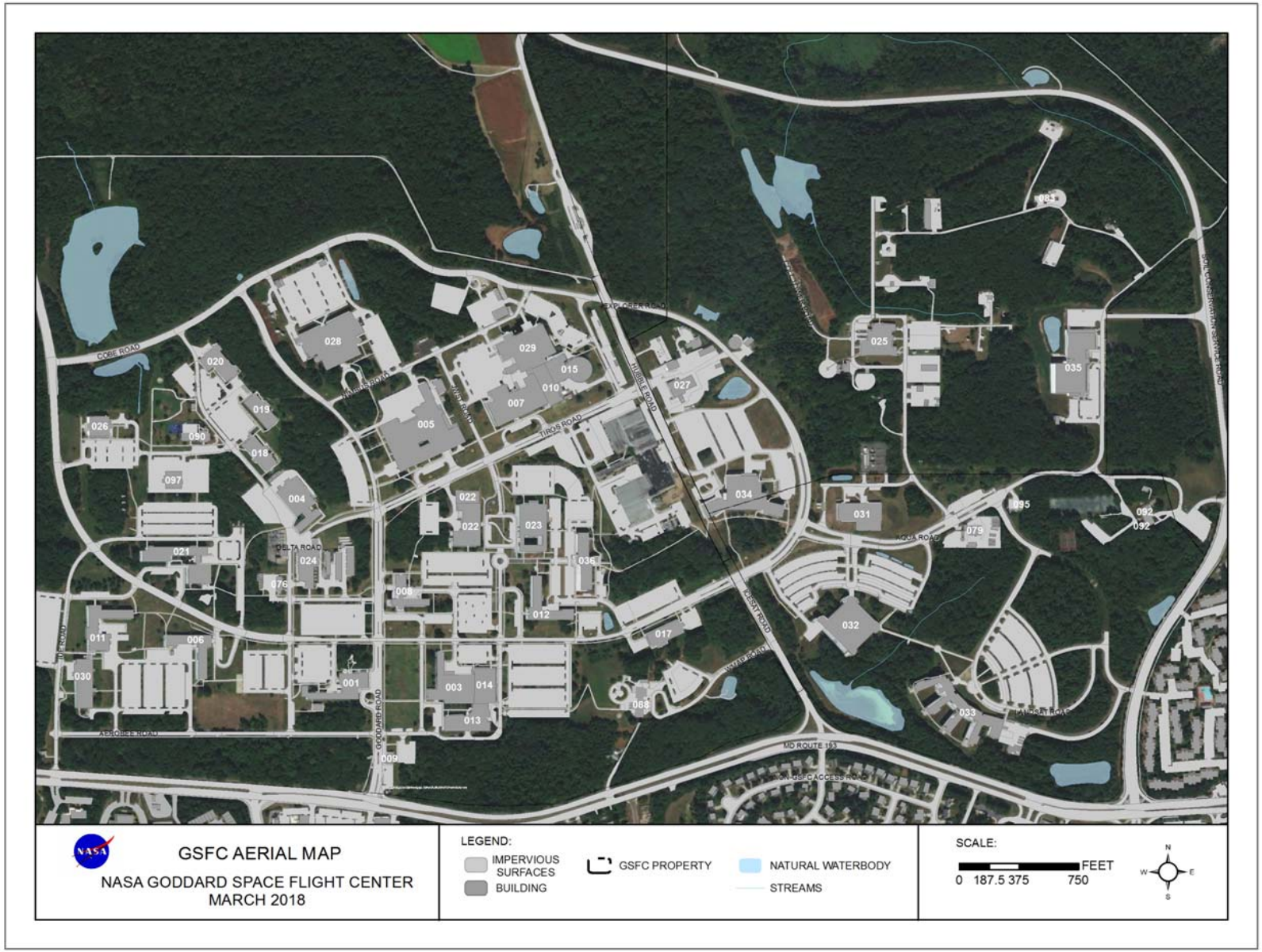


Figure A-6. GSFC Deed Composite Map

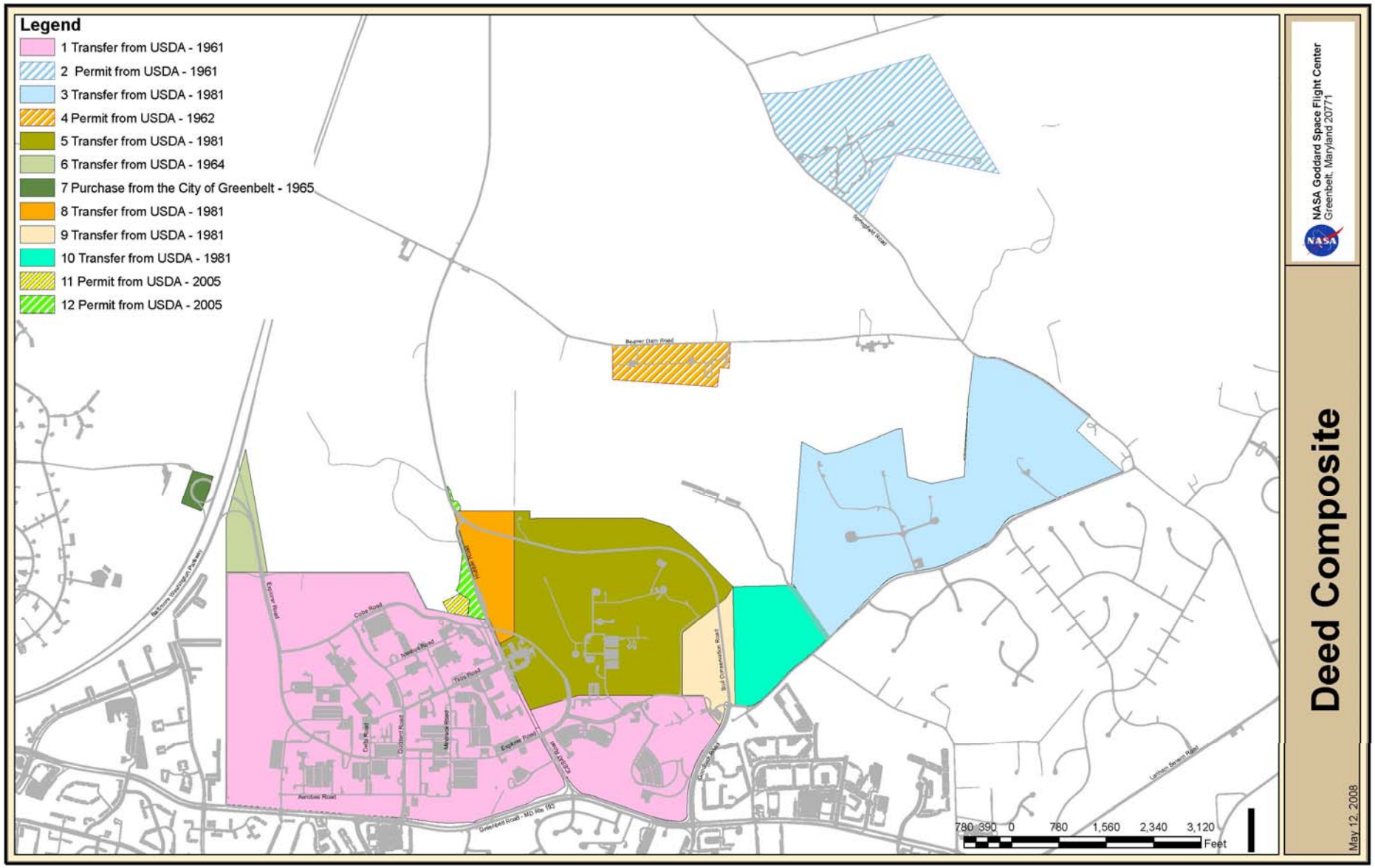


Figure A-7. GSFC Forest Conservation Areas

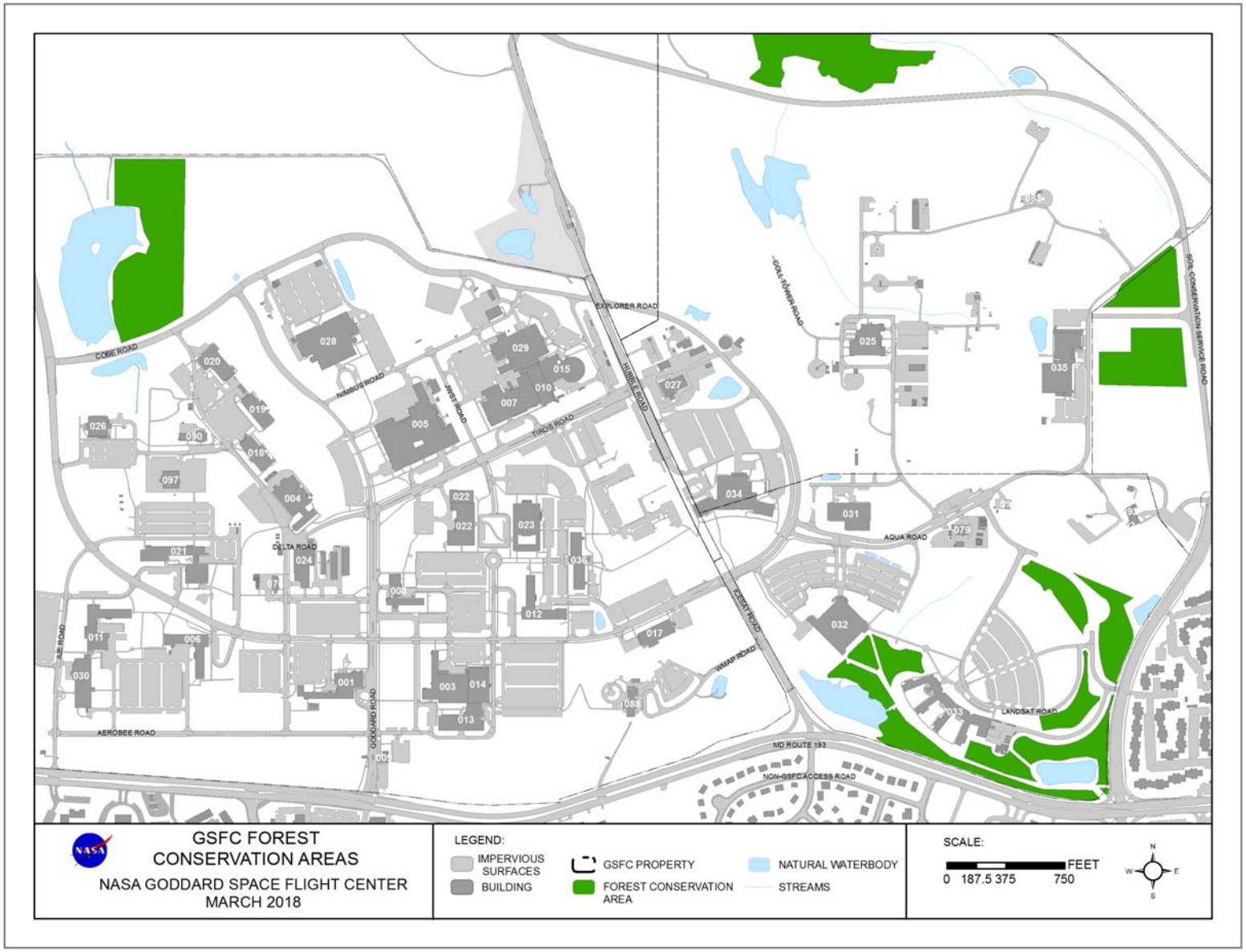


Figure A-8. Drainage Basin Outfalls – Greenbelt Site

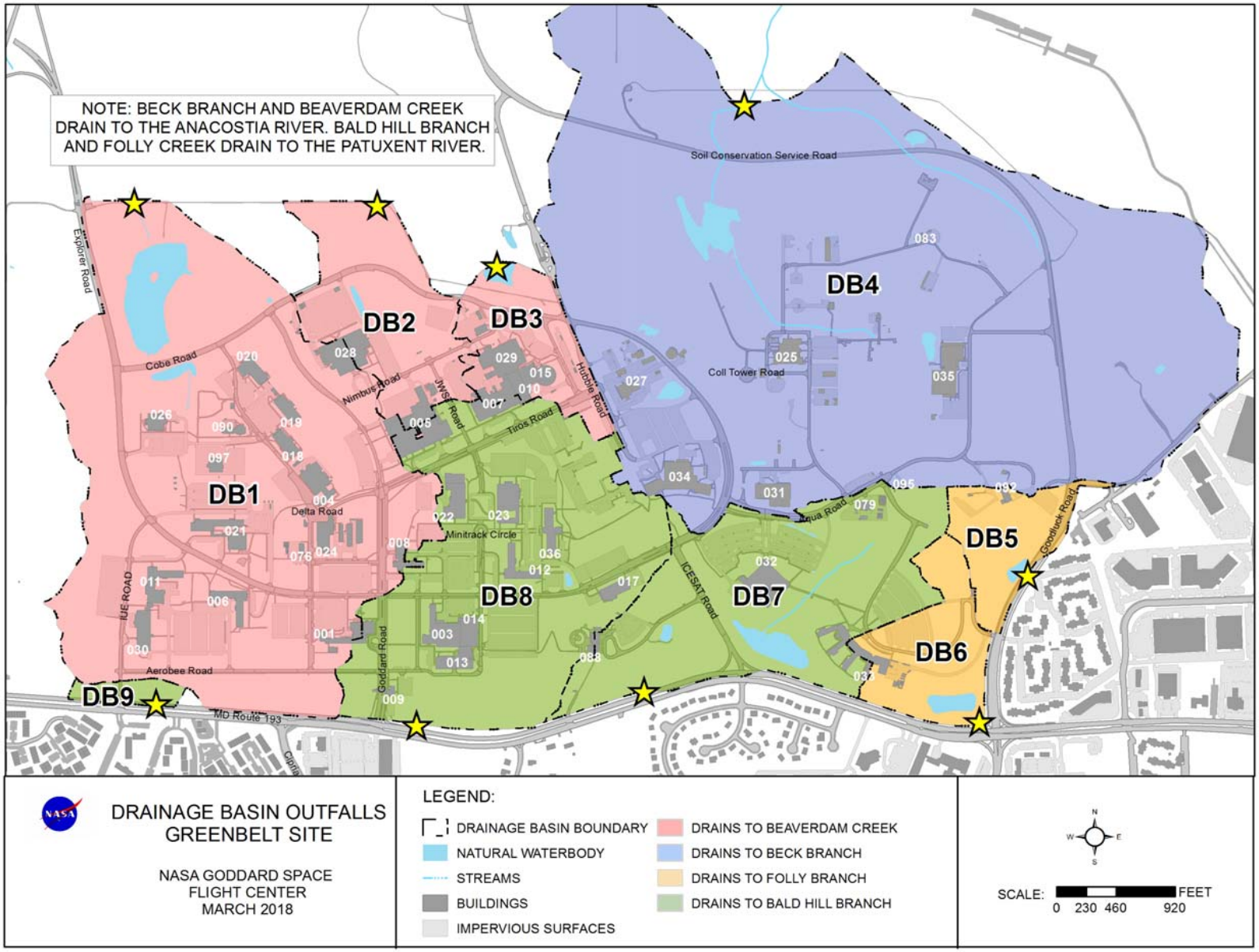


Figure A-9. Drainage Basin Outfalls – Outlying Areas

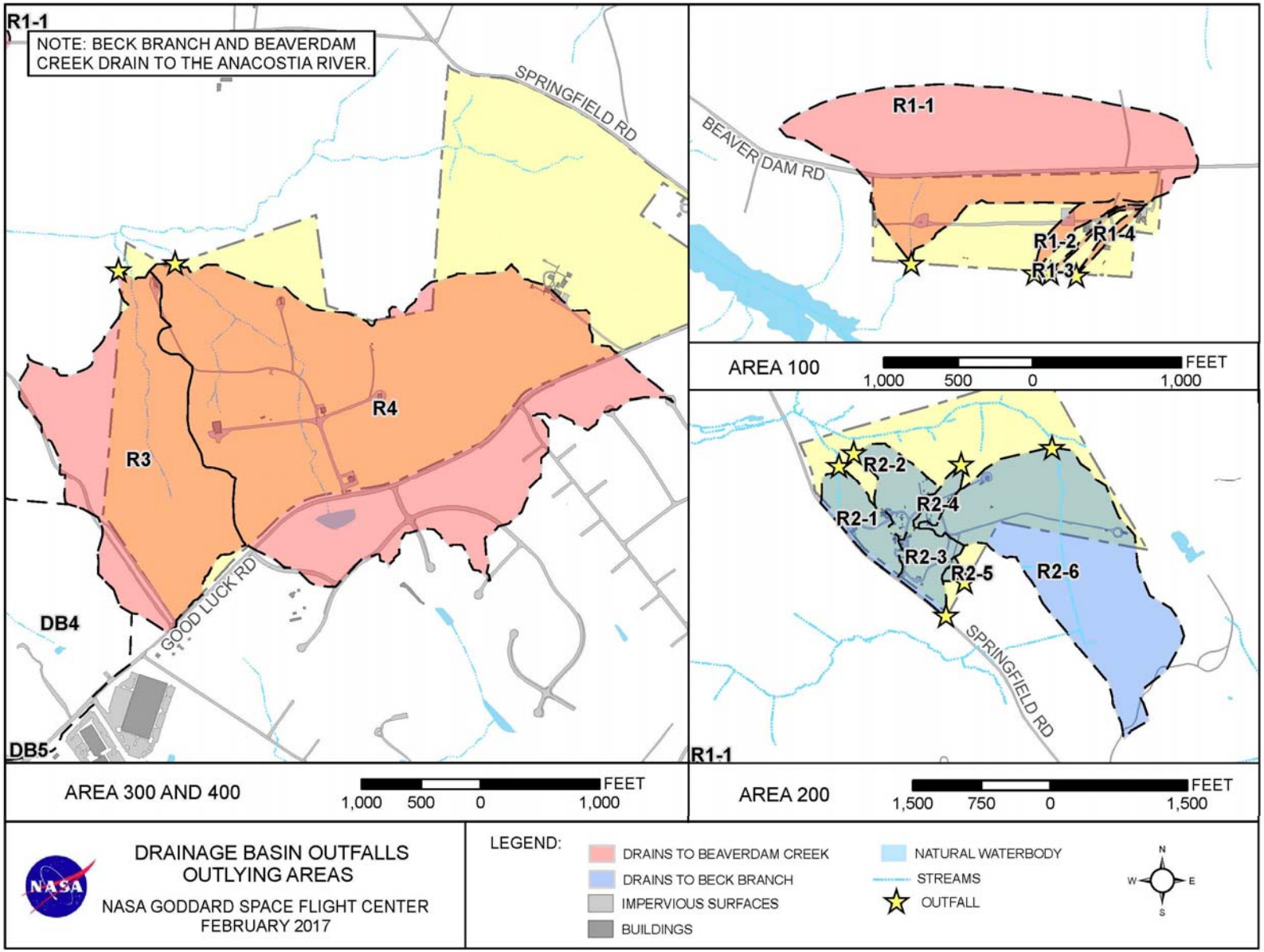


Figure A-10. Physiographic Provinces

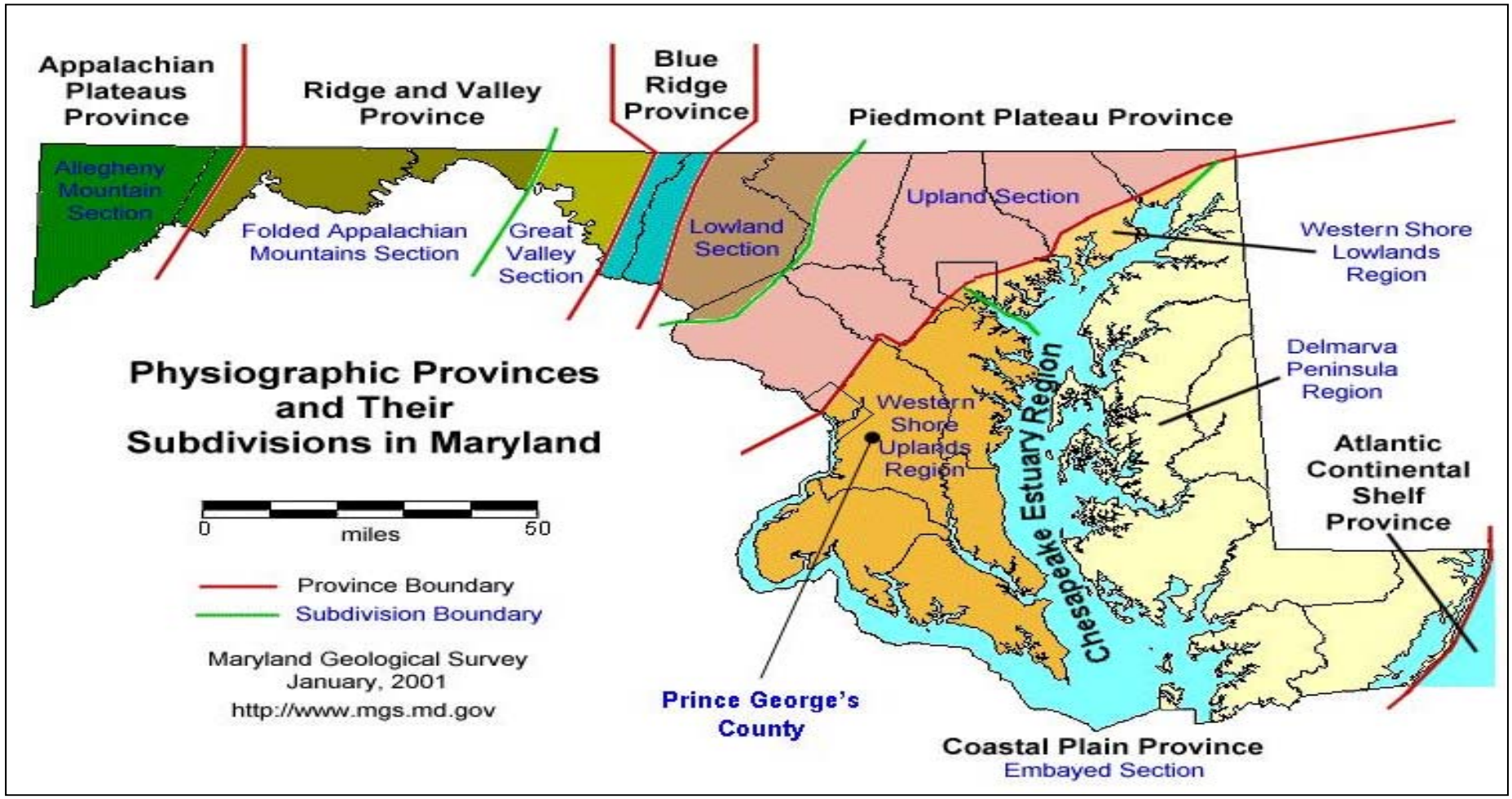


Figure A-11. Geology of Maryland

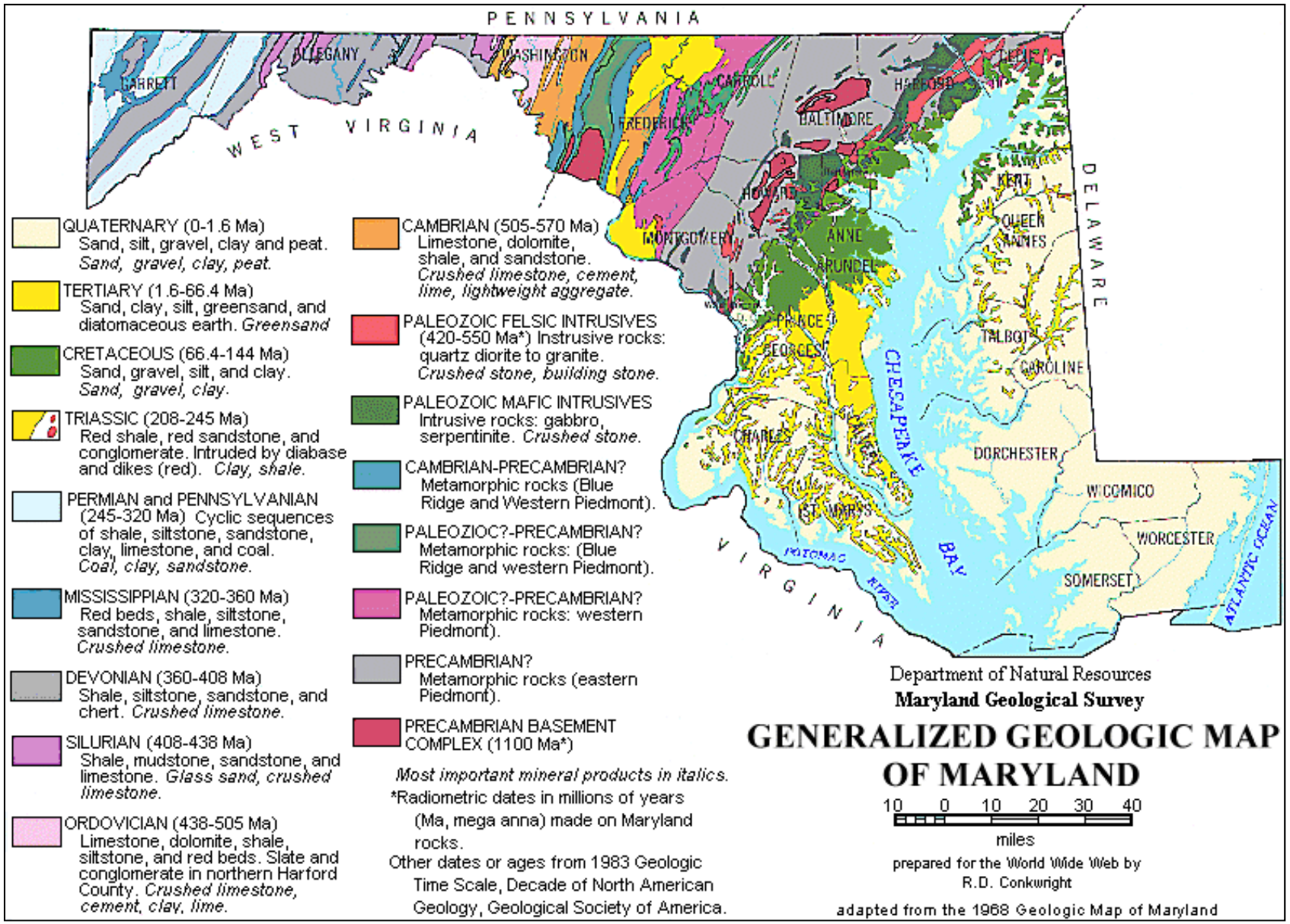


Figure A-12. Formations

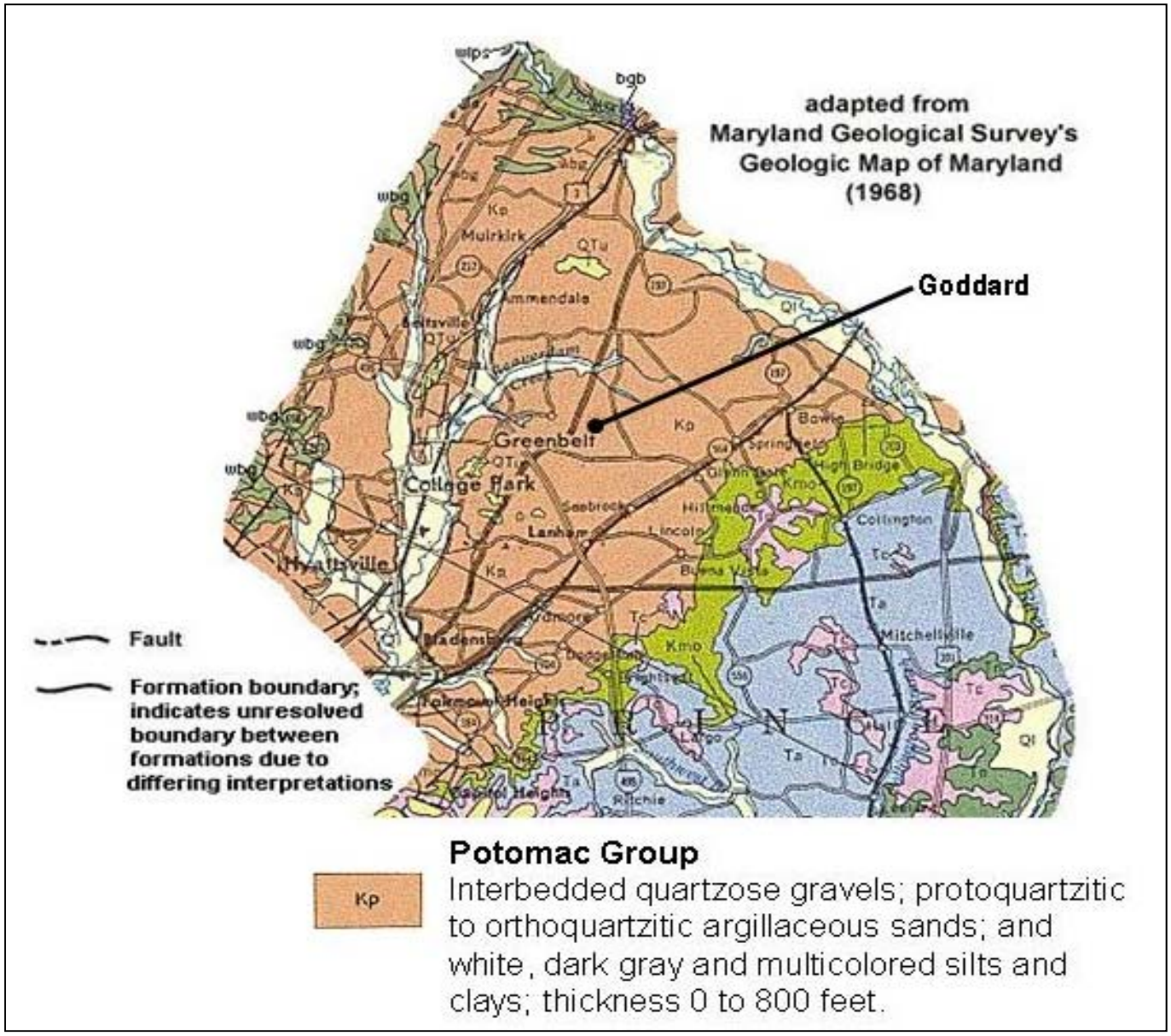


Figure A-13. Hydrogeologic Features

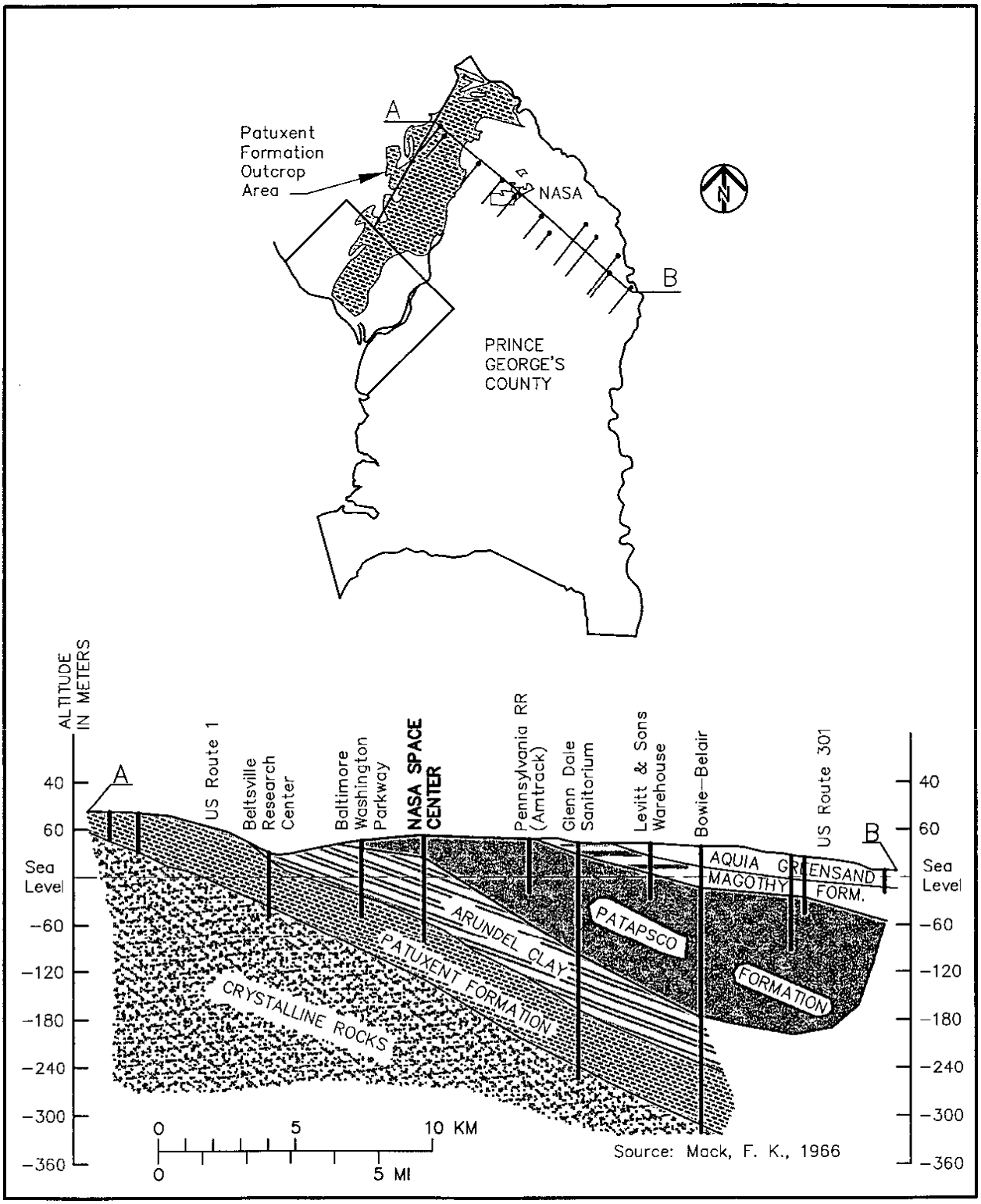


Figure A-14. Soil Types – Greenbelt Site

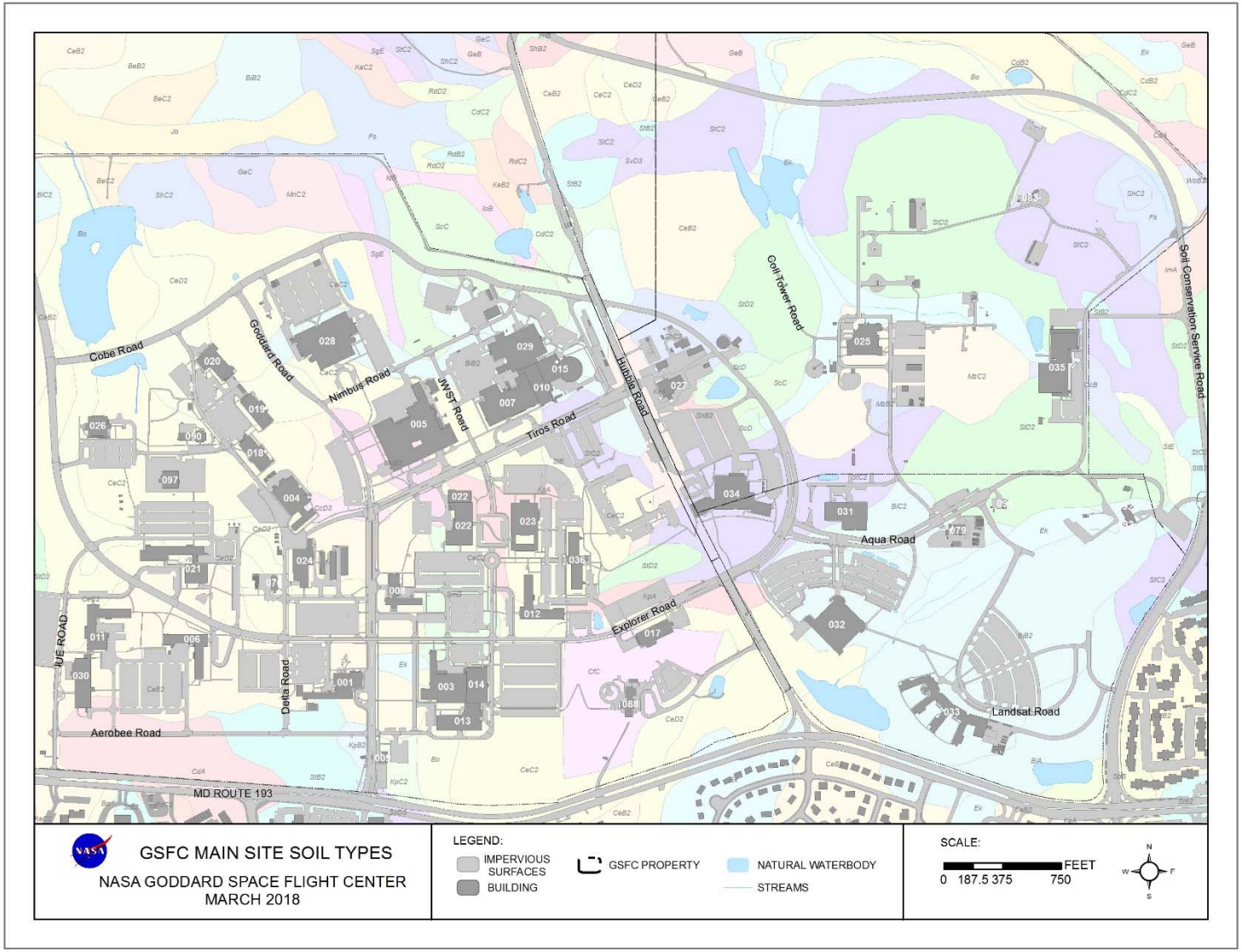


Figure A-15. Soil Type – Outlying Areas

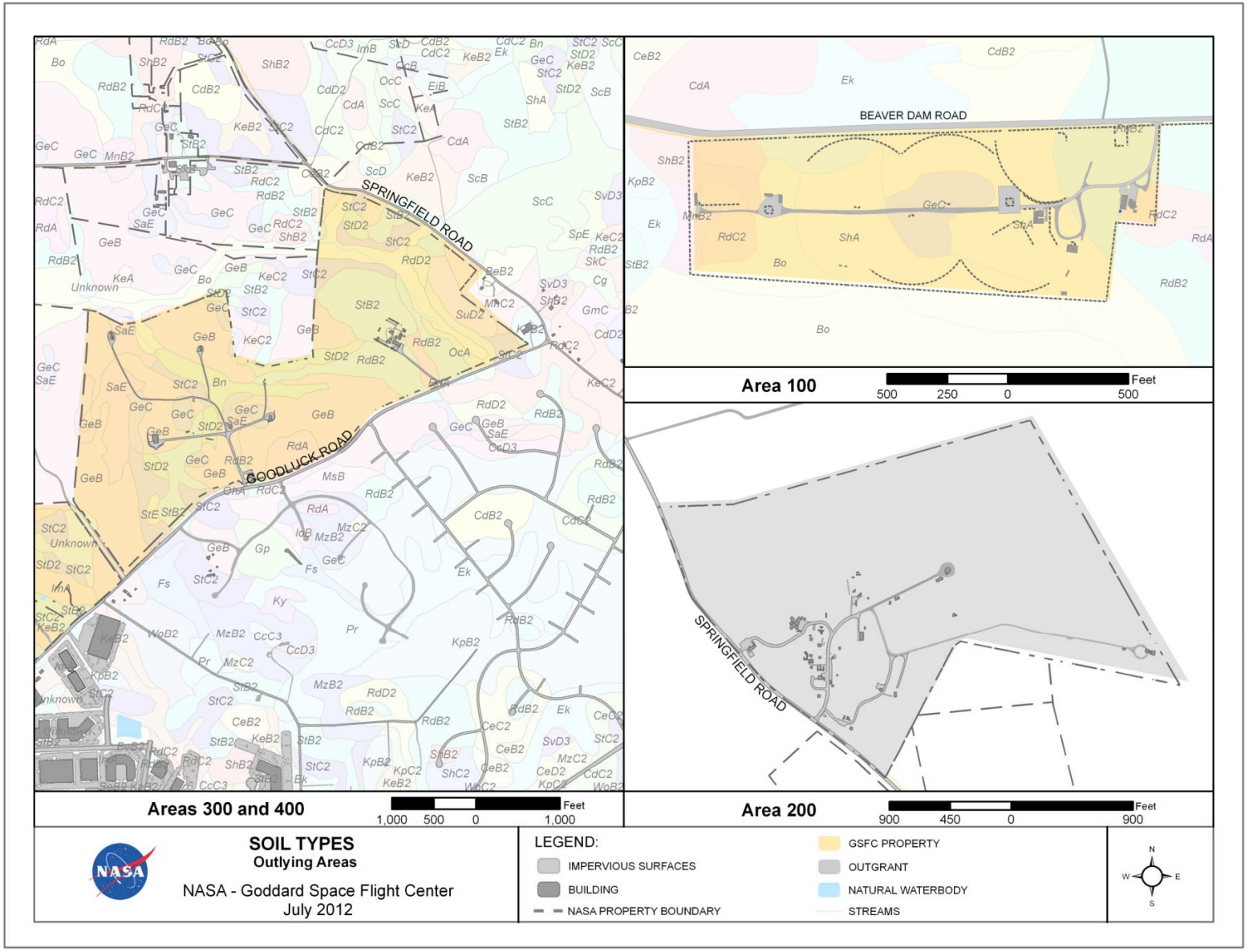


Figure A-16. Prince Georges County Planning Areas

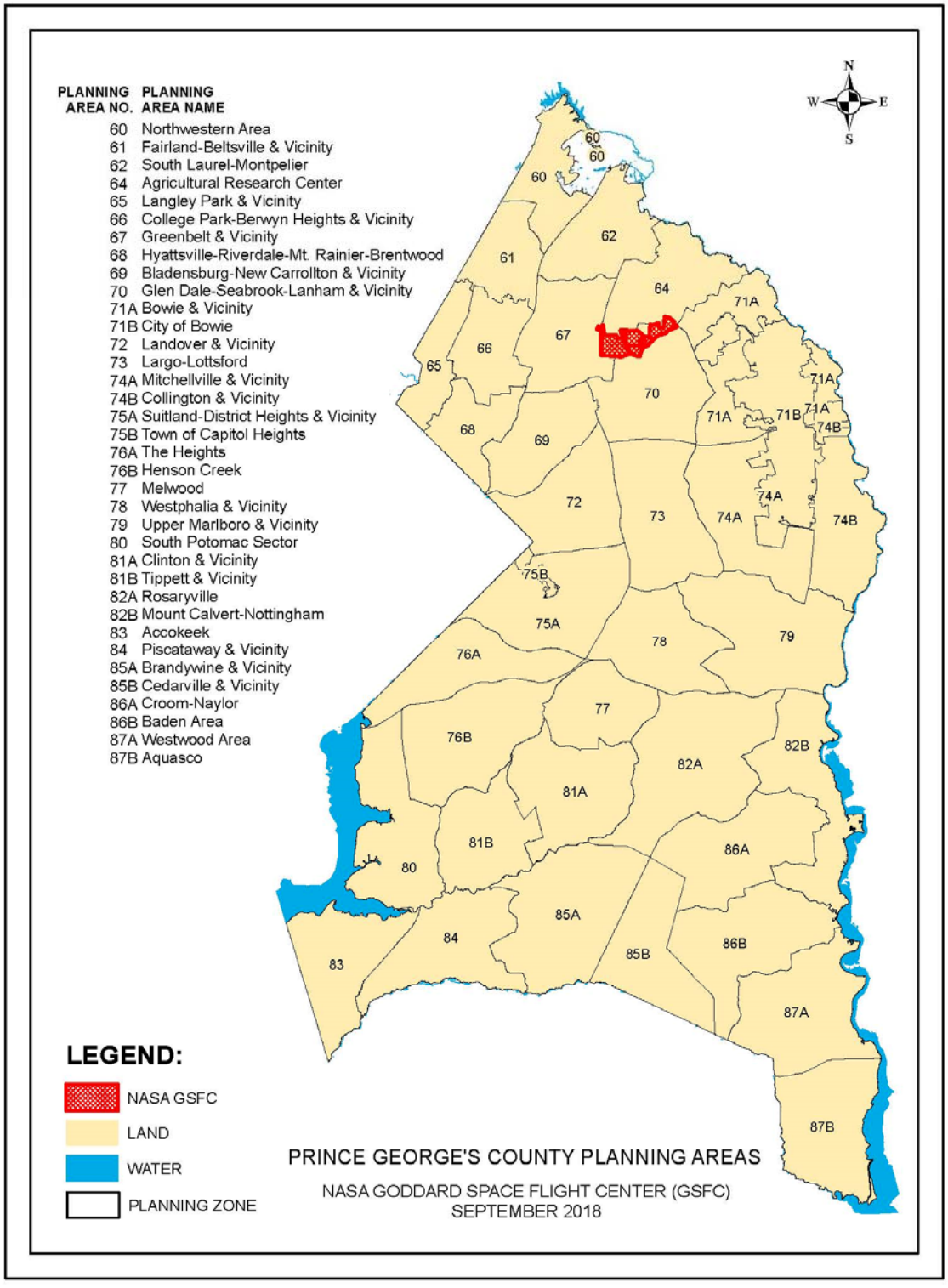


Figure A-17. Area 200 Dish Vegetation Map

Figure A-18. National Wetlands Inventory Map

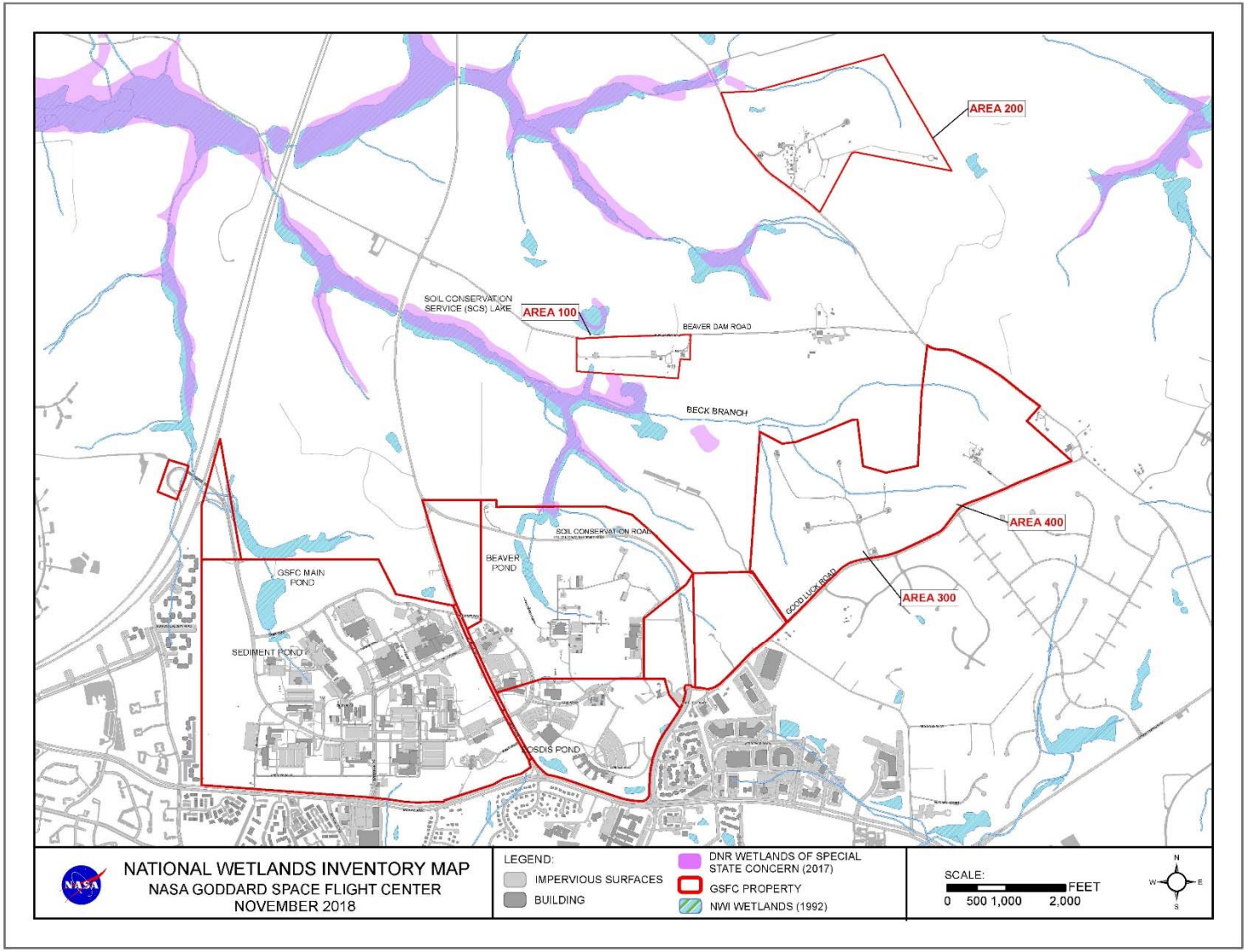


Figure A-19. Wetlands and Floodplains Map

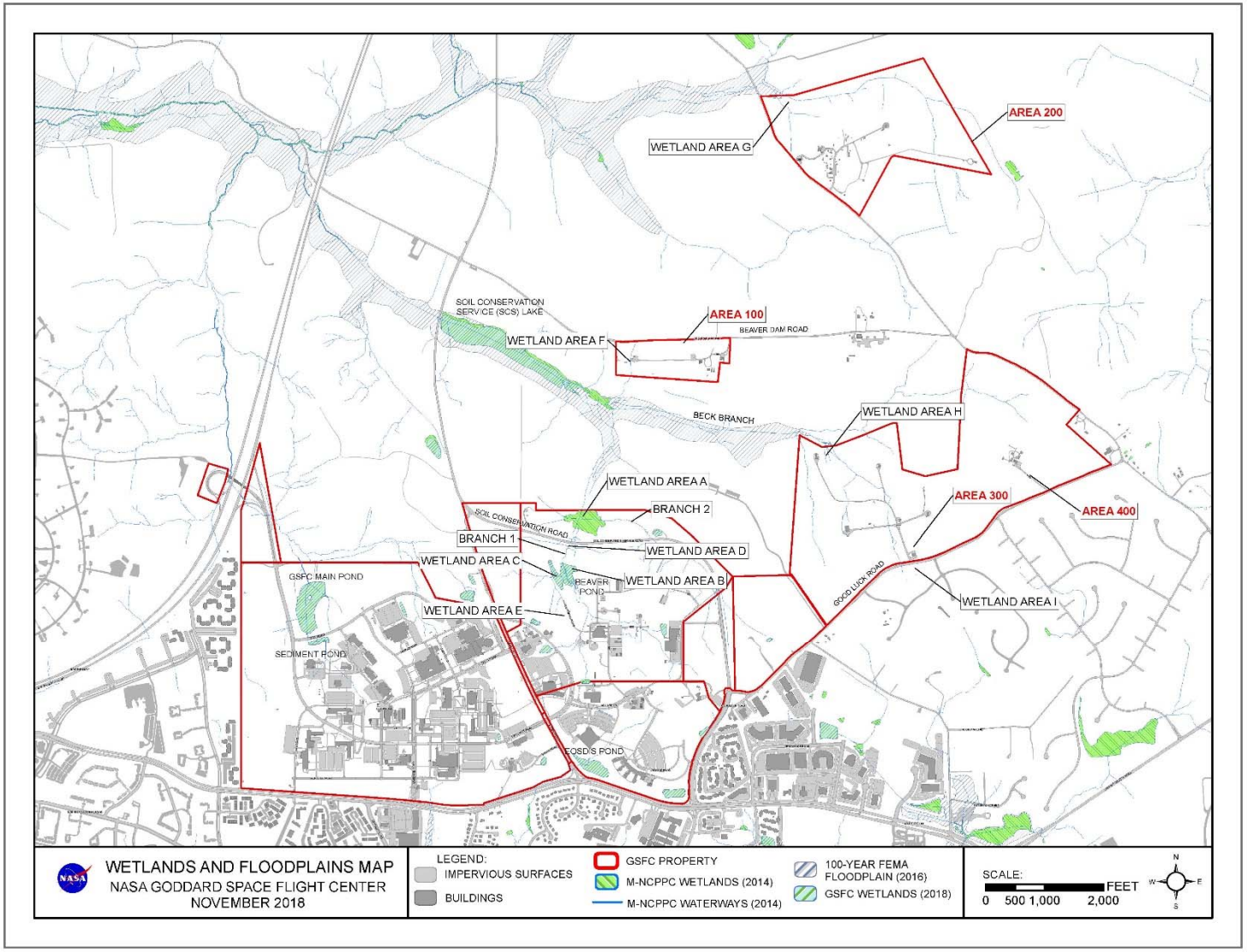


Figure A-20. Hydrogeologic Cross Section for the Upper and Lower Patapsco Aquifers

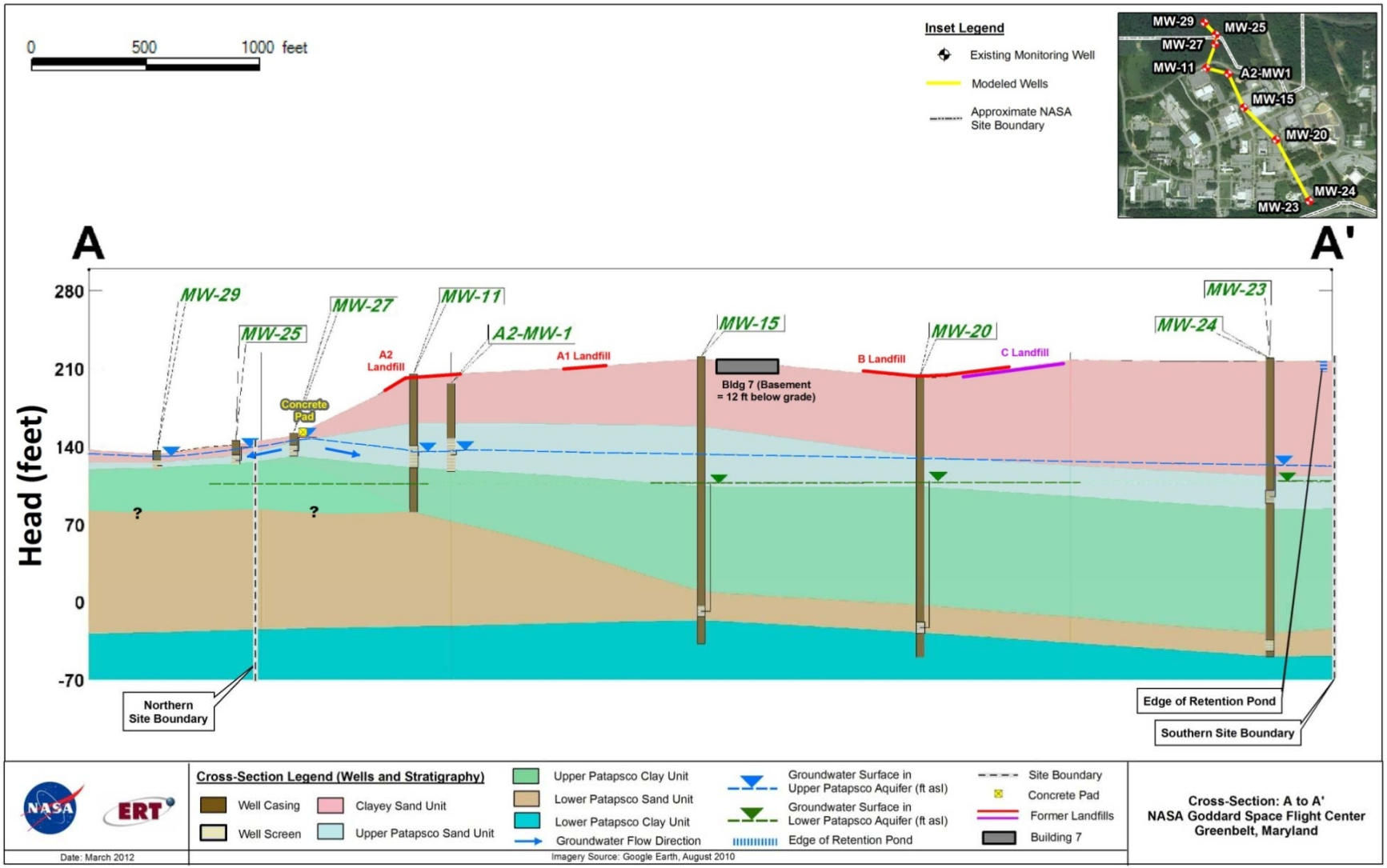


Figure A-21. Plant Survey Sites

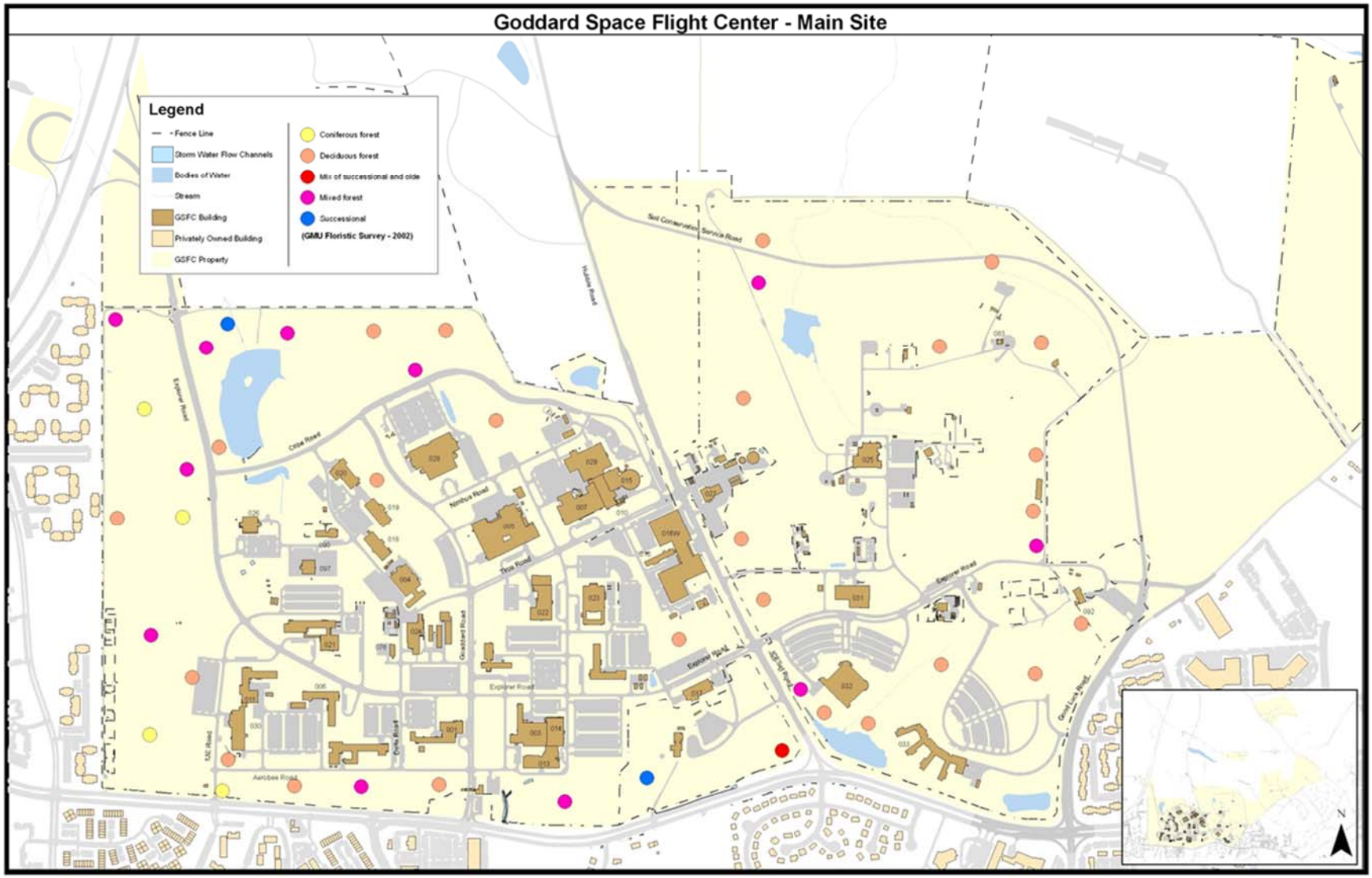


Figure A-22. Land Cover – Greenbelt Site

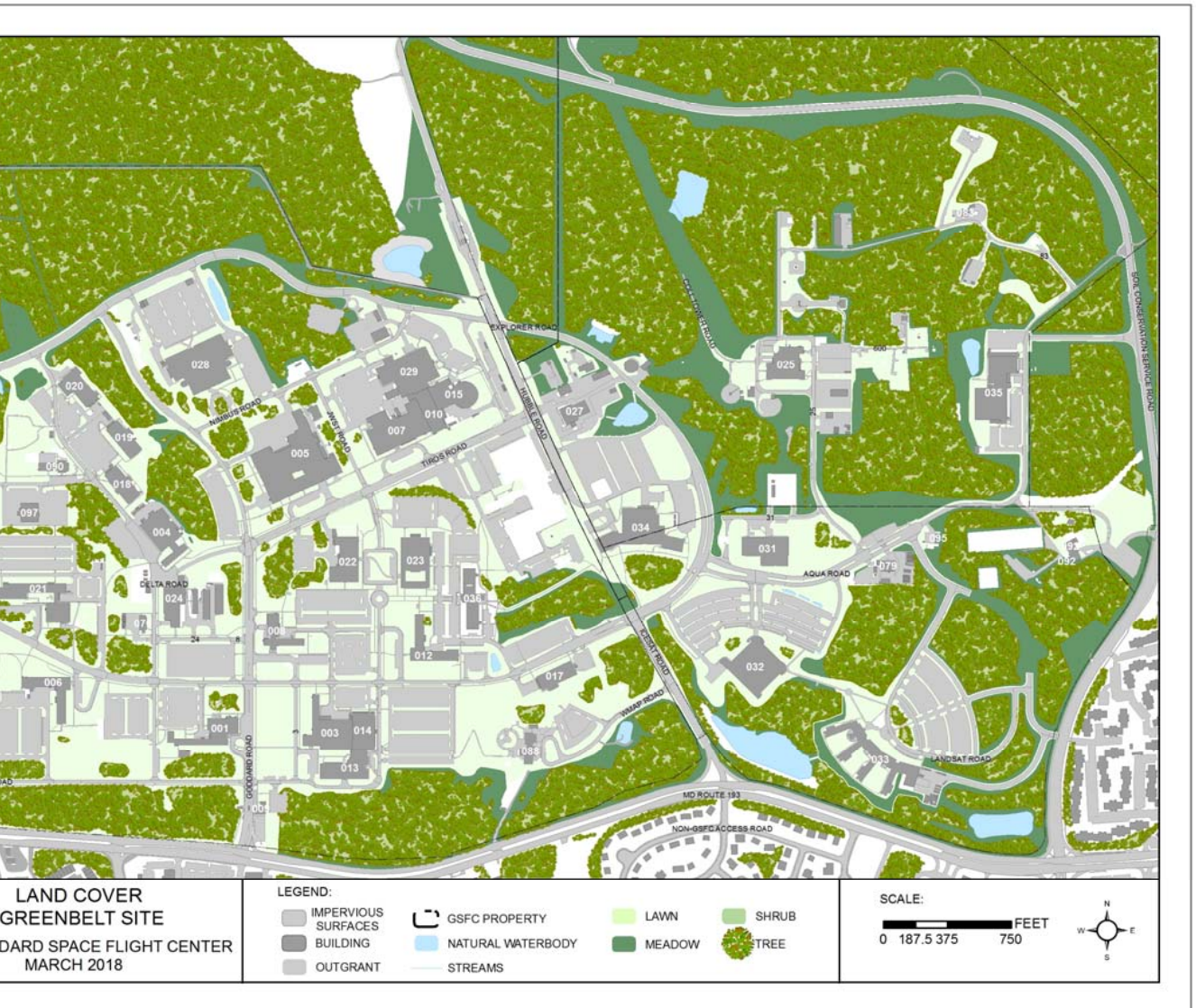


Figure A-23. Land Cover – Outlying Areas

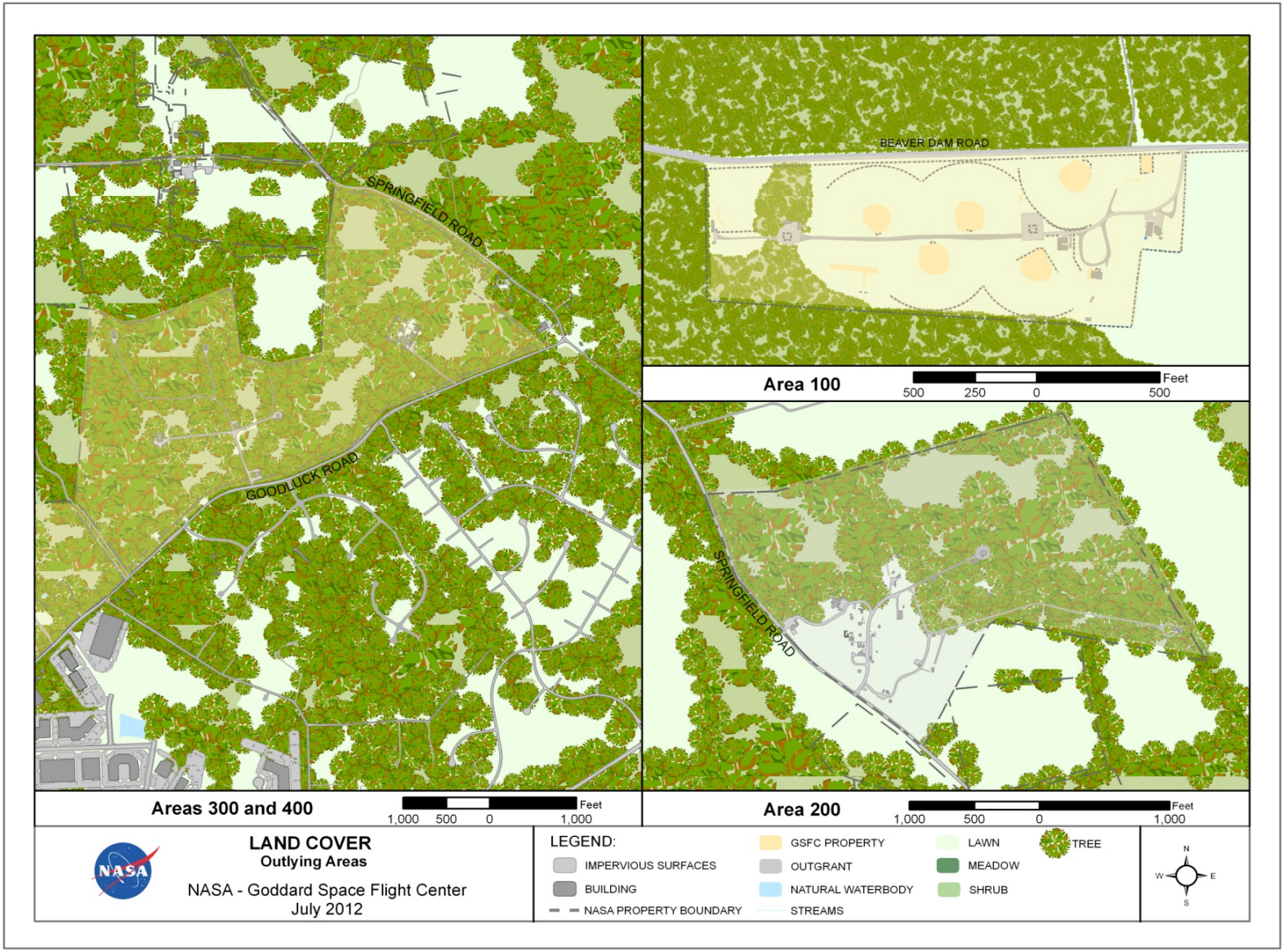


Figure A-24. Biodiversity Survey Sites

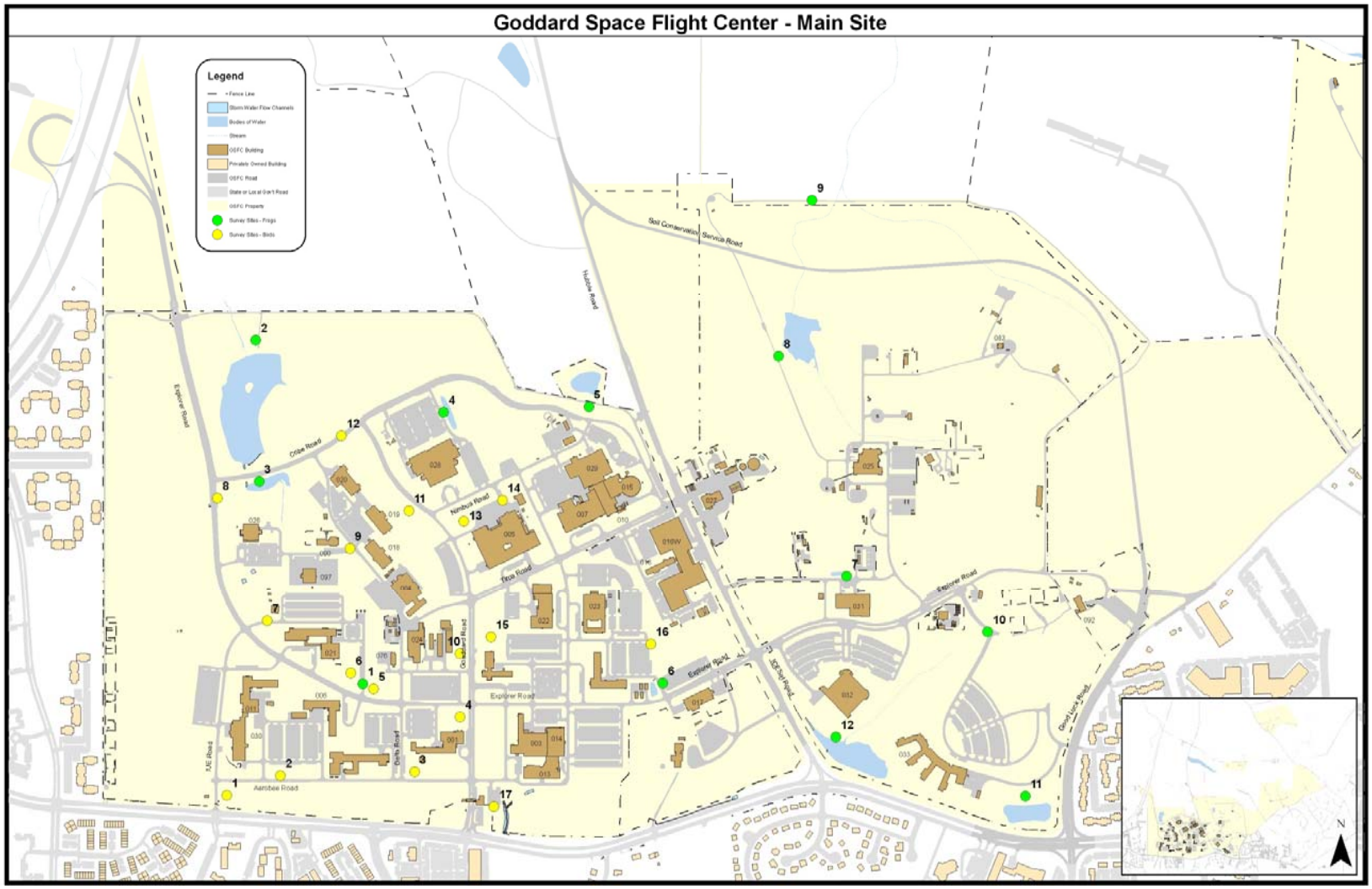


Figure A-25. Environmental Sites Subject to LUCs – Greenbelt

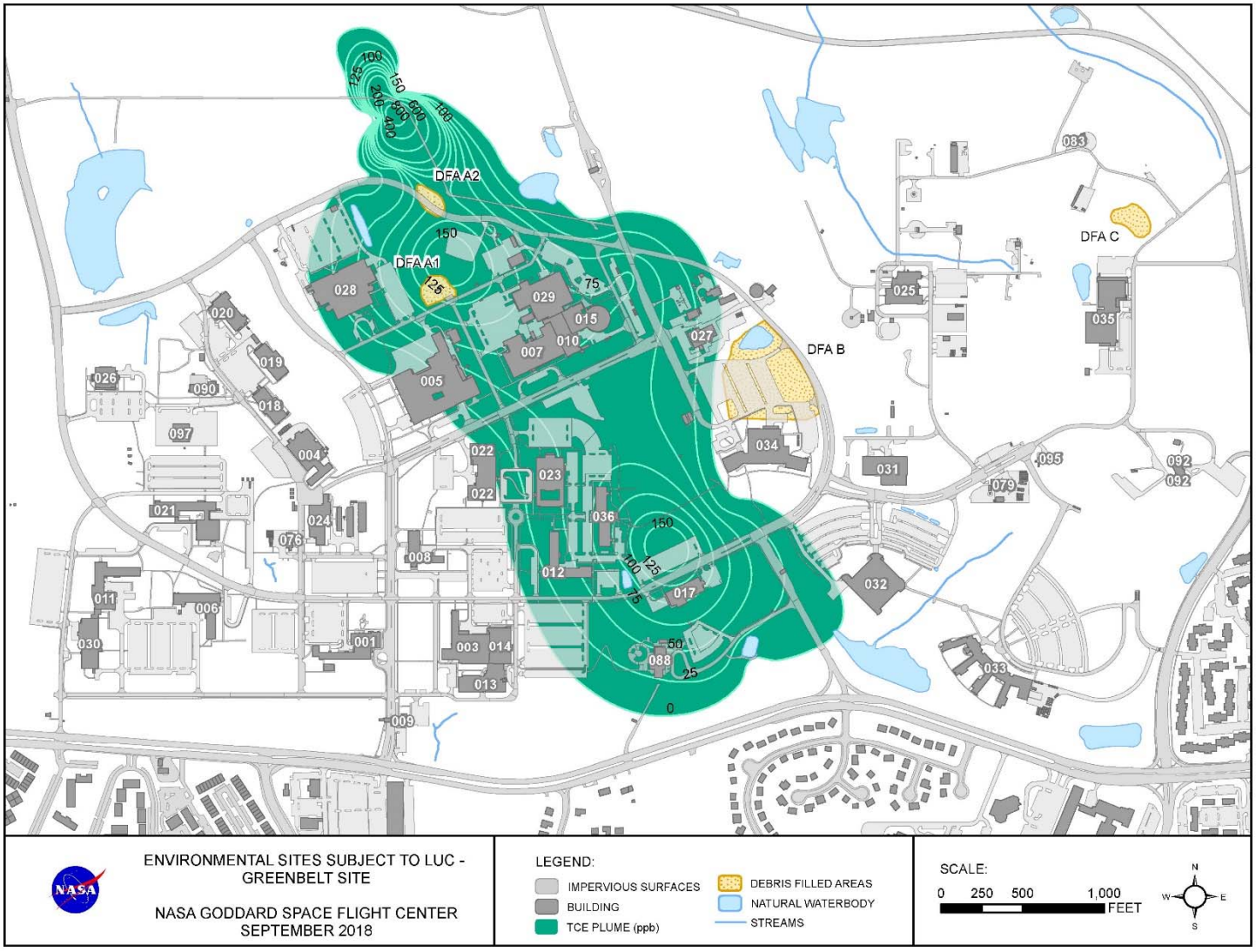


Figure A-26. Remediated Sites – Greenbelt Site

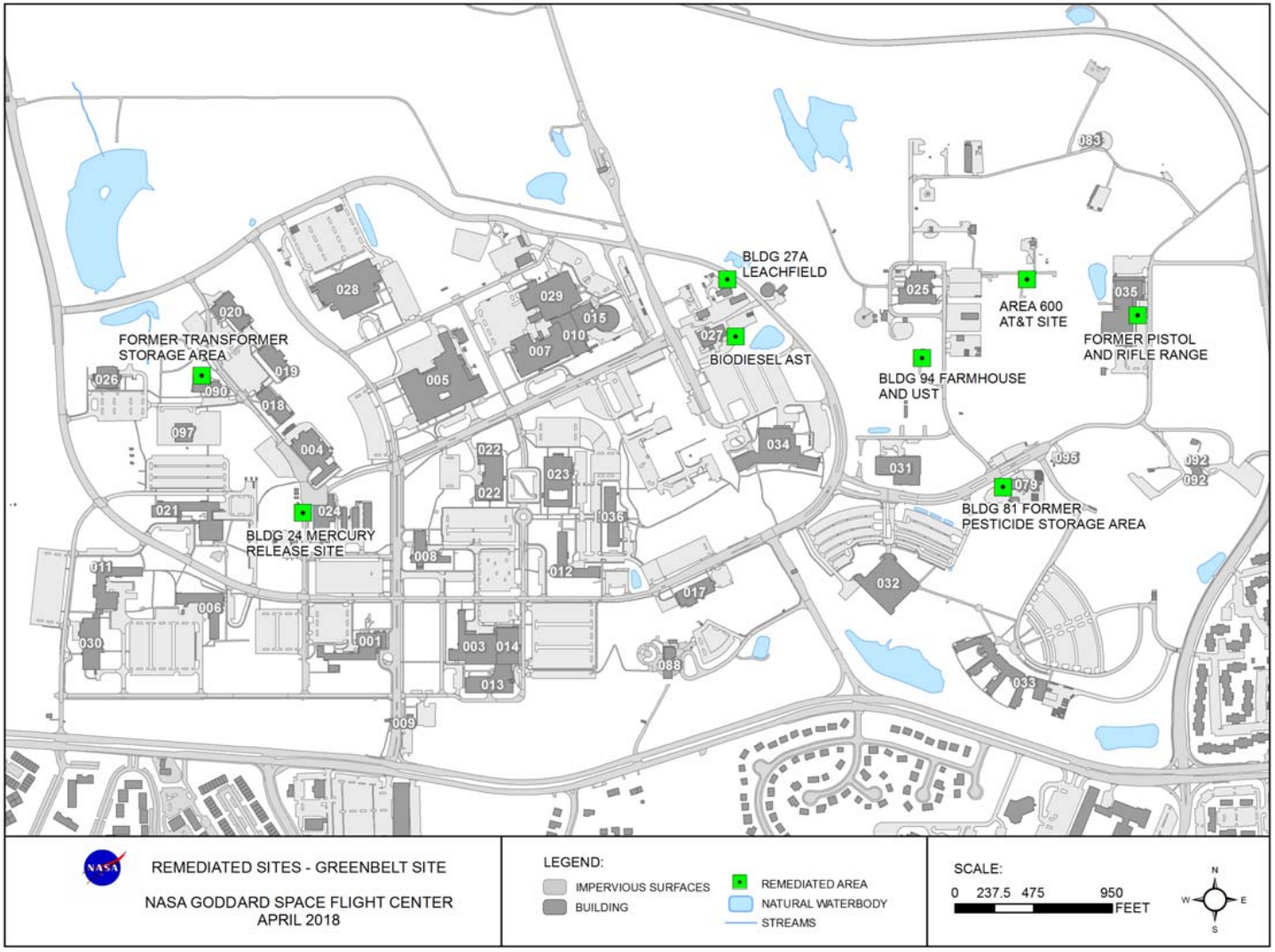


Figure A-27. Remediated Sites – Outlying Areas

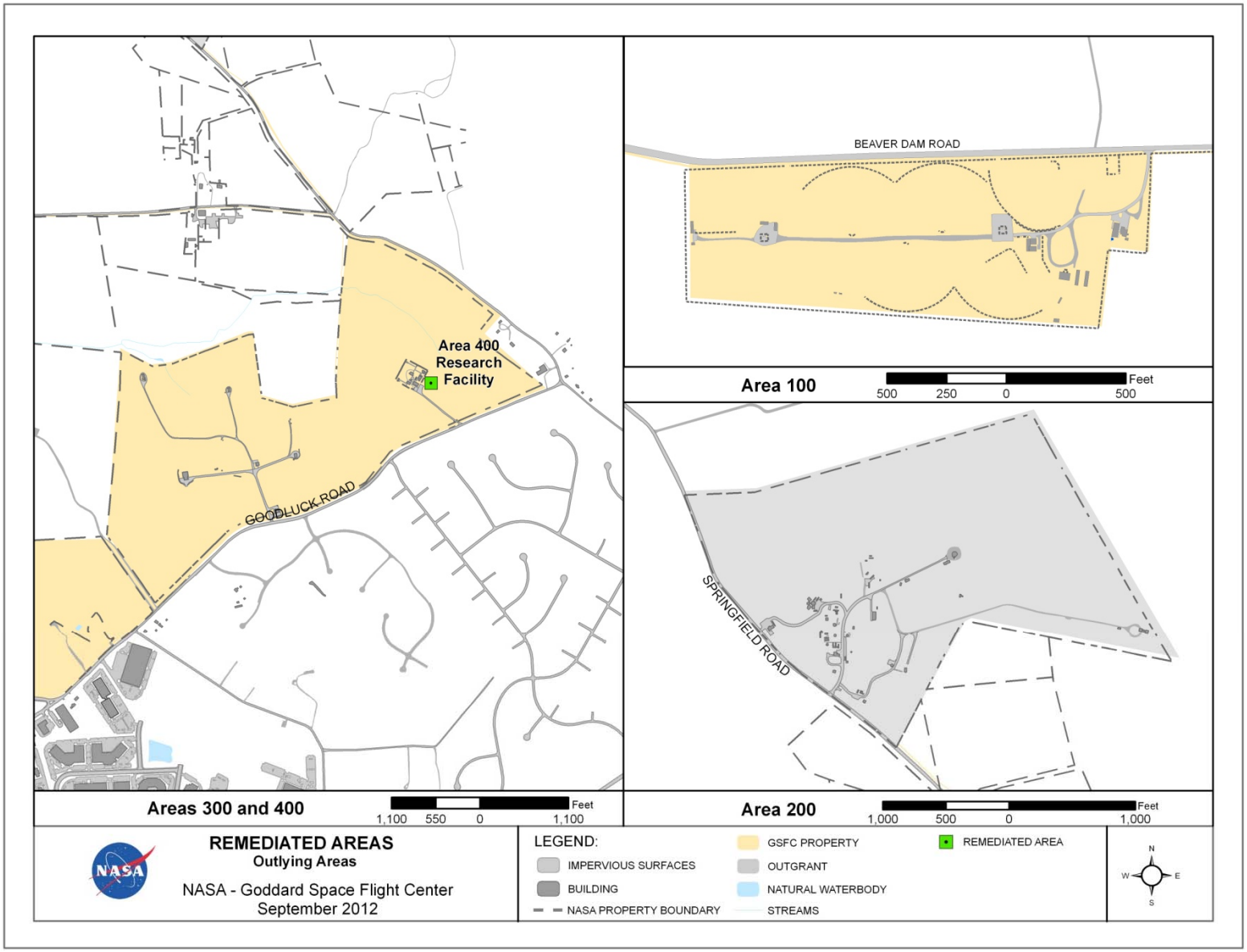


Figure A-28. Watershed Boundary Map

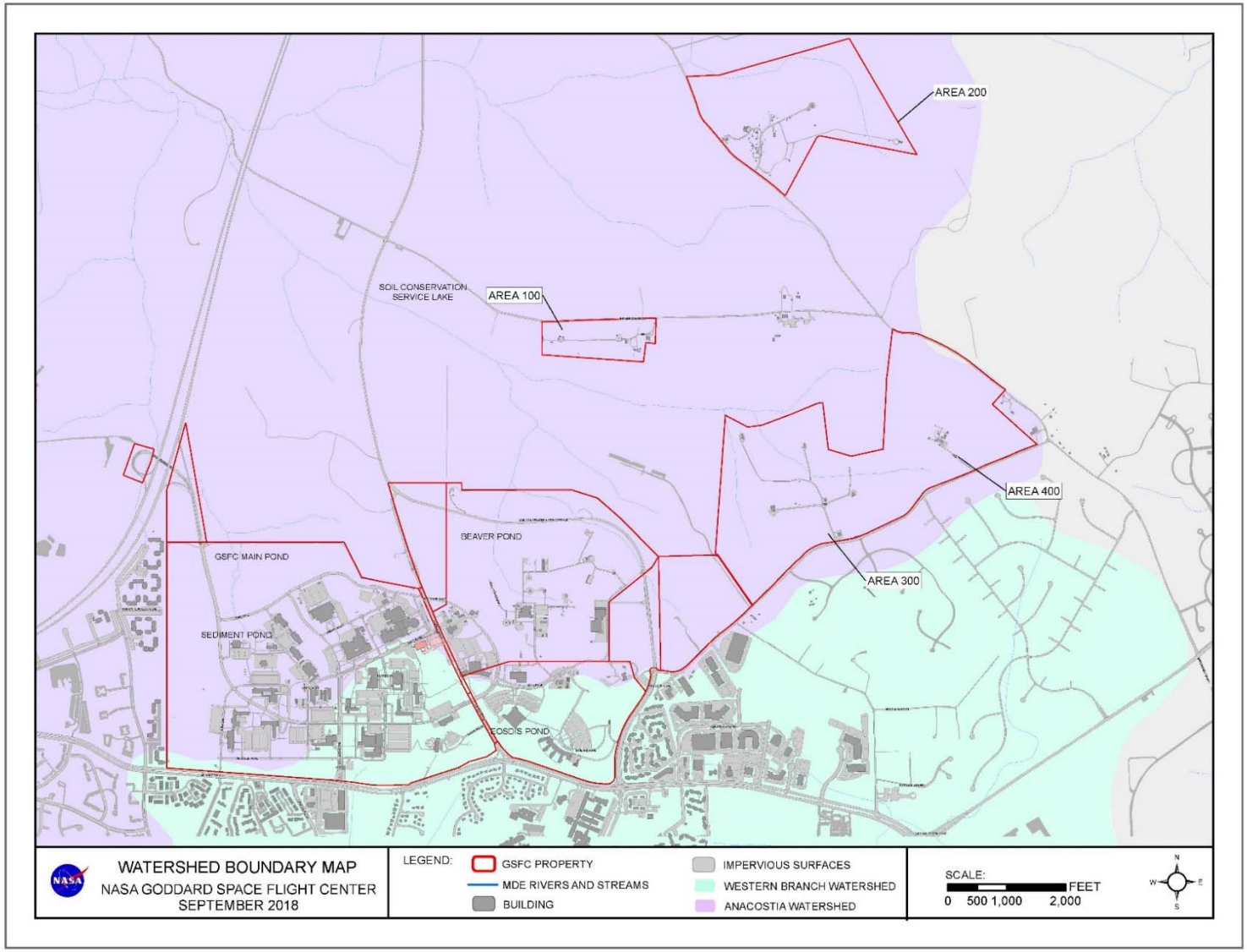
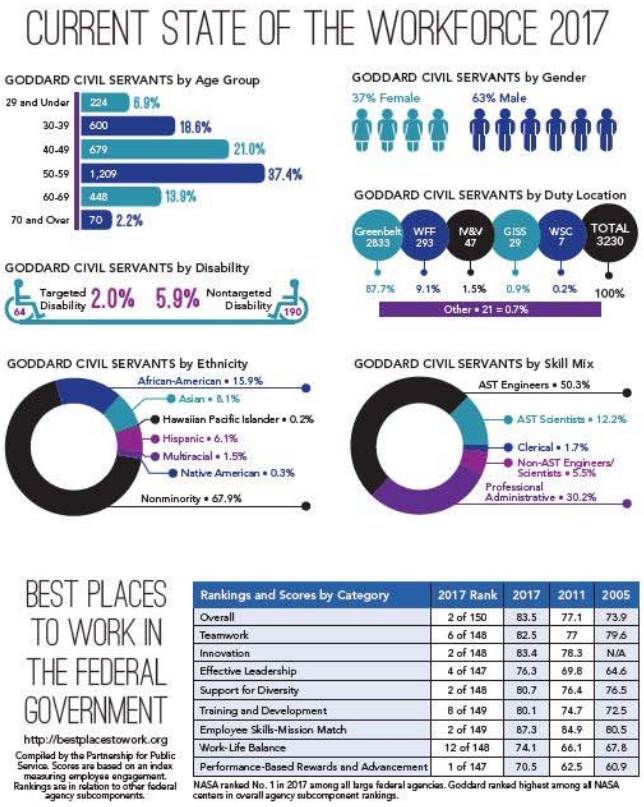
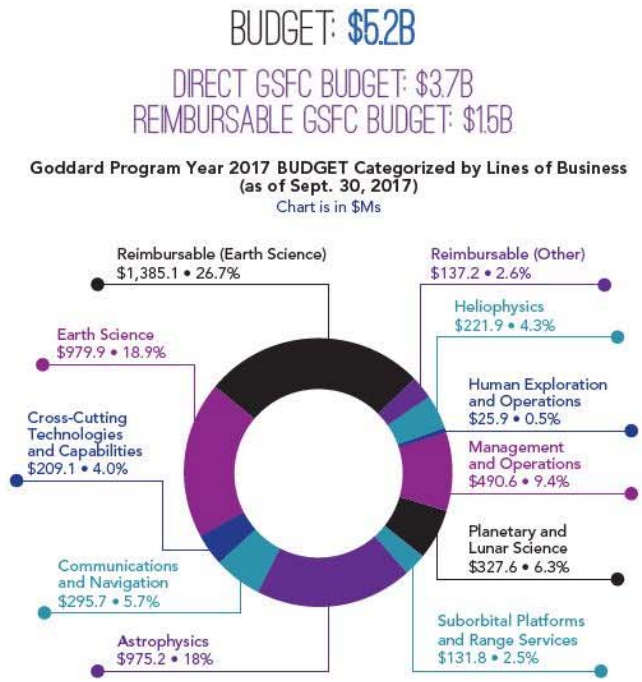


Figure A-29. GSFC Greenbelt Civil Servant Workforce and Budget



Rankings and Scores by Category	2017 Rank	2017	2011	2005
Overall	2 of 150	83.5	77.1	73.9
Teamwork	6 of 148	82.5	77	79.6
Innovation	2 of 148	83.4	78.3	N/A
Effective Leadership	4 of 147	76.3	69.8	64.6
Support for Diversity	2 of 148	80.7	76.4	76.5
Training and Development	8 of 149	80.1	74.7	72.5
Employee Skills-Mission Match	2 of 149	87.3	84.9	80.5
Work-Life Balance	12 of 148	74.1	66.1	67.8
Performance-Based Rewards and Advancement	1 of 147	70.5	62.5	60.9

NASA ranked No. 1 in 2017 among all large federal agencies. Goddard ranked highest among all NASA centers in overall agency subcomponent rankings.



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Appendix B
Tables

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Table B-1. GSFC Properties (in acres)

	Land Area		Land Cover				
	Owned	***Held by Permit***	***Impervious***	***Pervious[1]***	***Forested***	***Forested Conservation Areas***	***Total[5]***
Main Campus	869[3]	10[4]	203	676	407[2]	30	879
Area 100	-	28	2	26	3	0	28
Area 200	-	121	3	118	82	0	121
Area 300 and 400	251	-	5	246	219	0	251
TOTAL	1120	159	213	1066	711	30	1279

Source: GSFC 2010 Master.
** Value is included within Main Campus value.*
[1]-Pervious surfaces include gravel, unpaved roads and parking lots, bodies of water, and vegetation.
[2]-Main Campus forested acres may be skewed slightly because Building 035 was not included in the calculation.
[3]-This number includes 24 acres associated with Parkway Interchange.
[4]-This number includes 3 acres associated with pond north of B29 and 7 acres associated with the north gate.
[5]-This number is the sum of impervious and pervious surfaces.

Table B-2. NPDES Outfall Sampling Data Summary								
Source	**Parameter**	**Daily Minimum Limit**	**Daily Maximum Limit**	**Quarterly Average Limit**	**Water Quality Criteria[1] Acute Exposure**	**Water Quality Criteria[1] Chronic Exposure**	**Benchmark Values[2]**	**Sampling Data[3]**
NPDES Outfall 001	Total Copper (mg/L)		0.013	0.009	13	9	12.3	6.98
	Dissolved Copper (mg/L)				n/a	n/a	n/a	5.54
	Total Residual Chlorine[5] (mg/L)		0.019	0.011	0.011	0.019	n/a	0.03
	Hardness (mg/L)				n/a	n/a	100	73.27
	Temperature (°F)			90	90	90	n/a	61..45
	pH (s.u.)	6.5	8.5		6.5 – 8.5	6.5 – 8.5	6.0 – 9.0	7.37
	Nitrogen, Total Kjeldahl (mg/L)				n/a	n/a	n/a	1.42
	Nitrate+Nitrite (mg/L)				n/a	n/a	0.68	0.18
	Nitrogen, Total (mg/L)				n/a	n/a	n/a	1.6
	Phosphorus, Total (mg/L)				105	35	2.0	0.41
NPDES Outfall 004	Total Copper (mg/L)		0.013	0.009	13	9	12.3	9.25
	Dissolved Copper (mg/L)				n/a	n/a	n/a	5.55

Table B-2. NPDES Outfall Sampling Data Summary								
Source	**Parameter**	**Daily Minimum Limit**	**Daily Maximum Limit**	**Quarterly Average Limit**	**Water Quality Criteria[1] Acute Exposure**	**Water Quality Criteria[1] Chronic Exposure**	**Benchmark Values[2]**	**Sampling Data[3]**
	Total Residual Chlorine (mg/L)		0.019	0.011	0.011	0.019	n/a	0.04
	Hardness (mg/L)				n/a	n/a	100	77.69
	Temperature (°F)			90	90	90	n/a	65.15
	pH	6.5	8.5		6.5 – 8.5	6.5 – 8.5	6.0 – 9.0	7.22
	Kjeldahl Nitrogen, Total				n/a	n/a	n/a	1.57
	Nitrate+Nitrite				n/a	n/a	0.68	0.09
	Nitrogen, Total (mg/L)				n/a	n/a	n/a	1.62
	Phosphorus, Total (mg/L)				105	35	2.0	0.37

[1]Where a permit limit exists, the permit limit is used as the criteria. Acute exposure is the daily maximum value, and chronic exposure is the monthly average maximum value. Other criteria acquired from **http://www.dsd.state.md.us/comar/comarhtml/26/26.08.02.03-3.htm** *and* **http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable**.
[2]Benchmark values were acquired from USEPA's 2008 guidance document (EPA 833-B-09-002).
[3]Sampling data for NPDES outfalls represents the average of sampling data from October 2001 to December 2017; nutrient sampling data represents the average of sampling data from May 2012 to December 2017..
[4]Unit abbreviations: mg/L = milligrams per liter; °F = degrees Fahrenheit; s.u. = standard unit

Table B-3. WSSC Discharge Permit Limits			
Parameter	**Daily Maximum Limit (mg/L[2])**	**Sampling Frequency**	**Sample Type**
Flow (gpd[1])	N/A	2 days per quarter	Estimated
pH (units)	6.0 - 10.0	2 days per quarter	Continuous Meter
Cadmium	0.17	2 days per quarter	24 hour Composite
Chromium	7.0	2 days per quarter	24 hour Composite
Copper	2.0	2 days per quarter	24 hour Composite
Lead	0.40	2 days per quarter	24 hour Composite
Nickel	3.4	2 days per quarter	24 hour Composite
Silver	1.2	2 days per quarter	24 hour Composite
Zinc	4.20	2 days per quarter	24 hour Composite
Cyanide	1.0	2 days per quarter	Grab
Biological Oxygen Demand	300	2 days per quarter	24 Hour Composite
Chemical Oxygen Demand	Monitoring Only	At WSSC's Discretion	Composite
Total Suspended Solids	400	2 days per quarter	24 Hour Composite
Beryllium	Monitoring Only	At WSSC's Discretion	Composite
Fats, Oils, and Grease	100	At WSSC's Discretion	Grab
Total Dissolved Solids	1500	At WSSC's Discretion	Composite
Mercury	0.001	At WSSC's Discretion	Composite
Total Solids	1900	At WSSC's Discretion	Calculated

[1]*Gallons per day*
[2]*Milligrams per liter*

Table B-4. Soil Data								
Soil Series		**Location**	**Hydric**	**Erosion Hazard**	**Soil Group**	**Seepage**	**Profile [(2)] (inches)**	**Permeability (in/hr)**
Bo, Bn	Bibb	W, E, 1, 3, 4	Yes	Moderate	C	Varies	35 35-54	0.6-6.0 <0.2
Be, Bl	Beltsville	W, E, 4	No (4)	High	C	Low	0-14 14-50 50-72	0.6-2.0 <0.2 0.2-2.0
Cd, Ce	Christiana	W, E, 1, 2	No	Very High	C	Low	0-7 7-120	0.2-0.6 <0.2
Ek	Elkton	W, E, 1	Yes	Moderate	C/D	Low	0-10 10-96	0.2-0.6 <0.2
Fs	Falsington	W, E	Yes	Moderate	B/D	Low	0-12 12-34 34-48	0.2-0.6 0.6-2.0 0.6-6.0
Ge	Galestown	All	No	Low	A	Very High	0-120	6.0+
Io, Im	Iuka	W, E	No (4)	High	C	Medium	0-30 30-34	0.2-2.0 0.6-2.0
Jo	Johnston	W, 2	Yes	Moderate	D	Medium	0-38 38-48	0.6-2.0 2.0-6.0
Ke, Kp	Keyport	All	No(4)	High	C	Low	0-9 9-50	0.2-2.0 <0.2
Le	Leonardtown	W, E	Yes	Low	D	Very Low	0-12 49-70	0.2-0.6 <0.2 0.2-0.6
Mn	Matapeake	W, 1, 4	No	Moderate	B	High	0-7 7-34 34-60	0.6-6.0 0.2-0.6 0.6-6.0

Table B-4. Soil Data

Soil Series		Location	Hydric	Erosion Hazard	Soil Group	Seepage	Profile [2] (inches)	Permeability (in/hr)
Mz	Muikirk	E, W	No	Low	B	Varies	0-28 28-36 36-60	2.0-6.0 0.6-2.0 <0.2
Oc	Ochlocknee	E, 2, 4	No	High	B	Medium	0-45	0.6-2.0
Rd	Rumford	1, 2, 3, 4	No	Low	B	Medium	0-17 17-31 31-54	2.0-6.0 0.6-2.0 2.0-6.0
Sc	Sandy Clay	W, E, 2, 3	No	Moderate	C	Medium	Varies	2.0-6.0
Sg, Sh, Sk	Sassafras	W, E, 1, 2, 4	No	Moderate	B	Medium	0-10 10-40 100-122	2.0-6.0 0.6-2.0 2.0-6.0
Sm	Shrewsberry	W	Yes	Moderate	C/D	Medium	0-14 14-36 36-42	0.6-2.0 0.2-2.0 <0.2
St, Su	Sunnyside	W, E, 2, 3, 4	No	Moderate	B	Medium	0-48 48-60	0.6-2.0 2.0-6.0
Wo	Woodstown	E	No (4)	Moderate	C	Medium	0-12 12-36 36-54	0.6-6.0 0.6-2.0 2.0-6.0

Notes:

1.) W = western portion of the Greenbelt site
E = eastern portion of the Greenbelt site
1, 2, 3, 4 = Outlying areas 100, 200, 300, 400

2.) Hydric soil inclusions possible along drainage ways and stream channels

3.) depth from surface

4.) see text for limits

Source: Prince George's County Soil Survey, U.S. Soil Conservation Service, 1967 (out of print)
Urban Hydrology for Small Watersheds, U.S. Soil Conservation Service, 1986

Table B-5. National Ambient Air Quality Standards (NAAQS) and PG County Attainment Status					
Pollutant	**Primary/ Secondary**	**Averaging Time**	**Level**	**Form**	**Attainment Status**
Carbon Monoxide (CO)	primary	8-Hour	9 ppm	Not to be exceeded more than once per year	M
		1- Hour	35 ppm		M
Lead (Pb)	primary and secondary	Rolling 3-Month Average	0.15 µg/m^3 (1)	Not to be exceeded	A
Nitrogen Dioxide (NO_2)	primary	1- Hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years	A
	primary and secondary	Annual	53 ppb (2)	Annual Mean	A
Ozone (O_3)	primary and secondary	8-Hour	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years	N
Particulate Matter (PM_{10})	primary and secondary	24-Hour	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years	A
Particulate Matter ($PM_{2.5}$)	Primary	1 year	12.0 µg/m^3	annual mean, averaged over 3 years	A
	Secondary	1 year	15.0 µg/m^3	annual mean, averaged over 3 years	A
	primary and secondary	24 hours	35 µg/m^3	98th percentile, averaged over 3 years	A
Sulfur Dioxide (SO_2)	primary	1 hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years	A
	secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year	A

A - Attainment
M - Maintenance
N - Non Attainment
ppb - parts per billion
ppm - parts per million
mg/m^3 - milligram per cubic meter
µg/m^3 - microgram per cubic meter

(1) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 µg/m3 as a calendar quarter average) also remain in effect.
(2) The level of the annual NO_2 standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.
(3) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.
(4) The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2)any area for which an implementation plan providing for attainment of the current (2010) standard has not been submitted and approved and which is designated nonattainment under the previous SO_2 standards or is not meeting the requirements of a SIP call under the previous SO_2 standards (40 CFR 50.4(3)). A SIP call is an EPA action requiring a state to resubmit all or part of its SIP to demonstrate attainment of the required NAAQS

Table B-6. 8-Hour Ozone Exceedances in 2017 from Howard University-Beltsville Station

Howard University-Beltsville	
Date	Highest Concentration (ppb)
5/17/2017	73
5/18/2017	72

**Based on the 2015 O_3 standards.*

Table B-7. Boiler NO_X Emission Factors

	lbs/MMBTU		
Boiler	**Landfill Gas**	**Natural Gas**	**Fuel Oil**
1	0.0548	0.0576	0.0917
2	0.0548	0.0576	0.0917
3	NA	0.0881	0.1514
4	0.0548	0.0576	0.0917
5	NA	0.0881	0.1514

Table B-8. Boiler Emissions, 2017 Ozone Season (May to September)

Unit	Landfill Gas			Natural Gas			Fuel Oil			Emissions		
	Scf	MM BTU	EF	Scf	MM BTU	EF	gals	MM BTU	EF	lbs/day	lbs/yr	ton/yr
Boiler 1	46,280,000	23,140	0.05	14,405,929	14,694	0.06	0	0	0.09	56.3	2,119	1.1
Boiler 2	47,581,000	23,791	0.05	15,568,951	15,880	0.06	0	0	0.09	63.4	2,223	1.1
Boiler 3	NA	NA	NA	3,482,268	3,552	0.09	0	0	0.15	41.2	314	0.0
Boiler 4	102,424,000	51,212	0.05	17,885,432	18,243	0.06	0	0	0.09	73.1	3,862	1.9
Boiler 5	NA		NA	6,697,428	6,831	0.09	0	0	0.15	39.4	605	0.0

EF- Emissions Factor
All NO_X emission factors in lbs/MMBTU.
NO_X emission factors based on 2012 stack testing.
PM, SO_X, CO, and VOC emission factors for landfill and natural gas are in lbs/10^6 Scf.
PM, SO_X, CO, and VOC emission factors for fuel oil are in lbs/10^3 gallons.
Landfill gas energy content assumed to be 500 BTU/Scf.
Natural gas energy content assumed to be 1,020 BTU/Scf.
Fuel oil energy content assumed to be 140,000 BTU/gal.
S = sulfur content of fuel oil, assumed to be at regulatory limit of 0.3 percent.

Total NO_X	273.4	9,123	4.1
Other Emissions Summary			
Total PM	25.4	1,172	0.6
Total SO_X	3.4	153	0.1
Total CO	355.6	12,958	6.5
Total VOC	23.3	848	0.4

Table B-9. Boiler Emissions, 2017 Calendar Year

Unit	Landfill Gas			Natural Gas			Fuel Oil			Emissions		
	Scf	MM BTU	EF	Scf	MM BTU	EF	gals	MM BTU	EF	lbs/day	lbs/yr	ton/yr
Boiler 1	150,529,000	75,265	0.05	44,133,404	45,016	0.06	80	11	0.09	72.4	6,731	3.4
Boiler 2	180,456,000	90,228	0.05	59,572,682	60,764	0.06	0	0	0.09	74.5	8,462	4.2
Boiler 3	NA	NA	NA	15,682,028	15,996	0.09	566	79	0.15	54.5	1,428	0.7
Boiler 4	228,632,000	114,316	0.05	53,275,723	54,341	0.06	12	2	0.09	80.5	9,410	4.7
Boiler 5	NA	NA	NA	27,096,178	27,638	0.09	0	0	0.15	43.6	2,447	1.2
								Total NO_X		325.5	28,478	14.2
								Other Emissions Summary				
								Total PM		38.4	3,604	1.8
								Total SO_X		32.0	484	0.2
								Total CO		412.6	39,826	20.0
								Total VOC		27.0	2,608	1.3

EF- Emissions Factor
All NO_X emission factors in lbs/MMBTU.
NO_X emission factors based on 2012 stack testing.
PM, SO_X, CO, and VOC emission factors for landfill and natural gas are in lbs/10^6 Scf.
PM, SO_X, CO, and VOC emission factors for fuel oil are in lbs/10^3 gallons.
Landfill gas energy content assumed to be 500 BTU/Scf.
Natural gas energy content assumed to be 1,020 BTU/Scf.
Fuel oil energy content assumed to be 140,000 BTU/gal.
S = sulfur content of fuel oil, assumed to be at regulatory limit of 0.3 percent.

Table B-10. 2017 Boiler Fuel Input (12-Month Rolling Sum)	
Month	**MMBTU**
Jan	496,116
Feb	436,109
Mar	496,002
Apr	491,606
May	491,701
Jun	492,120
Jul	492,548
Aug	491,841
Sep	491,964
Oct	488,961
Nov	485,598
Dec	484,655
Note: The 12-month rolling heat input shall not exceed 750,000 MMBtu.	

Table B-11. NO_X Emissions for Generators, 2017						
	Generator NO_X Emissions			**Ozone Season NO_X Emissions**		
	Operating Hours	**lbs/yr**	**tons/yr**	**Operating Hours**	**lb/yr**	**tons/yr**
EU10-3	2	32.2	0.02	1	16.1	0.01
EU24C-1	10	321.9	0.16	7	225.3	0.11
EU24C-2	10	321.9	0.16	7	225.3	0.11
EU24C-3	7	225.3	0.11	4	128.7	0.06
EU24C-4	9	289.7	0.14	7	225.3	0.11
EU24C-6	10	126.9	0.06	7	88.8	0.04
EU24C-8	7	225.3	0.11	4	128.7	0.06
EU29-1	3	31.4	0.02	1	13.6	0.01
EU31-1	15	700.0	0.35	9	420.0	0.21
EU31-2	15	700.0	0.35	9	420.0	0.21
EU31-3	15	700.0	0.35	9	420.0	0.21
EU31-4	11	513.3	0.26	8	373.3	0.19
EU31-5	16	746.7	0.37	10	466.7	0.23
EU7-2	2	32.2	0.02	1	16.1	0.01
EU7-3	23	370.1	0.19	11	177.0	0.09

Table B-12. GSFC Drainage Areas		
Drainage Basin	**Tributary**	**River Basin**
Greenbelt site: DB-1, DB-2, and DB-3 Area 200: R2-1, R2-2, R2-3, R2-4, and R2-5	Beaverdam Creek	Anacostia
Greenbelt site: DB-4 Area 100: R1-1 and R1-2 Area 300, R3 Area 400, R4	Beck Branch	Anacostia
Greenbelt site: DB-5 and DB-6	Folly Branch	Patuxent
Greenbelt site: DB-7, DB-8 and DB-9	Bald Hill Branch	Patuxent

Table B-13. GSFC Stormwater Management Structures							
BMP ID (Asset number)	**Structure Name**	**Year Constructed**	**BMP Type**	**Impervious Acres**	**Impervious Acres Treated**	**Urban Acres**	**Drainage Basin ID**
SWM001	Main	1966	PWET	58.46	0.00	183.52	DB1
SWM002	Sediment	1966	PWET	53.80	0.00	140.35	DB1
SWM003	Building 28	1992	XDPD	3.62	0.00	4.82	DB2
SWM004	Building 29	1990	PWED	13.24	11.60	22.15	DB3
SWM005	Building 17	1963	PWET	2.27	0.00	6.17	DB8
SWM006	Beaver	1963	WEDW	29.58	0.00	87.63	DB4
SWM007	Building 31	1994	PWET	2.37	0.00	6.81	DB4
SWM008	EOSDIS (Bldg. 32)	1992	PWET	19.36	14.79	44.35	DB7
SWM009	ESSB (Bldg. 33)	1998	PWET	5.11	5.11	19.29	DB6
SWM010	Visitor Center	2007	PWED	1.95	1.95	3.56	DB7
SWM011	Hubble Road	2007	PWED	0.83	0.83	2.18	North of DB3
SWM012	Soil Conservation Service Road	2007	PWED	ND	0.07	1.32	DB4
SWM013	Good Luck Road	2008	PMED	3.27	3.27	15.19	DB5
SWM014	Wetland Mitigation	2008	WEDW	ND	0.00	29.4	DB4
SWM015	Cobe Road	1990	PWET	0.285	0.00	1.37	DB1
SWM016	Corn Field (Good Luck Rd Soil Stock Pile)	2006	PWET	0.08	0.00	nd	DB4

Table B-13. GSFC Stormwater Management Structures

BMP ID (Asset number)	Structure Name	Year Constructed	BMP Type	Impervious Acres	Impervious Acres Treated	Urban Acres	Drainage Basin ID
SWM017	ESB (Bldg. 34)	2010	PWET	ND	10.89	19.73	DB4
SWM018	Explorer Road	2007	PWET	ND	2.38	5.74	DB4
SWM019	Bioretention (Bldg. 32)	2008	FBIO	0.11	0.00	0.26	DB7
SWM020	Bioretention (Bldg. 32)	2008	FBIO	0.09	0.00	0.14	DB7
SWM021	Bioretention (Bldg. 32)	2008	FBIO	0.18	0.00	0.44	DB7
SWM022	Building 35	2012	XDPD	ND	3.73	5.49	DB4
SWM023	Rain Garden (Bldg. 32)	2010	MRNG	ND	0.00	0.35	DB7
SWM024	Bioretention (Bldg. 36)	2016	REDE	0.26	0.26	0.49	DB8
SWM025	Bioretention (Bldg. 36)	2016	REDE	0.29	0.29	0.44	DB8
SWM026	Bioretention (Bldg. 36)	2016	REDE	0.30	0.30	0.35	DB8
SWM027	Bioretention (Bldg. 36)	2016	REDE	0.72	0.72	1.19	DB8
SWM028	Bioretention (Bldg. 36)	2016	REDE	0.34	0.34	0.44	DB8

[1] No data. Pond not designed as management facility
PWET: Retention Pond (Wet)
XDPD: Detention Structure (Dry Pond)
PWED: Extended Detention Structure (Wet)
WEDW: ED-Wetland
FBIO: Bioretention
MRNG: Rain Gardens
REDE: Redevelopment Project

Table B-14. Distribution and Abundance of Frogs and Toads on GSFC	
Species	% Sites*
Southern leopard frog	83
American toad	75
Gray treefrog	75
Northern spring peeper	67
Green frog	58
Bullfrog	50
Northern cricket frog	50
Fowler's toad	42
Pickerel frog	17
**Percent of sites surveyed that species was found*	
Source: *Biodiversity Survey of the Goddard Space Flight Center, Greenbelt, Maryland by University of Maryland, 2004.*	

Table B-15. Distribution of Birds on GSFC							
Species	**Lg**	**Med**	**Sm**	**Species**	**Lg**	**Med**	**Sm**
Area Sensitive Birds				Black-and-white warbler	X		
Red-shouldered hawk	X			Worm-eating warbler	X		
Yellow-billed cuckoo	X	X		Ovenbird	X		
Red-bellied woodpecker	X	X	X	Summer tanager	X		
Hairy woodpecker	X	X	X	Scarlet tanager	X	X	
Pileated woodpecker	X			**Suburban Birds**			
Eastern wood-peewee	X	X	X	Blue jay	X	X	X
Acadian flycatcher	X	X		American robin	X	X	X
White-breasted nuthatch	X	X	X	Gray catbird	X	X	X
Blue-gray gnatcatcher	X	X	X	Northern mockingbird	X	X	X
Wood thrush	X	X		European starling		X	X
Yellow-throated vireo	X	X		Northern cardinal	X	X	X
Red-eyed vireo	X	X		Song sparrow		X	X
Northern parula	X	X		House sparrow	X	X	X
Source: Biodiversity Survey of the Goddard Space Flight Center, Greenbelt, Maryland by University of Maryland, 2004.							

Table B-16. Steam Production (lbs)			
Month	**Steam Produced**	**Month**	**Steam Produced**
Jan	39,767,000	Jul	22,559,622
Feb	34,603,991	Aug	22,573,147
Mar	39,865,228	Sep	22,718,340
Apr	29,156,000	Oct	25,575,291
May	27,331,252	Nov	32,931,751
Jun	23,058,775	Dec	40,921,479
		Total	361,061,876

Table B-17. Total Water Use		
Fiscal Year (FY)	**Well Water (gal)**	**Domestic Water (gal)**
2012	62,176,000	86,200,000
2013	75,052,000	94,700,000
2014	73,102,000	85,400,000
2015	81,470,000	90,000,000
2016	87,570,000	99,100,000
2017	77,427,000	89,200,000
Note: Well data source:Semi-Annual Well Withdraw Repoort *Domestic Water data source: NASA Environmental Tracking System*		

Table B-18. Average Daily Well Water Consumption, (gal/day)						
Month	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
January	136,323	152,000	164,194	170,097	158,387	148,645
February	149,536	153,679	162,607	116,571	175,857	149,750
March	156,097	177,323	166,581	139,387	199,806	171,903
April	165, 600	208,933	184,933	185,800	257,733	201,633
May	219,935	230,129	233,032	270,032	226,806	192,323
June	242,500	240,067	214,033	291,500	287,600	297,667
July	109,355	345,742	261,774	319,935	360,129	353,839
August	242,645	309,323	251,419	313,742	360,645	308,742
September	201,433	238,033	208,300	301,400	294,567	269,333
October	156,258	164,548	156,839	185,065	229,065	219,806
November	133,267	181,167	197,667	189,967	182,800	185,067
December	131,161	62, 968	198,452	187,097	141,452	174,871
Annual Average	**169,880**	**205,622**	**200,279**	**223,205**	**239,262**	**212,129**

Note: This data is acquired from two production wells-- one at the Central Heating and Refrigeration Plant and the other at the East Campus Heating and Refrigeration Plant. The water is used for heating and cooling operations.
Permit limits for the Water and Appropriation and Use Permit No, PG1998G023 (3) are 257,000 gallons on a yearly basis (daily average) and 375,000 gallons for the month of maximum use (daily average).

Table B-19. Septic Tanks at GSFC	
Building	**Have permit?**
83	Yes
101	No
104	No
201	No
205	No
206	Yes
208	No
302	No
304	No
405, 407, 414	No

Table B-20. Natural and Landfill Gas Use		
Month	**Natural Gas (Scf)**	**Landfill Gas (Scf)**
Jan	23,890,001	61,371,000
Feb	20,840,001	50,526,000
Mar	28,459,999	47,158,000
Apr	11,280,005	54,963,000
May	10,430,000	52,707,000
Jun	18,560,002	22,936,000
Jul	9,890,004	39,454,000
Aug	10,250,005	39,361,000
Sep	8,909,997	41,827,000
Oct	11,679,999	44,829,000
Nov	19,489,999	47,840,000
Dec	26,080,003	56,645,000
Totals	199,760,015	559,617,000

Table B-21. No. 2 Fuel Oil Use (gallons)			
Month	**Boilers**	**Emergency Generators**	**Monthly Total**
Jan	520	34	554
Feb	0	1,039	1,039
Mar	0	114	114
Apr	0	955	955
May	0	101	101
Jun	0	3,301	3,301
Jul	0	1,844	1,844
Aug	0	955	955
Sep	0	1,096	1,096
Oct	0	101	101
Nov	0	1,636	1,636
Dec	138	449	587
Total	658	11,624	12,282

Table B-22. GSFC Solid Waste Generation			
Fiscal Year (FY)	**Recycled (lbs)**	**Disposal (landfill and Incineration lbs.)**	**Percent of Solid Waste Diverted**
2012	40,751,719	3,056,020	93%
2013	1,586,971	2,324,100	41%
2014	2,021,146	1,733,260	54%
2015	2,343,826	2,229,021	51%
2016	1,925,184	1,841,900	51%
2017	1,356,144	1,711,400	44%

Table B-23. Hazardous Waste Generation	
Reporting Year	**Hazardous Waste (lbs)**
2012	42,452
2013	45,376
2014	23,729
2015	58,724
2016	32,588
2017	43,048

Table B-24. Total Waste Generation by Organization (Hazardous, Universal, and Non-RCRA wastes)			
Organization	**CY 2015 (lbs)**	**CY 2016 (lbs)**	**CY 2017 (lbs)**
Code 200: Facilities Management	118,063	63,735	73,287
Code 400: Flight Programs & Projects	360	445	484
Code 500: Applied Engineering & Technology	41,025	47,095	39,959
Code 600: Sciences & Exploration	6,200	6,857	8,819
Center-Wide Total	167,201	119,323	125,552

Table B-25. GSFC Tier II Chemicals, 2017		
Chemical Name	**TPQ (lbs)**	**On GSFC (lbs)**
Acetone	**10,000**	**11000**
Argon, Refrigerated	10,000	24,999
Chlorodifluoromethane	10,000	74,999
Chloroform	500	999
E-85	10,000	49,999
Freon 22	10,000	74,500
#2 Fuel Oil	10,000	1,538,280
Gasoline	10,000	99,999
Helium, Refrigerated	10,000	12,549
Hydrochloric Acid	500	999
Hydrofluoric Acid	100	218
Hydrogen Peroxide	500	538
Isopropanol	10,000	24,999
Lead	10,000	10,000
Nickel Carbonyl	1	1
Nitrogen, cryogenic	10,000	37,885
Nitric Acid	1,000	4,999
Oils	10,000	481,360
Oxygen	10,000	31,891
Potassium Cyanide	100	161
Sulfuric Acid	500	9,999
Sodium Cyanide	100	110

Table B-26. Maryland Noise Standards		
Zoning District	**Environmental Noise Standards**	**Maximum Allowable Noise Levels Day/Night (dBA)**
Industrial	70 $L_{eq}(24)$	75/75 dBA
Commercial	64 L_{dn}	67/62 dBA
Residential	55 L_{dn}	65/55 dBA
$L_{eq}(24)$ = The time-weighted average for 24 hours. *L_{dn} = The day-night average sound level.* *dBA = A-weighted decibel*		

Table B-27. Prince George's County Population by Race and Ethnicity		
Race/Ethnic Origin	**Persons**	**Distribution**
Total Population	912,756	100%
Black or African American	574,112	63%
White	148,281	16%
American Indian and Alaska Native	3,114	>1%
Asian	39,223	4%
Native Hawaiian and Other Pacific Islander	512	>1%
Some Other Race	123,795	14%
Two or More Races	23,719	3%
Hispanic	169,039	19%
Source: American Community Survey 2017; Margin of error estimated to be 7% *Hispanic can be of any race.*		

Table B-28. Prince George's County Household Composition				
	2010		**2017**	
Family Households	203,520	66.9%	204,044	66%
Married-couple families	122,000	40.1%	123,697	40%
Female householder, no husband	62,001	20.4%	59,846	19%
Male householder, no wife	30,802	10.1%	20,501	7%
Nonfamily Households	100,522	33.1%	106,686	34%
Source: U.S. Census Bureau; 2010 Decennial Census and American Community Survey 2016 5-year counts *Note: Adding all percentages will not total 100 percent*				

Table B-29. Prince George's County Employment Statistics					
	2017	**2016**	**2015**	**2014**	**2013**
Labor Force	524,032	510,407	512709	508,974	505,012
Employment	477,960	469,724	465776	459,978	455,167
Unemployment	29,943	40,683	44,323	48,996	49,845
Unemployment Rate	*5.3%*	*8.0%*	*8.7%*	*9.6%*	*9.9%*
Source: American Community Survey and American FactFinder - Results.					

Table B-30. GSFC Power Consumption	
Fiscal Year (FY)	**Total Consumption (Kilowatt-Hours)**
2011	159,762
2012	160,337
2013	161,281
2014	161,224
2015	163,550
2016	165,425
2017	162,809

Table B-31. Population Counts at Greenbelt Site	
Greenbelt (On-Campus)	As of January, 2018
Civil Servants:	2,840
Contractors & Other:	5,360
Total:	8,200
Note: Other means Civil Servant but not Goddard employed (i.e. NAVY, NOAA, etc.). Contractor numbers fluctuate frequently.	

Table B-32. Prince George's County Household Income Statistics				
YEAR	**2017**	**2016**	**2015**	**2014**
Median Household Income	$81,240	$75,925	$74,260	$73,856
Average Household Income	$99,417	$92,135	$90,268	$89,867
Per Capita income	$35,947	$33,220	$32,639	$32,637
Source: American Community Survey and American FactFinder - Results				

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Appendix C - Rare, Threatened and Endangered Species List

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Current and Historical Rare, Threatened, and Endangered Species for Maryland

Maryland Department of Natural Resources Wildlife and Heritage Service

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	STATE STATUS
Animals				
Alasmidonta undulata	Triangle Floater	G4	S1	E
Autochton cellus	Golden-banded Skipper	G4	SH	X
Botaurus lentiginosus	American Bittern	G4	S1B	T
Cambarus acuminatus	Acuminate Crayfish	G4Q	S2	I
Celithemis martha	Martha's Pennant	G4	S1	
Chlorotettix sp. 1	A Cicadellid Leafhopper	GNR	SU	
Cicindela patruela	Northern Barrens Tiger Beetle	G3	S1	E
Cistothorus platensis	Sedge Wren	G5	S1B	E
Cordulegaster bilineata	Brown Spiketail	G5	S3	
Cordulegaster erronea	Tiger Spiketail	G4	S3	
Cordulegaster obliqua	Arrowhead Spiketail	G4	S2	
Elliptio lanceolata	Yellow Lance	G2G3	SU	
Enneacanthus obesus	Banded Sunfish	G5	S2	
Epitheca costalis	Slender Baskettail	G5	S1	
Etheostoma vitreum	Glassy Darter	G4G5	S1S2	T
Euphydryas phaeton	Baltimore Checkerspot	G4	S2	
Gomphaeschna antilope	Taper-tailed Darner	G4	S2	
Gomphus parvidens	Piedmont Clubtail	G4	SH	X
Gomphus rogersi	Sable Clubtail	G4	S2	I
Haliaeetus leucocephalus	Bald Eagle	G5	S3S4	
Helocordulia selysii	Selys' Sundragon	G4	S2	T
Ixobrychus exilis	Least Bittern	G5	S2S3B	I
Laccophilus schwarzi	Schwarz' Diving Beetle	GNR	SX	
Lepisosteus osseus	Longnose Gar	G5	S2?	
Leptodea ochracea	Tidewater Mucket	G3G4	S1S2	
Lethenteron appendix	American Brook Lamprey	G4	S1S2	T
Libellula flavida	Yellow-sided Skimmer	G5	S2S3	
Limotettix minuendus	Eastern Sedge Barrens Leafhopper	G1	S1	E
Lophodytes cucullatus	Hooded Merganser	G5	S3B	
Nannothemis bella	Elfin Skimmer	G4	S1	E
Nehalennia gracilis	Sphagnum Sprite	G5	S2	
Nehalennia integricollis	Southern Sprite	G5	S1S2	
Nephus gordoni	A Coccinellid Beetle	GNR	SU	
Percina bimaculata	Chesapeake Logperch	G1G2	S1S2	T
Percina notogramma	Stripeback Darter	G4	S1	E
Peucaea aestivalis	Bachman's Sparrow	G3	SHB	X
Phagocata virilis	A Planarian	GNR	S1	

Podilymbus podiceps	Pied-billed Grebe	G5	S2S3B	
Porzana carolina	Sora	G5	S2B	
Reithrodontomys humulis	Eastern Harvest Mouse	G5	SH	X
Rhionaeschna mutata	Spring Blue Darner	G4	S1	E
Somatochlora filosa	Fine-lined Emerald	G5	S2	
Sorex hoyi winnemana	Southern Pygmy Shrew	G5T4	S2	
Sorex longirostris	Southeastern Shrew	G5	S3S4	
Sperchopsis tessellatus	A Hydrophilid Beetle	GNR	S2	
Strophitus undulatus	Creeper	G5	S2	I
Stygobromus indentatus	Tidewater Amphipod	G3	S1	
Stygobromus tenuis potomacus	Potomac Amphipod	G4T4	S3	
Stygobromus tenuis tenuis	Slender Amphipod	G4T4	SU	
Stylurus laurae	Laura's Clubtail	G4	S2S3	
Tachopteryx thoreyi	Gray Petaltail	G4	S3	

Plants

Aeschynomene virginica	Sensitive Joint-vetch	G2	S1	E
Agalinis acuta	Sandplain Gerardia	G1	S1	E
Agalinis auriculata	Earleaf False Foxglove	G3	S1	E
Agalinis obtusifolia [h]	Ten-lobe False Foxglove	G4G5Q	SH	X
Agalinis setacea [h]	Thread-leaved Gerardia	G5?	S2	E
Agalinis skinneriana	Pale False Foxglove	G3G4	S1	E
Agrimonia striata [h]	Woodland Agrimony	G5	S1	E
Aletris aurea [h]	Golden Colicroot	G5	SH	X
Amianthium muscitoxicum [h]	Fly-poison	G4G5	S2	
Anagallis minima [h]	Chaffweed	G5	SU	X
Anemone canadensis [h]	Canada Anemone	G5	SH	X
Antennaria solitaria	Single-head Pussytoes	G5	S2	T
Arethusa bulbosa [h]	Swamp-pink	G4	SH	X
Arnica acaulis [h]	Leopard's-bane	G4	S1	E
Aronia prunifolia	Purple Chokeberry	G4G5Q	S3	
Arundinaria tecta	Switch Cane	G5	S2	
Asclepias rubra	Red Milkweed	G4G5	S1	E
Asclepias verticillata [h]	Whorled Milkweed	G5	S3	
Aureolaria flava [h]	Smooth Yellow False Foxglove	G5	S3	
Baptisia australis [h]	Blue Wild Indigo	G5	S2	T
Bartonia paniculata	Twining Screwstem	G5	S3	
Betula populifolia	Gray Birch	G5	S1?	
Botrychium matricariifolium	Chamomile Grapefern	G5	S1?	
Bromus nottowayanus	Nottoway Brome	G3G5	S3S4	
Buchnera americana [h]	Bluehearts	G5?	SH	X
Calopogon tuberosus	Tuberous Grass-pink	G5	S1	E
Calystegia spithamaea ssp. spithamaea [h?]	Low Bindweed	G4G5T4T5	S2	

Cardamine douglassii	Purple Cress	G5	S3	
Carex albursina	White Bear Sedge	G5	S3	
Carex aquatilis	Water Sedge	G5	S1	
Carex bullata	Button Sedge	G5	S3	
Carex buxbaumii	Buxbaum's Sedge	G5	S2	T
Carex conoidea	Field Sedge	G5	S1	E
Carex echinata [h]	Prickly Sedge	G5	S3	
Carex hirtifolia	Pubescent Sedge	G5	S3	
Carex hitchcockiana	Hitchcock's Sedge	G5	S1	E
Carex hyalinolepis	Shoreline Sedge	G4G5	S2S3	
Carex lacustris [h]	Lake-bank Sedge	G5	S2	
Carex louisianica	Louisiana Sedge	G5	S3	
Carex pedunculata	Long-stalked Sedge	G5	S1	E
Carex shortiana	Short's Sedge	G5	S2	E
Carex tenera [h]	Slender Sedge	G5	SH	X
Carex venusta	Dark Green Sedge	G4	S3S4	
Carex vestita [h]	Velvety Sedge	G5	S2	T
Centrosema virginianum	Coastal Butterfly Pea	G5	S2	
Chelone obliqua	Red Turtlehead	G4	S2	T
Chimaphila umbellata	Common Wintergreen	G5	S3	
Chrysogonum virginianum [h]	Green-and-gold	G5	S3	
Coptis trifolia [h]	Goldthread	G5	S1	E
Corallorhiza wisteriana	Spring Coralroot	G5	S1	E
Coreopsis verticillata	Whorled Coreopsis	G5	S3	
Crocanthemum bicknellii [h]	Plains Frostweed	G5	S1	E
Cyperus diandrus [?]	Umbrella Flatsedge	G5	SU	
Cyperus lancastriensis	Many-flowered Umbrella-sedge	G5	SU	
Cyperus refractus	Reflexed Flatsedge	G5	S2?	
Cypripedium parviflorum var. pubescens [h]	Large Yellow Lady's-slipper	G5T5	S3	
Desmodium canadense [h]	Showy Tick-trefoil	G5	SH	
Desmodium laevigatum	Smooth Tick-trefoil	G5	S3	
Desmodium obtusum [h]	Stiff Tick-trefoil	G4G5	S1	E
Dicentra eximia [l]	Wild Bleedinghearts	G4	S2	T
Dichanthelium bicknellii	Bicknell's Witchgrass	G5	SU	
Dichanthelium laxiflorum	Open-flower Witchgrass	G5	S1?	
Dichanthelium oligosanthes var. oligosanthes [h]	Few-flowered Witchgrass	G5T5?	S2S3?	
Dichanthelium ravenelii [h]	Ravenel's Witchgrass	G5	SH	
Diphasiastrum tristachyum	Deep-root Clubmoss	G5	S3	
Doellingeria infirma [h]	Cornel-leaf Aster	G5	S3	
Drosera rotundifolia	Roundleaf Sundew	G5	S3	
Elatine americana [h]	American Waterwort	G4	SU	

Eleocharis engelmannii	Engelmann's Spikerush	G4G5	S3	
Eleocharis tortilis	Twisted Spikerush	G5	S3	
Erigenia bulbosa	Harbinger-of-spring	G5	S3	
Eriocaulon decangulare	Ten-angle Pipewort	G5	S1	
Eriophorum virginicum	Tawny Cottongrass	G5	S3	
Eupatorium leucolepis [h]	White-bracted Thoroughwort	G5	S2S3	T
Eurybia radula	Rough Wood Aster	G5	S1	E
Fimbristylis annua h	Annual Fimbry	G5	S3	
Gaylussacia dumosa	Dwarf Huckleberry	G5	S1	E
Gentiana andrewsii	Fringe-top Bottle Gentian	G5?	S2	T
Gentiana villosa h	Striped Gentian	G4	S1	E
Geum laciniatum h	Rough Avens	G5	S3	
Gratiola viscidula	Short's Hedge-hyssop	G4G5	S1	E
Hemianthus micranthemoides h	Nuttall's Micranthemum	GH	SH	X
Hibiscus laevis	Halberd-leaf Rosemallow	G5	S3	
Homalosorus pycnocarpos	Glade Fern	G5	S2	T
Hylodesmum pauciflorum	Few-flowered Tick-trefoil	G5	S2	E
Hypericum gymnanthum	Clasping-leaf St. John's-wort	G4	S3	
Hypericum virgatum h	Sharpleaf St. John's-wort	G4?	SH	
Ilex decidua	Deciduous Holly	G5	S2	
Iris prismatica h	Slender Blueflag	G4G5	S2	E
Iris verna h	Dwarf Iris	G5T3T5	S1	E
Iris virginica h	Virginia Blueflag	G5	S3	
Isoëtes engelmannii	Engelmann's Quillwort	G4	S3	
Isoëtes riparia h	Riverbank Quillwort	G5	SU	
Juncus longii	Long's Rush	G3Q	S1	E
Juncus torreyi	Torrey's Rush	G5	S1	E
Kalmia angustifolia	Sheep Laurel	G5	S3S4	
Krigia dandelion	Potato Dwarf-dandelion	G5	S2S3	
Lathyrus palustris h	Vetchling Peavine	G5	S1	E
Lechea tenuifolia h	Slender Pinweed	G5	SH	X
Lespedeza stuevei	Silky Lespedeza	G4?	S3	
Linum intercursum	Sandplain Flax	G4	S2	T
Liparis liliifolia h	Large Twayblade	G5	S2S3	
Listera australis	Southern Twayblade	G4	S3	
Lithospermum virginianum h	Virginia False Gromwell	G4	S1	E
Ludwigia decurrens	Primrose-willow	G5	S2S3	
Ludwigia hirtella h	Hairy Ludwigia	G5	S1	E
Lupinus perennis h	Sundial Lupine	G5	S2	T
Lygodium palmatum	Climbing Fern	G4	S2	T
Lythrum alatum h	Winged Loosestrife	G5	S1	E
Magnolia tripetala	Umbrella Magnolia	G5	S3	
Malaxis unifolia h	Green Adder's-mouth Orchid	G5	S1S3	
Malus angustifolia	Southern Crabapple	G5?	S3	
Matelea carolinensis !	Carolina Anglepod	G4	S2	E
Matteuccia struthiopteris h	Ostrich Fern	G5	S2S3	
Mecardonia acuminata !	Purple Mecardonia	G5	S2	E
Melica mutica h	Narrow Melicgrass	G5	S3	
Melothria pendula !	Guadeloupe Cucumber	G5?	S2	E

Monarda media l	Purple Bergamot	G4?	SH	
Monotropsis odorata h	Sweet Pinesap	G3	S1	E
Muhlenbergia capillaris h	Hair-awn Muhly	G5	S1	E
Muhlenbergia glabriflora h	Hairgrass	G4?	SH	
Muhlenbergia sylvatica h	Woodland Muhly	G5	S3	
Myosotis macrosperma	Large-seed Forget-me-not	G5	S3S4	
Myosotis verna	Spring Forget-me-not	G5	S3	
Nemophila aphylla	Small-flower Baby-blue-eyes	G5	S2	
Oldenlandia uniflora h	Clustered Bluets	G5	S3	
Orbexilum pedunculatum var.				
Orthilia secunda h	One-side Wintergreen	G5	SH	X
Panax quinquefolius h	American Ginseng	G3G4	S2S3	
Panicum philadelphicum h	Philadelphia Panicgrass	G5	SU	
Parthenium integrifolium h	American Feverfew	G5	S1	E
Pedicularis lanceolata	Swamp Lousewort	G5	S1	E
Penstemon laevigatus h	Smooth Beardtongue	G5	SU	
Phacelia covillei	Buttercup Scorpionweed	G3	S2	E
Phacelia purshii	Miami-mist	G5	S3	
Phemeranthus teretifolius h?	Roundleaf Fameflower	G4	S2	T
Phyllanthus caroliniensis h	Carolina Leaf-flower	G5	S3	
Pilea fontana	Springs Clearweed	G5	S3	
Plantago cordata h	Heartleaf Plantain	G4	SH	X
Platanthera blephariglottis var.				
Platanthera ciliaris h	Yellow Fringed Orchid	G5	S2	T
Platanthera cristata	Crested Yellow Orchid	G5	S3	
Platanthera flava	Pale Green Orchid	G4?	S2	
Platanthera peramoena h	Purple Fringeless Orchid	G5	S1S2	T
Pluchea camphorata h	Marsh Fleabane	G5	S1	E
Podostemum ceratophyllum	Threadfoot	G5	S3	
Pogonia ophioglossoides	Rose Pogonia	G5	S3	
Polygala cruciata	Crossleaf Milkwort	G5	S2	T
Polygala incarnata h	Pink Milkwort	G5	S2S3	
Polygala polygama	Racemed Milkwort	G5	S1	T
Potamogeton amplifolius ?	Large-leaved Pondweed	G5	S1S2	
Potamogeton foliosus !	Leafy Pondweed	G5	S1?	E
Potamogeton perfoliatus	Claspingleaf Pondweed	G5	S3	
Potamogeton pusillus	Slender Pondweed	G5	S2S4	
Potamogeton robbinsii h	Flatleaf Pondweed	G5	SH	X
Prunus susquehanae h	Susquehanna Sandcherry	G5	SH	
Pseudolycopodiella caroliniana	Carolina Clubmoss	G5	S1	E
Ptelea trifoliata	Common Hoptree	G5	S3	
Pycnanthemum				
Pycnanthemum verticillatum h	Whorled Mountainmint	G5	S1	E
Pyrola chlorantha h	Green-flower Wintergreen	G5	SH	X
Quercus macrocarpa l	Bur Oak	G5	S1	
Ranunculus ambigens !h	Water-plantain Spearwort	G4	S1	X
Ranunculus flabellaris	Yellow Water Crowfoot	G5	S1	E
Ranunculus hederaceus h	Long-stalked Crowfoot	G5	S1	E
Ranunculus pusillus	Pursh's Buttercup	G5	SU	

Rhynchospora alba	White Beakrush	G5	S3	
Rhynchospora cephalantha	Capitate Beakrush	G5	S1	E
Rhynchospora glomerata h	Clustered Beakrush	G5	S3	
Rhynchospora microcephala	Small-headed Beakrush	G5	S2	
Rhynchospora oligantha h	Few-flowered Beakrush	G4	SH	X
Rhynchospora rariflora !	Few-flowered Beakrush	G5	SU	X
Rhynchospora recognita h	Cymose Beakrush	G5?	S2	
Ribes cynosbati	Prickly Gooseberry	G5	S3	
Rudbeckia fulgida h	Orange Coneflower	G5	S3	
Sagittaria engelmanniana h	Engelmann's Arrowhead	G5?	S2	T
Sagittaria rigida h	Sessile-fruit Arrowhead	G5	S1	E
Salix exigua	Narrowleaf Willow	G5	S1	E
Salix occidentalis h	Dwarf Prairie Willow	G5T4T5	S2	
Sanguisorba canadensis h	Canada Burnet	G5	S2	T
Sarracenia purpurea	Northern Pitcherplant	G5	S2	T
Schoenoplectus novae-angliae	Salt-marsh Bulrush	G5	S2	
Schoenoplectus smithii h	Smith's Bulrush	G5?	SH	X
Scirpus expansus ?	Woodland Bulrush	G4	S3	
Scleria muehlenbergii h	Muhelenberg's Nutrush	G5	S1S2	
Scleria reticularis h	Reticulated Nutrush	G4	S2S3	
Scleria triglomerata	Whip Nutrush	G5	S3	
Scutellaria nervosa !	Veined Skullcap	G5	S1S2	E
Scutellaria serrata h	Showy Skullcap	G4G5	S3	
Silene nivea h	Snowy Campion	G4?	S1	E
Smilax pseudochina	Long-stalk Greenbrier	G4G5	S2	T
Solidago latissimifolia h	Elliott's Goldenrod	G5	S3	
Solidago patula	Sharp-leaved Goldenrod	G5	S3	
Solidago speciosa h	Showy Goldenrod	G5	S2	T
Solidago uliginosa	Bog Goldenrod	G4G5	S3	
Sparganium eurycarpum	Giant Bur-reed	G5	S3	
Sphenopholis pensylvanica	Swamp Wedgescale	G4	S2	T
Spiranthes tuberosa	Little Ladies'-tresses	G5	S1?	
Stachys hyssopifolia h	Hyssopleaf Hedge-nettle	G4G5	S1	
Stellaria alsine	Trailing Stitchwort	G5	S1	E
Stenanthium gramineum h	Eastern Featherbells	G4G5	S1	T
Symphyotrichum concolor h	Eastern Silvery Aster	G5	S1	E
Thelypteris simulata	Bog Fern	G4G5	S2	T
Torreyochloa pallida var. pallida	Pale Mannagrass	G5T5	S3	
Triantha racemosa h	Coastal False Asphodel	G5	SX	X
Trichophorum planifolium h	Bashful Bulrush	G4G5	S2	
Utricularia striata	Fibrous Bladderwort	G4G5	S1	E
Utricularia subulata	Zigzag Bladderwort	G5	S3	
Vaccinium macrocarpon h	Large Cranberry	G4	S3	
Veratrum virginicum	Virginia Bunchflower	G5	S3	
Viburnum lentago Ih	Nannyberry	G5	S1	
Vitis rupestris h	Rock Grape	G3	S1	
Xyris fimbriata	Fringed Yellow-eyed-grass	G5	S1	E

Symphyotrichum concolor [h]	Eastern Silvery Aster	G5	S1	E
Thelypteris simulata	Bog Fern	G4G	S2	T
Torreyochloa pallida var. pallida	Pale Mannagrass	G5T5	S3	
Triantha racemosa [h]	Coastal False Asphodel	G5	SX	X
Trichophorum planifolium [h]	Bashful Bulrush	G4G	S2	
Utricularia striata	Fibrous Bladderwort	G4G	S1	E
Utricularia subulata	Zigzag Bladderwort	G5	S3	
Vaccinium macrocarpon [h]	Large Cranberry	G4	S3	
Veratrum virginicum	Virginia Bunchflower	G5	S3	
Viburnum lentago [lh]	Nannyberry	G5	S1	
Vitis rupestris [h]	Rock Grape	G3	S1	
Xyris fimbriata	Fringed Yellow-eyed-grass	G5	S1	E

Definitions of qualifiers used in the county distribution of species.

Distributional Qualifier	Definition
{species}$^{?}$	Record for the county is reported but unverified or may indicate that the record occurs outside of the known range or in atypical habitat.
{species}^{h}	Record for the county is based upon a historical collection but no extant population is known.
{species}^{I}	Record for the county is the result of an introduction.
{species}!	An indicator that the conservation status of that species is currently under review.

Table 1. Definitions of Global (G) and State (S) Conservation Ranks and Rank Qualifiers.

Rank	Definitions global/state
GX or SX	**Presumed Extirpated**—Species believed to be extirpated from the jurisdiction (i.e. global, or state/province). Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.
GH or SH	**Historical (Possibly Extirpated)**—Known only from historical records but still some hope of rediscovery. There is evidence that the species may no longer be present in the jurisdiction, (i.e. global, or state/province) but not enough to state this with certainty.
G1 or S1	**Critically Imperiled/Highly State Rare**—At very high risk of extinction or extirpation due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors. Typically occurring in five or fewer populations.
G2 or S2	**Imperiled/State Rare**—At high risk of extinction or extirpation due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors. Typically occurring in 6-20 populations.
G3 or S3	**Vulnerable/Watchlist**—At moderate risk of extinction or extirpation due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors. Typically occurring in 21-80 populations.

G4 or S4	**Apparently Secure**—At fairly low risk of extinction or extirpation due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
G5 or S5	**Demonstrably Secure—**At very low risk of extinction or extirpation due to a very extensive range, abundant populations or occurrences, and little to no concern
S3.1	**Vulnerable and globally rare—**A species that is actively tracked by the Service because of the global significance of Maryland occurrences. Although not currently threatened or endangered, Maryland occurrences may be critical to the long-term security of the species.
SE	**Exotic**—Established but not native to Maryland.
SNA	**Not Applicable—**A conservation status rank is not applicable because the species is not a suitable target for conservation activities.
SNR	**Not ranked**.
SR	**Reported**—Reported from Maryland but without persuasive evidence that would provide a basis for either accepting or rejecting the report. These species are presented in Appendix
SRF	**Reported falsely—**Reported in error from Maryland and the error may persist in the
SU	**Status Uncertain**—A numerical rank cannot be established with confidence for reasons including lack of historical records, low survey effort, cryptic nature of the species, or concerns that the species may not be native to the state. Uncertainty spans a range of more than three ranks as defined above.
Q	**A rank qualifier—**Indicates that the taxon has questionable, controversial, or uncertain taxonomic standing, e.g., treated by some authors as a species whereas others treat as a subspecies or variety or not at all.
T	**A rank qualifier—**Indicates that the infraspecific taxon (subspecies or variety) is ranked differently than the typical species.
?	**A rank qualifier—**Indicating uncertainty that may span 2-3 ranks as defined above.
!	**An indicator** that the conservation status of that species is currently under review.

Table 2. Definitions of State and Federal legal protection Status.

State Status	Definition
Endangered (E)	A species whose continued existence as a viable component of Maryland's flora is determined to be in jeopardy.
Threatened (T)	A species that appears likely, within the foreseeable future, to become endangered in Maryland.
Endangered Extirpated (X)	A species that was once a viable component of the flora of Maryland, but for which no naturally occurring populations are known to exist.
Proposed Delist (PD)	A species proposed for delisting by the Service. These proposals are indicated in parentheses to the right of the current State Status.
Proposed Endangered (PE)	A species proposed for listing as endangered in Maryland. These proposals are indicated in parentheses to the right of the current State Status.

Proposed Threatened (PT)	A species proposed for listing as threatened in Maryland. These proposals are indicated in parentheses to the right of the current State Status.

Federal Status	**Definition**
Endangered (LE)	Taxa listed as Endangered under the federal ESA; in danger of extinction throughout all or a significant portion of its range.
Threatened (LT)	Taxa listed as Threatened under the federal ESA; likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Maryland Natural Heritage Program. 2018. Rare, Threatened, and Endangered Plants of Maryland, C. Frye Ed., Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, MD 21401. DNR 03-010418-43.

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