JUNE 12, 2015

HISTORIC ASSESSMENT
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
GAITHERSBURG, MARYLAND

PREPARED FOR:

METROPOLITAN ARCHITECTS & PLANNERS
ON BEHALF OF THE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

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June 2015

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Metropolitan Architects & Planners
on behalf of the
National Institute of Standards and Technology

Executive Summary

This report presents the results of a comprehensive study of the history and development of the National Institute of Standards and Technology (NIST) campus in Gaithersburg, Maryland. NIST is a non-regulatory Federal agency within the U.S. Department of Commerce (National Institute of Standards and Technology [NIST] 2014). This historic context and architectural survey was designed to develop an historical overview of NIST, to identify associated historic themes and property types, and to identify those resources eligible for inclusion in the National Register of Historic Places (NRHP). This investigation included comprehensive architectural survey and evaluation applying the NRHP Criteria for Evaluation (36 CFR 60.4[a-d]) for all buildings, structures, objects, and landscapes included at the NIST campus. Assessments of significance and integrity were made applying the historic context prepared as part of this current investigation. This project was undertaken by R. Christopher Goodwin & Associates, Inc. for Metropolitan Architects, Inc. on behalf of NIST to support the agency in its program to identify, evaluate, and protect cultural resources in accordance with Section 106 and Section 110 of the National Historic Preservation Act of 1966, as amended (NHPA).

The purpose of this project was threefold: to develop an historic context to support the evaluation of cultural resources that may be present on the NIST Gaithersburg campus, to comprehensively survey the built resources at the Gaithersburg campus, and to evaluate those buildings, structures, objects, and sites applying the NRHP Criteria for Evaluation (36 CFR 60.4[a-d]). Archival research was undertaken to develop an historic context appropriate for the assessment of NIST built resources. Architectural investigations supplemented the archival research. Assessments of significance and integrity were made applying the historic context developed during this current investigation.

The objectives of this current investigation were as follows:

- To develop a historic overview of NIST;
- To develop the background and administrative history of NIST;
- To identify the historical themes, time periods, and people significant to the history of NIST;
- To document resources located at the NIST Gaithersburg campus;
- To identify the range of properties associated with significant themes and time periods; and,
- To evaluate the significance and integrity of properties applying the National Register Criteria for Evaluation (36 CFR 60.4[a-d]) within the appropriate historic context.

All work was completed in accordance with the guidelines set forth in the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation (National Park Service 1983) and the Maryland Historical Trust (MHT)'s *Standards and Guidelines for Architectural and Historical Investigations in Maryland* (Maryland Historical Trust 2000). NIST has not developed agency guidance on the preparation of cultural resources investigations or technical reports. All work was undertaken by project staff who meet, or exceed, the Secretary of the Interior's professional qualifications in the disciplines of history, architectural history, and/or historic preservation.

A total of 74 buildings, structures, objects, sites, and landscapes were surveyed under the current investigation. Data analysis and application of the National Register NRHP Criteria for Evaluation to the NIST resources located at the Gaithersburg campus identified a collection of buildings, structures, and landscapes that represent a recognizable entity necessary for a NIST historic district with a 1961 – 1969 period of significance representing the first decade of development at NIST. The buildings were evaluated individually and collectively applying the Criteria for Evaluation.

The NIST historic district is significant under Criterion A for its association with events that have made important contributions to the broad patterns of history under the Science and Technology and Postwar Research Campus design themes. Ten buildings are included in the NRHP-eligible historic district; one of them (Building 227), is non-contributing. The campus landscape plan, including the Newton Apple Tree, also is a contributing resource to the district. Contributing objects include the flag pole. In addition to contributing to the NRHP, Building 101 individually is eligible for listing in the NRHP. All contributing built resources in the NIST NRHP-eligible historic district were completed between 1965 and 1966.

The AML complex comprising buildings 215, 216, 217, 218, and 219 are excluded from the proposed historic district. The interconnected buildings, while incorporating similar building materials as the GPLs, were designed as a complex unique from the general purpose labs architecturally, structurally, and in sophistication of the environmental controls systems. Two of the five buildings are completely underground. Additionally, the buildings were constructed within the past thirteen years. Insufficient time has elapsed to enable evaluation of the complex under National Register Criteria A and C. The complex does not appear to rise to the level of exceptional significance as defined under Criteria Consideration G.

The historic district also meets National Register Criterion C as a significant and distinguishable entity whose components may lack individual distinction. The collection of resources comprising the NIST historic district achieves significance as an integrated campus associated with NIST history and the Science and Technology and Postwar Research Campus design themes. Resources in the historic district are related through function and design within the research campus. Buildings in the historic district were designed by an architecture and engineering firm with an established national practice in the design of research campuses. HLW International were acknowledged experts in designing research laboratories and were innovators in the field. They introduced such concepts as the modular laboratory. In addition, they worked collaboratively with scientists and administrators to ensure the buildings and the campus met their needs. Ample landscaping also was incorporated into the design of their campuses. A suburban setting and the use of the International Style are characteristics of their designs. The inclusion of such elements in research campuses became standard practice during the postwar years. The campus is representative of the firm's body of work.

Buildings generally located west of Research Drive and south of South Drive are excluded from the potential historic district. Service and support related resources generally are located west of West Drive. While some buildings, i.e., Buildings 301 and 302, were constructed during the Initial Period of construction, others, such as Buildings 318 and 320 were built during the Third Period of construction. Support buildings were constructed to support the agency's scientific mission and were not integral to the agency's task of advanced scientific investigation and inquiry. Additionally, many of the buildings excluded from the potential historic district have undergone modifications that include numerous additions.

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List of Acronyms

ACHP	Advisory Council on Historic Preservation
AML	Advanced Measurements Laboratory
APE	Area of Potential Effects
CRPL	Central Radio Propagation Laboratory
CRS	Congressional Research Service
DES	Data Encryption Standard
DOE	Determination of Eligibility
EPA	Environmental Protection Agency
ESSA	Environmental Science Services Administration
FHA	Federal Housing Administration
FY	Fiscal Year
GPL	General Purpose Laboratory
GPS	Global Positioning System
ICC	Interstate Commerce Commission
IRPL	Interservice Radio Propagation Laboratory
JILA	Joint Institute for Laboratory Astrophysics
LESL	Law Enforcement Standards Laboratory
LINAC	Linear Accelerator
MIHP	Maryland Inventory of Historic Properties
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
NEL	National Engineering Laboratory
NML	National Measurement Laboratory
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NPS	National Park Service
NRHP	National Register of Historic Places
PML	Physical Measurement Laboratory
SEAC	Eastern Automatic Computer
SRM	Standard Reference Materials

Chapter 1.0

Introduction

1.1 Project Description

This report presents the results of a comprehensive study of the history and development of the National Institute of Standards and Technology (NIST) campus in Gaithersburg, Maryland. NIST is a non-regulatory Federal agency within the U.S. Department of Commerce (National Institute of Standards [NIST] 2014a).

The project was undertaken to support NIST in its efforts to comply with Section 106 and Section 110 of the National Historic Preservation Act of 1966 (NHPA), as amended, through the identification and evaluation of built historic properties. The NIST campus is approaching 50 years old, the minimum age generally needed for consideration for inclusion in the National Register of Historic Places (NRHP). Master planning efforts currently are underway. The purpose of the project is to identify and evaluate historic properties at NIST.

This historic context and architectural survey was designed to develop an historical overview of NIST, to identify associated historic themes and property types, and to identify those resources that meet the criteria for significance and integrity for inclusion in the NRHP. This investigation included comprehensive architectural survey and evaluation applying the NRHP Criteria for Evaluation (36 CFR 60.4[a-d]) for all buildings, structures, objects, and landscapes included at the NIST campus. This project was undertaken by R. Christopher Goodwin & Associates, Inc. for Metropolitan Architects, Inc. on behalf of NIST to support the agency in its program to identify, evaluate, and manage historic properties in accordance Section 110 of the NHPA.

NIST is located in Montgomery County, Maryland, approximately 27 miles northwest of Washington, D.C. (Figures 1.1 and 1.2). The campus encompasses approximately 578 acres in the City of Gaithersburg (NIST 2014a). NIST also maintains a research campus in Boulder, Colorado. The NIST campus is accessed from West Diamond Avenue. Interstate 270 forms the eastern boundary of the facility and Quince Orchard Road serves as the western boundary. The campus abuts a residential neighborhood along its southwest border.

1.2 Objective

The objective of the current investigation was to support NIST through the systematic identification of historic properties pursuant to Section 110 of the National Historic Preservation Act of 1966, as amended. This objective was accomplished through an integrated program of archival research, site investigation, and data analysis. Archival research was undertaken to develop the historic context appropriate for the assessment of NIST built resources. An historic context defines the events, trends, and patterns of history through which a property is understood and its meaning made clear. Comprehensive architectural survey of built resources contained within the campus was completed to systematically document all buildings, structures, and landscapes. Archival and field data then were analyzed applying the NRHP Criteria for Evaluation (36 CFR 60.4[a-d]) to identify properties that possess the significance and integrity necessary for listing in the NRHP. To accomplish the objective of identifying historic properties, the following tasks were undertaken:

- Development of a historic overview of NIST;
- Development of the background and administrative history of NIST;
- Identification of the historical themes, time periods, and people significant to the history of NIST;
- Documentation of resources located at the NIST Gaithersburg campus;

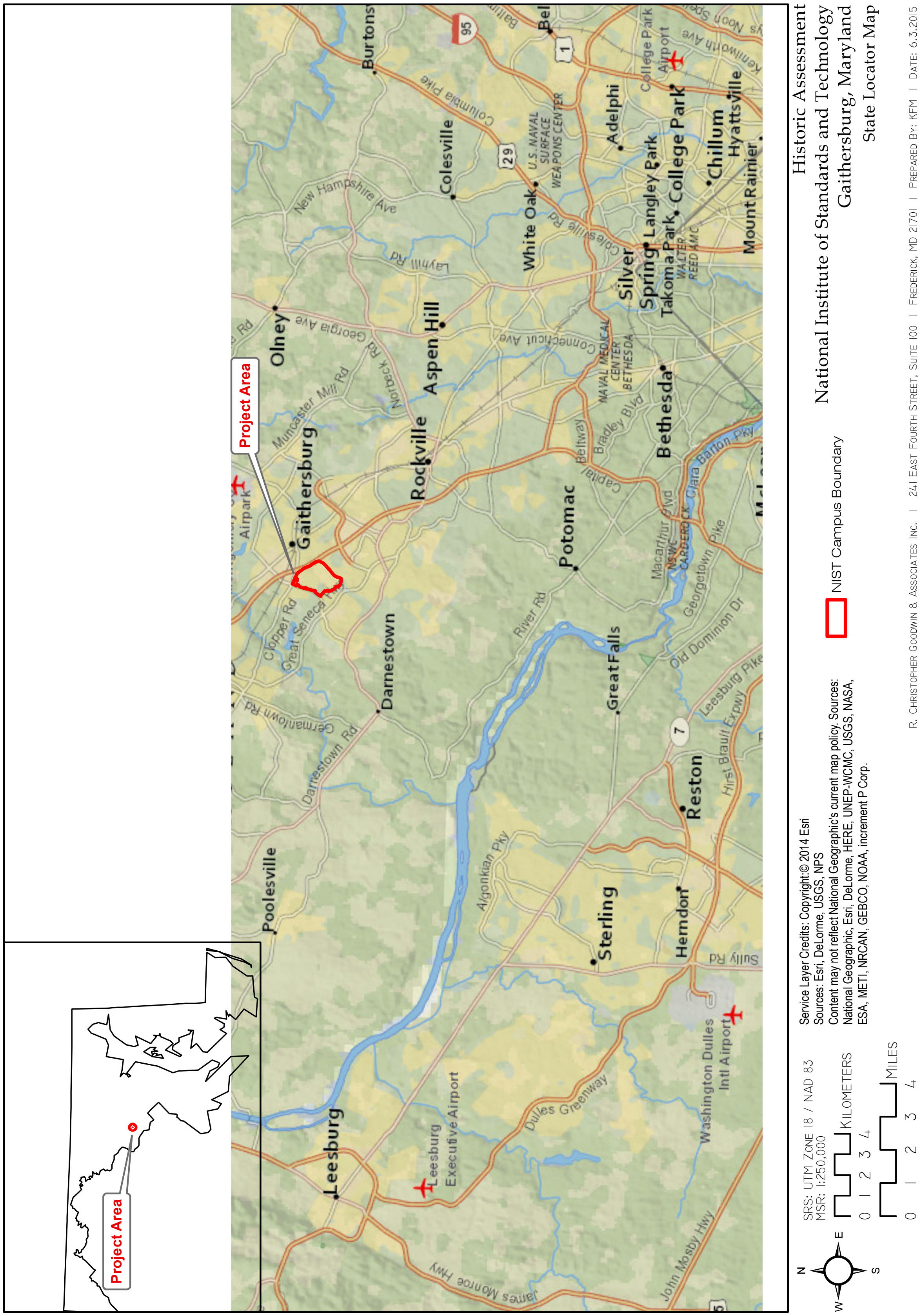

Figure 1.1 State Locater Map, (Source: RCG&A 2015).

Figure 1.2 NIST Campus, (Source: RCG&A 2015).

- Identification of the range of properties associated with significant themes and time periods; and,
- Evaluation of the significance and integrity of properties applying the National Register Criteria for Evaluation (36 CFR 60.4[a-d]) within the appropriate historic context.

All work was completed in accordance with the guidelines set forth in the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation (National Park Service 1983) and the Maryland Historical Trust (MHT)'s *Standards and Guidelines for Architectural and Historical Investigations in Maryland* (Maryland Historical Trust 2000). All work was undertaken by project staff who meet, or exceed, the Secretary of the Interior's professional qualifications in the disciplines of history, architectural history, and/or historic preservation.

1.3 Regulatory Overview

Section 106 of the NHPA requires Federal agencies to take into consideration the effects an undertaking may have on historic properties. An historic property is any resource, i.e., building, structure, object, site, or district, eligible for or is included in the NRHP. The procedures for complying with the Section 106 are codified in 36 CFR 800. Section 110 requires Federal agencies to identify, evaluate, and nominate resources to the NRHP. In addition, Section 110 directs Federal agencies to develop a preservation program.

NIST's compliance with Federal cultural resources laws and regulations is directed through the Department of Commerce's broader environmental compliance program. Specific regulations and policies governing the treatment of historic properties are presented in two documents. The Department of Commerce Administrative Order 217-16 issued on 5 April 2012 directs the implementation of the NHPA and further directs all departmental offices and operating units to comply with all Federal, state, and local environmental and cultural and historic resources laws and regulations in addition to complying with Executive Orders and other Department of Commerce regulations, policies, and requirements (U.S. Department of Commerce 2012a:2). The Administrative Order further mandates compliance with the department's *Energy and Environmental Management Manual*. The manual, which is an extension of the administrative order, provides detailed guidance on the department's environmental program and policies (U.S. Department of Commerce 2012a:5). The *Energy and Environmental Management Manual* referenced in the Administrative Order, outlines the department's cultural resources management program and department responsibilities. NIST is responsible for complying implementing all cultural resources management regulations, policies, and directives (U.S. Department of Commerce 2012b:24-5).

NIST manages historic properties in accordance with Federal laws and Department of Commerce regulations. The primary steps undertaken in cultural resources management include:

- resource identification,
- resource evaluation,
- planning, and
- treatment of historic properties.

The NRHP establishes the criteria for significance and integrity used in the identification of historic properties.

The NRHP was authorized under the NHPA as the official list of properties significant in American history, architecture, archeology, engineering, and culture. Properties worthy of preservation are included in the NRHP, which continually is expanded to represent the many facets of American history. The NRHP serves as an important planning tool. The Secretary of the Interior maintains the NRHP and has developed regulations defining the procedures for listing properties in the NRHP (36 CFR 60) The NRHP program is administered by the National Park Service (NPS).

Two important provisions of the NHPA particularly are relevant to NIST's cultural resources management responsibilities. Under Section 110 of the NHPA, Federal agencies are charged with the identification of historic properties under their stewardship. Section 106 of the legislation requires Federal agencies to consider the effects of their undertakings on properties that are listed in, or are eligible for listing in, the NRHP and to afford the Advisory Council on Historic Preservation (ACHP) the opportunity to comment.

1.4 Organization of the Report

Chapter 1 summarizes the purpose of the investigations. The research design and methodology are presented in Chapter 2. Chapter 3 provides a summary history of NIST, while Chapter 4 summarizes the construction of the NIST Gaithersburg campus. A discussion on the scientific research undertaken at the Gaithersburg campus is provided in Chapter 5. The principles of postwar research campus design are presented in Chapter 6. Chapter 7 identifies property types associated with the NIST campus. Survey and evaluation results are presented in Chapter 8. A Maryland Inventory of Historic Property (MIHP) and a Determination of Eligibility (DOE) form are included in Appendix A.

Chapter 2.0

Research Design and Methodology

This project was completed through an integrated program of archival research, site investigation, data analysis applying the Criteria for Evaluation (36 CFR 60.4[a-d]) and integrity, and report preparation. All work was completed in accordance with the guidelines set forth in the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation (National Park Service 1983), and, the MHT's *Standards and Guidelines for Architectural and Historical Investigations in Maryland* (Maryland Historical Trust 2000). All project staff meet, or exceed, the Secretary of the Interior's professional qualifications in the disciplines of history and architectural history.

2.1 The Role of the Historic Context in Resource Evaluation

An appropriate historic context is fundamental to the evaluation of historic properties. The NRHP, a program under the NPS, Department of the Interior, refined the concept of an historic context for use in cultural resources management. An historic context is an organizational framework based on theme(s), geographic area, property type, and chronological period(s). An historic context provides the foundation for decisions regarding the significance and integrity of real property.

The historic context provides the foundation for assessing real property, including buildings, structures and landscapes, located at the Gaithersburg campus of NIST. The historic context facilitates the evaluation of resources individually and collectively (as potential historic districts):

- for their association with events that have made a significant contribution to the broad patterns of our history (Criterion A);
- for their association with the lives of persons significant in our past (Criterion B);
- for their ability to embody the distinctive characteristics of a type, period, or method of construction, to represent the work of a master or possess high artistic values, or to represent a significant and distinguishable entity whose components may lack individual distinction (Criterion C); and,
- for their ability to yield, or be likely to yield, information important to prehistory or history (Criterion D).

2.2 Archival Research

Archival research into both primary and secondary sources was undertaken to develop a site-specific historic context for NIST. This historic context includes the following tasks:

- Development of a general historic overview for NIST to achieve an understanding of the role that NIST plays within the Department of Commerce as well as the role the Gaithersburg campus plays within the larger NIST context;
- Synthesis of the NIST organizational history, doctrines, significant events, and policies that influenced the development and evolution of the NIST Gaithersburg campus between 1961, when construction of the campus was begun, and the present;
- Identification of events, historical themes, people and time periods important in American history and represented in the NIST history;
- Identification of important themes and time periods relevant to the development of the campus in Gaithersburg; and,
- Identification of specific property types associated with NIST and the Gaithersburg location by time period.

Research was conducted at the following repositories to achieve these objectives: the National Archives and Records Administration, Washington, D.C. and College Park, Maryland; the Montgomery County Historical Society, and the Gaithersburg Museum. In addition, a review of the materials in the collection of the NIST library and the drawing vault maintained by NIST's Office of Facilities and Property Management was undertaken. A variety of data were collected during the archival investigations. General information regarding the establishment of NIST and information on key agency programs and areas of scientific investigation were collected. Data related to the creation of the Gaithersburg campus, including the planning, construction, and modification of NIST real property were acquired. Information gathered included construction dates, original uses, architects/engineers, and subsequent alterations. Resources particularly useful for the preparation of this technical report include three official NIST histories: *Measures for Progress: A History of the National Bureau of Standards; A Unique Institution: The National Bureau of Standards 1950-1969*; and, *Responding to National Needs* (Cochrane 1966; Passaglia 1999; Schooley 2000).

A review of previous documentation prepared as part of cultural resources investigations conducted at the NIST Gaithersburg campus also was completed. In 2014, cultural resources investigations were completed in support of the *Corridor Cities Transitway Bus Rapid Transit Build Alternative* project. The investigations were completed by RK&K on behalf of the Maryland Transit Administration in cooperation with the Federal Transit Administration (RK&K 2014:S-1). The report preparers recommended that an NRHP-eligible historic district comprised of the entire 579.5 acre-parcel was present at the NIST campus. The report further recommended the Administration Building (Building 101) individually eligible for inclusion in the NRHP as "a successful example of the GSA's application of the International Style" (Criterion C) (RK&K 2014:S-2). In correspondence dated 12 January 2015, the MHT concurred with the recommendation that the NIST parcel is eligible for inclusion in the NRHP under Criteria A and C and further "accepted the results and conclusions presented in FTA/MTA's survey documentation" (Hughes 2015:2).

2.3 Comprehensive Architectural Survey

The purpose of the architectural field investigations was to collect data sufficient to document the current appearance of permanent built resources in the NIST inventory to enable assessment of their individual and collective significance and integrity. The current investigation comprised the survey of buildings, structures, sites, objects, and landscapes located at the Gaithersburg campus; no archeological investigation was completed.

Comprehensive survey data were compiled for NIST real property (Table 2.1). In addition, resources identified during the course of field investigations, including landscape features and building interiors, were documented. Objects such as flag poles and sun dials also were recorded. Temporary buildings, such as trailers and prefabricated storage buildings not integral to NIST's core missions, were excluded from the architectural survey.

The following information was collected for each property:

- Date constructed;
- Type of construction;
- Overall descriptive data including building type, style, location, number of stories, plan shape and type, exterior wall materials, roof shape and materials, placement of building openings, and modifications over time;
- Function; and,
- Association with the NIST and Gaithersburg missions.

Due to security considerations, some buildings were not photographed. Others could not be fully documented because of restricted access. In addition, security concerns precluded the inclusion of certain building details.

Written, graphic, and digital photographic data were collected for each resource using electronic data collection tools, including Terrasync V 5.20 software and Trimble GeoXH 6000 units containing Global Positioning System (GPS)

Table 2.1 Building Inventory

BUILDING NUMBER	BUILDING NAME
101	ADMINISTRATION BUILDING
102	# Retired
103	VISITOR’S CENTER and GATE HOUSE
202	ENGINEERING MECHANICS
203	STANDARD REFERENCE MATERIALS BUILDING
205	LARGE FIRE FACILITY
205E	EMISSIONS CONTROL ELECTRICAL
205M	EMISSIONS CONTROL MECHANICAL
206	CONCRETE MATERIALS BUILDING
207	ROBOT TEST FACILITY
208	NET-ZERO ENERGY RESIDENTIAL TEST FACILITY
215	NANOFABRICATION FACILITY
216	CENTER for NANOSCIENCE & TECHNOLOGY (INSTRUMENT EAST)
217	INSTRUMENT WEST BUILDING
218	METROLOGY EAST BUILDING
219	METROLOGY WEST BUILDING
220	METROLOGY BUILDING
221	PHYSICS BUILDING
222	CHEMISTRY BUILDING
223	MATERIALS BUILDING
224	POLYMER BUILDING
225	TECHNOLOGY BUILDING
226	BUILDING RESEARCH BUILDING
227	ADVANCED CHEMICAL SCIENCES LABORATORY
230	FLUID MECHANICS BUILDING
231	INDUSTRIAL BUILDING
233	SOUND BUILDING
235	NCNR
236	SPECIAL PROJECTS BUILDING
237	NON-MAGNETIC BUILDING
238	NON-MAGNETIC BUILDING
245	RADIATION PHYSICS BUILDING
301	SUPPLY and PLANT BUILDING
302	STEAM and CHILLED WATER GENERATION PLANT
303	SERVICE BUILDING
304	SHOPS BUILDING
305	COOLING TOWER BUILDING
306	PEPCO SUB-STATION
307	MATERIALS PROCESSING STORAGE
308	BOWMAN HOUSE
309	GROUNDS MAINTENANCE BUILDING
310	PLANT STORAGE BUILDING
311	GROUNDS STORAGE SHED

BUILDING NUMBER	BUILDING NAME
312	MATERIALS PROCESSING BUILDING
313	SITE EFFLUENT NEUTRALIZATION BUILDING
314	BACKFLOW PREVENTER BUILDING - EAST
315	BACKFLOW PREVENTER BUILDING - NORTH
316	ELECTRICAL SERVICE BUILDING
317	COOLING TOWER WEST
318	ES CONSOLIDATED FACILITY
319	EMERGENCY SERVICES STORAGE BUILDING
320	CCC
321	LIQUID HELIUM RECOVERY FACILITY
411	TEMPORARY RELOCATABLE FACILITY
412	TEMPORARY RELOCATABLE FACILITY
413	TEMPORARY RELOCATABLE FACILITY
414	JANITORIAL STORAGE BUILDING
418	NCNR STORAGE BUILDING
419	TEMPORARY BUILDING
420	OFPM STORAGE BUILDING
421	RADIATION PHYSICS STORAGE BUILDING
422	CONCRETE MATERIALS STORAGE BUILDING
423	RESEARCH HOUSE
424	# Retired
425	NCNR STORAGE BUILDING II
426	NCNR TRAILER 2
427	NCNR TRAILER 1
428	FACILITIES BUILDING
*Buildings having a 400 number are designated as temporary buildings. Temporary buildings were not surveyed as part of this current investigation.	

with sub-meter accuracy. The electronic data collection provided the ability to process data to support data analysis, including resource mapping.

2.4 Data Analysis Guidelines

The National Register program has established guidance for the evaluation of historic properties. In order for a property to merit consideration for inclusion in the NRHP, a property must have significance and retain integrity. The NRHP Criteria for Evaluation (36 CFR 60.4[a-d]) were applied to the NIST resources to determine whether the resources are significant. Integrity is a property's ability to convey its significance. Integrity is discussed in greater detail later in this chapter.

In addition to that issued by the NPS, guidance prepared by the ACHP was consulted in the evaluation of archival data. *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities* provides direction on the evaluation of resources associated with highly technical or scientific facilities. As the report notes, "Many of the facilities and much of the equipment associated with scientific engineering advancements remain in active use today, but need to be continuously upgraded and modified to stay at the cutting edge of technology" (Advisory Council on Historic Preservation [ACHP] 2002). The report acknowledges that a balance between cultural resources management needs and the needs of active research institutions is necessary. Further, the report makes a distinction between the quantity and changes in use or character as opposed to "natural, ongoing change and improvement to and in structures or equipment as they are continually subjected to minor change while they continue to function for their original purpose" (ACHP 2002). The ACHP acknowledges that resources used for scientific purposes can be altered and modified to enable the resources to continue to be used for their scientific purposes. Consequently, these changes may not necessarily affect resource integrity.

NIST actively has been responsible for the buildings in its real property since it was established. The agency maintained real property oversight even after the creation of the General Services Administration (GSA) in 1949, which established a division within the Federal government to design, construct, and manage buildings in the Federal inventory (General Services Administration [GSA] 2005:10). Real property oversight was reinforced through continuous modification to the agency's Organic Act (i.e., enabling legislation), which was last revised in 2010. Under the 2010 revisions regarding the administration and functions of NIST, the Secretary of Commerce was authorized to use NIST-appropriated funds to "undertake such construction of buildings and other facilities and to make such improvements to existing buildings, grounds, and other facilities occupied or used by the Institute" (NIST 2010a).

NIST has not developed internal guidance for assessing the significance and integrity of resources in its real property inventory. Therefore, a review of guidance prepared by the GSA, which has a robust and comprehensive cultural resources management program, was deemed apt. GSA developed an historic context for Federal buildings in the GSA real property inventory designed during the Modern period. *Growth, Efficiency, and Modernism. GSA Buildings of the 1950s, 60s, and 70s* identifies key design philosophies of Modern architecture, provides a summary history of the GSA, and presents policies and guidelines that governed Federal construction during the 1950s through the 1970s (GSA 2005). The report provides a framework for the management of buildings constructed between 1950 and 1970 that are in the GSA real property inventory. In addition, the report provides an historic context for the GSA against which the GSA real property inventory can be evaluated.

While GSA guidance on modern buildings under its stewardship informed this current investigation it should be noted that the GSA's historic context is different than that of NIST. The GSA was established to provide a "centralized support service for the Federal government" (GSA 2005:10). Further, the 2005 report summarizes the GSA's role in the design, construction, and management of Federal buildings constructed throughout the country. The GSA guidance concludes with a methodology for evaluating the relative significance of resources in the GSA real property inventory constructed during the Modern era within the context of GSA's nationwide construction program. As was common during the years following World War II, the GSA served as the construction manager for the construction of the Gaithersburg campus. Upon completion of the campus, the buildings were turned over to NIST. GSA had no further role in the operation and management of the Gaithersburg resources. The relationship between the GSA and NIST is explored in greater detail in Chapter 4. The NIST historic context is explored in the chapters that follow.

In addition to the GSA guidance, a review of guidelines issued by other Federal agencies with a similar science and technology mission and resource type as NIST was deemed appropriate. The policies developed by the National Aeronautics and Space Administration (NASA) were reviewed for application to NIST. The applicability of the 50 year guidance for resources constructed between 1960 and 1969 in the assessment resources from the recent past was raised during discussions between the NASA Federal Preservation Officer and National Register staff during a National Register symposium in May 2011. Subsequent coordination between NASA and National Register program administrators in January 2012 affirmed that 50 years is a guideline for resource evaluation. The suggested age may not be necessary to achieve historical perspective in all cases. Therefore, resource evaluation under Criteria Consideration G was determined unnecessary in cases such as the Goddard Space Flight Center campus, where significance can be demonstrated clearly under the general criteria for evaluation (R. Christopher Goodwin & Associates, Inc. 2012:2-8).

2.5 Evaluation of Built Resources

Associations with the property types associated with NIST missions were noted during the field investigations. Research data were analyzed to identify property types and character-defining features and were verified during field investigation. Property types were used to link the resources to important events and historic themes identified in the historic context developed for this current investigation applying the NRHP Criteria for Evaluation (36 CFR 60.4[a-d]). Character-defining features assisted in assessing resource integrity.

Architectural field data were analyzed within the appropriate historic context applying the NRHP Criteria for Evaluation (36 CFR 60[a-d]). The historic context prepared as part of this current investigation provided the basis for assessing resources located at the NIST Gaithersburg campus for the qualities of significance in American history, architecture, engineering, and culture present in districts, sites, buildings, structures, and objects and for integrity of location, design, setting, materials, workmanship, feeling, and association. Further, the historic context made possible the individual and collective (as potential historic districts) evaluation of resources for their association with events that have made a significant contribution to the broad patterns of our history (Criterion A); for their association with the lives of persons significant in our past (Criterion B); for their ability to embody the distinctive characteristics of a type, period, or method of construction, to represent the work of a master or possess high artistic values, or to represent a significant and distinguishable entity whose components may lack individual distinction (Criterion C); and, for their ability to yield, or be likely to yield, information important to prehistory or history (Criterion D). The results of the evaluations are presented in subsequent chapters and are summarized in a facility-wide MIHP and DOE forms presented in the appendix to this report. The evaluations identify contributing and non-contributing resources to a potential NRHP historic district or districts.

2.6 The Evaluation of Properties Using the NIST Historic Context

2.6.1 <u>NRHP Categories, and Historic District vs. Individual Eligibility</u>

The NRHP recognizes five resource categories. These include buildings, structures, objects, sites, and districts. Buildings are those resources that were constructed for creating human shelter whereas structures are those that were built for purposes other than human shelter. Each resource category may be present at NIST. Sites, which may include archeological resources, may also include resources associated with the environment including landscape design and site plan. Landscape design and site plan can incorporate elements such as circulation networks, building setbacks, and plant materials.

Not every resource associated with the themes of Science and Technology or the Postwar Research Campus Design individually possesses significance and the qualities of integrity necessary for listing in the NRHP. The framework established by the historic context presented in this technical report allows for the assessment of resources located at the NIST Gaithersburg campus on a collective basis within the history of science and technology and postwar research campus design. Resources at the Gaithersburg campus constructed for NIST to support its mission are included in the real property inventory. For component structures and buildings to contribute to an NRHP historic district within the identified themes, they should meet one of the four significance criteria. NIST's primary mission is to support innovation and industrial competitiveness through the advancement and development of measurement science, standards, and technology. The various research projects undertaken at the Gaithersburg campus may contribute to larger science and technology efforts. Other research facilities might provide a greater appreciation of NIST's contribution to postwar research campus design. Associated resources may be located at other facilities.

2.6.6.2 Integrity

In addition to possessing significance within an historic context, a property must possess integrity, a property's ability to convey its significance through the retention of essential physical characteristics from its period of significance, to be eligible for inclusion in the NRHP. The evaluation of NIST resources was completed through an assessment of the integrity of location, design, setting, materials, workmanship, feeling, and association for resources located at the Gaithersburg campus.

Buildings at NIST individually were analyzed to determine if they were contributing or non-contributing resources to a potential NIST historic district, and if those resources retained the character-defining features related to the period of significance. For an historic district to be present at NIST, the contributing resources must retain sufficient integrity to be eligible for the NRHP and the key buildings and structures associated with the period of significance within the historic context must be retained. In a potential district associated with science and technology and postwar corporate campus design themes, the buildings were evaluated to ascertain if the majority of the individual components that comprise the historic character of the potential district date from that period of significance and retain integrity. In those instances where the buildings and structures in a potential historic district possessed significance from more than one period, each resource was evaluated for integrity from multiple periods. The relationships among the components of the potential district, i.e., massing, arrangement of buildings, and installation plan, also were assessed.

Chapter 3.0

Historic Context – NIST Administrative History

3.1 Introduction

NIST is charged with establishing national measurement standards and keeping them uniform, compatible, and reliable. Basic measurements include mass, length, time, temperature, electric current, resistance, and chemical composition. The original measures comprised a metal cylinder weighing a kilogram and the platinum-iridium meter bar inherited from the predecessor organization the Office of Standard Weights and Measures founded in 1836.

This chapter presents a general historic overview of the origins of NIST from its founding in 1901 as the National Bureau of Standards to its recent history. The overview focuses on the agency's evolution and summarizes some of the varied research projects conducted at NIST. NIST is tasked to disseminate the data regarding the national measures to government, industry, and the public. This task has expanded tremendously throughout the agency's history. From its founding, data from the experiments conducted at NIST were published as research publications, scientific and technical publications, articles in professional journals, circulars, data reference materials, standard reference materials, and conference materials. In 1988, Congress changed the agency's name to the National Institute of Standards and Technology and refocused the agency's mission to play a major role in revitalizing U.S. trade. This mission is reflected in the current NIST mission statement: "To promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life" (NIST 2012).

The following overview history is based on three official histories of NIST: *Measures for Progress (1901-1950)* by Rexmond C. Cochrane (1966); *A Unique Institution (1950-1969)* by Elio Passaglia (1999); and, *Responding to National Needs (1969-1993)* by James F. Schooley (2000). The overview is augmented through materials collected from the NIST Library at Gaithersburg, the National Archives and Records Administration, the Montgomery County Historical Society, and the NIST website.

3.2 Establishment of the National Bureau of Standards to World War I

This section details the initial establishment of the National Bureau of Standards (NBS). It presents the early years of its development and its growth until World War I. The section outlines a few of the early research programs undertaken at the NBS that influenced its future growth.

The U.S. Congress chartered the NBS in March 1901 (Public Law 177-56th Congress, 2d Session quoted in Cochrane 1966:541). The NBS took over the duties of the Office of Standard Weights and Measures founded in 1836 as part of the Coast and Geodetic Survey. The original purpose of the Office of Standard Weights and Measures was to provide the states with standardized weights and measures to support the collection of taxes by ensuring uniform shipment of goods across state lines and internationally. The work of the office was focused on the measurements of length, volume, and weight (Cochrane 1966:20-21, 29).

By the late nineteenth century, the Federal and state governments had no legislated standards for weights and measurements. Wide variations existed from state to state for the most basic of measurements. In addition, new standards were required for electrical measurements; for building materials, such as the tensile strength for concrete and the composition of steel; and, for consumer products to avoid chaos in the market place (Cochrane 1966:37, 38).

The development of scientific standards was further advanced in Europe than in the United States. European countries already had established national standards laboratories and were working collaboratively to establish international standards. The *Bureau International des Poids et Mesures* was established in 1875 in Sevres, France. The *Physikalisch-Technische Reichsanstalt* was organized in Germany in 1887 and was credited with greatly improving production standards for German goods and precision instruments. In England, the Standards Department was established in 1879, the Electrical Standardizing Laboratory in 1890, and the National Physical Laboratory in 1899 (Cochrane 1966:29, 39, 44).

In 1900, Secretary of the Treasury Lyman J. Gage proposed the formation of a national standards laboratory in the United States. He selected Samuel W. Stratton to draft a bill establishing such an agency and to become its first director (Cochrane 1966:39-40). As legislated, the NBS duties comprised the following tasks:

- the custody of the standards [of measurement];
- the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the government;
- the construction, when necessary, of standards, their multiples and subdivisions;
- the testing and calibration of standard measuring apparatus;
- the solution of problems which arise in connection with standards; and,
- the determination of physical constants and properties of materials, when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere (Passaglia 1999:19, 152, 608).

The legislation identified the NBS as both the "source of the standards and their custodian," but provided no policing powers; policing powers were assigned to the states (Cochrane 1966:43).

The NBS was authorized to provide services to the U.S. government, any state or municipal government, and "any scientific society, educational institution, firm corporation, or individual with the United States engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments" (Passaglia 1999:608). As legislated, the staff comprised the following: a director, a chemist, a physicist, two scientific assistants, two laboratory assistants, a secretary, a clerk, a messenger, an engineer, a machinist, a watchman, and a laborer. The director was appointed by the U.S. President with the consent of the U.S. Senate. The legislation also authorized the new agency the sum of $250,000 to construct a fireproof laboratory on property purchased by the Secretary of the Treasury (Schooley 2000:790).

The NBS originally was placed in the Department of the Treasury. In 1903, the NBS was assigned to the Department of Commerce and Labor. When the Department of Commerce and Labor was divided in 1913, NBS was assigned to the Department of Commerce. The agency's placement in the Department of Commerce ensured that it would serve U.S. commerce and industry as directed by the Secretary of Commerce (Cochrane 1966:68-69).

Director Stratton spent the first years of the NBS hiring personnel, organizing research departments and programs, acquiring and designing new equipment, and designing new laboratories. He patterned the NBS organization on Germany's *Physikalisch-Technische Reichsanstalt* (Cochrane 1966:65). He immediately began to plan for new laboratory buildings. In 1901, he secured eight acres on Connecticut Avenue in northwest Washington, D.C., and negotiated a construction contract (Cochrane 1966:62). The D.C. campus was occupied by NBS personnel during late 1904 and served as the organization's primary facility until the move to Gaithersburg during the mid-1960s. By 1902, the original staff of 12 had increased to 22 persons, who were organized into 15 offices and laboratories. In 1903, the authorized number of staff rose to 58 (Cochrane 1966:67, 69).

The early NBS organization was divided into three divisions; the divisions reflected the focus of each division's research projects. Division I included weights and measures, heat and thermometry, light and optical instruments, engineering instruments, instrument shop, and administration. Division II was devoted to electricity, including resistance and electromotive force, magnetism and absolute measurement of current, induction and capacity, electrical measuring instruments, photometry, and the engineering plant. Division III was chemistry, which was not yet organized in 1904 (Cochrane 1966:74-75).

The NBS quickly expanded into new areas of research. In 1904, NBS scientists purchased the liquid hydrogen production equipment exhibited by the British Oxygen Company at the 1904 St. Louis World Fair. The purchase of the equipment was the beginning of research into cryogenics, the study of low temperatures (Cochrane 1966:83). Research was also undertaken to standardize firefighting equipment hoses after a fire occurred on the new laboratory campus and in downtown Baltimore in 1904. When attempting to extinguish a fire on the D.C. campus, employees discovered that the fire hoses installed in two laboratories could not be joined together due to differences in coupling threads. Similarly, the differences in coupling threads among fire companies in Baltimore hampered efforts to bring the downtown fire under control. NBS began a study on fire hose couplings that identified over 600 sizes and variations of couplings across the country. In 1905, NBS scientists provided a recommendation for a standard coupling to the National Fire Protection Association, but it was many years before the standard was widely accepted (Cochrane 1966:84-86).

In 1908, Director Stratton requested special funding from the Congress to "investigate what the states are doing with their standards." Between 1909 and 1911, NBS staff visited each state and tested 30,000 scales, weights, and dry and liquid measures. The results of the tests indicated that a large proportion of the weights and measures used in the market place were fraudulent. The NBS work attracted the notice of journalists. The public outcry resulted in the states adopting the model law for standards for weights and measure proposed by the NBS. In addition, an amendment to the Pure Food and Drug Act in 1913 required that net weight, measure, or numerical count of contents be printed on sealed packages. This work by the NBS assured consumers that accurate weights and measures were used in the market place (Cochrane 1966:89-91).

In 1911, the NBS personnel increased to 269 and included personnel transferred from the Geological Survey structural materials laboratories. The structural materials laboratories were engaged in researching and testing such items as paints, cements and concrete, clays, ceramics, steel, and protective coatings. The laboratories were located in Pittsburgh and Northampton, Pennsylvania; Atlantic City, New Jersey; and, Washington, D.C. These laboratories continued their work under the direction of the NBS (Cochrane 1966:94).

That same year, a purchasing agent of the Federal government requested that NBS test a shipment of light bulbs, three-quarters of which the NBS eliminated as substandard. Thus, a long-standing program was initiated for testing products to develop procurement specifications for government purchasing to ensure that government funds were well spent. A sample of products tested by the NBS included rubber products, paper, inks, textiles, cordage, lubricating oils, leather and leather goods, metals and metal products, and refrigeration equipment (Sangster 1975:D-18; Cochrane 1966:90-91).

Electrical measurements and calibration of electrical equipment occupied a large percentage of time during the NBS' first decade. As U.S. industry transitioned to electric power, the NBS electricity laboratory was flooded with requests for basic electrical measurements, tests, and calibrations from electric light and power companies, appliance manufacturers, communication companies, and streetcar companies. NBS scientists made significant progress in precise electrical measurement, refining the accuracy of measurements to within a few parts in 100,000. Progress also was made in improving the constancy of measurements for the standard electrical cell used to measure the volt. One avenue of study was defining a uniform standard for electric lighting, or candle power, through comparisons of carbon-filament and tungsten-filament bulbs. NBS testing led to the 1907 specification for light bulbs purchased by the government (Cochrane 1966:103-105, 112).

In 1909, representatives of the coal industry requested that NBS develop safety standards for the use of electric lighting in mine shafts. The electric lights then in use frequently sparked, often resulting in hazardous and dangerous work conditions. After several years of study, the NBS published in 1915 the nation's first model electrical safety code for general use (NIST 2014b).

NBS extended its research work to other public utilities including gas, telephone and telegraph, street railways, and railroads after companies in these sectors became subject to government regulation under public service commissions after 1907. Over the next decade, the NBS developed standards, distributed through circulars, for such areas as gas service. The standards were intended for use by public service commissions (Cochrane 1966:110-114).

In 1913, at the request of the Interstate Commerce Commission (ICC), the NBS received Congressional funding to initiate an investigation of large railroad scales used to measure freight for interstate commerce. In 1913, the NBS outfitted a railroad car with calibrated weights and traveled the rails to test railroad scales used for interstate commerce. The investigation revealed that over 75 per cent of the railroad scales used to weigh loads transported by railroad cars were highly inaccurate. After this finding, state agencies revised inspection procedures and required the use of more accurate track scales. This NBS program continued until the 1930s (Cochrane 1966:116-117).

The ICC also requested that the NBS analyze railroad components from train derailments, which had reached an alarming annual number of 41,578 in 1912. Faulty maintenance, inferior steel, and excessive wheel loads were suspected causes of the derailments. The ICC sent failed rail components, such as broken rails and broken axles, to the NBS for analysis to determine the quality of the steel used in the tracks. The NBS researchers conducted chemical, microscopic, and mechanical tests on the metal and found transverse fissures in the interior of the rails. Between 1912 and 1923, NBS' Metallurgical Division investigated heat stress and treatments to develop recommendations for improvements in the manufacturing process to eliminate the fissures (Cochrane 1966:118-119).

Research into radio also began at the NBS during the first decades of the twentieth century. Guest researchers from the Navy and the Army conducted initial research on the practical applications of radiotelegraphy beginning in 1908. In 1911, NBS received a request to calibrate a wavemeter to measure high-frequency current in a radio transmitting apparatus. The project was assigned to J. Howard Dellinger, who would become a noted expert in the radio field for his research in high-frequency radio waves. Other radio work focused on development of an improved radio direction finder that was widely used to locate enemy positions during World War I (Cochrane 1966:139-140, 143-144; NIST 2000:n.p.; NIST 2014b).

As World War I raged in Europe, the NBS was requested to explore new areas of research. In 1915, the NBS staff began research into materials used in aircraft design. The manufacture of optical glass also became a critical priority. All high-quality optical glass prior to World War I was imported from Germany; no U.S. company possessed the capacity to produce such glass. NBS researchers spent a year working to perfect methods for the production of high-quality optical glass (NIST 2000:n.p.). A sample of other wartime activities involving the NBS included investigations into airplane engines and instruments for the National Advisory Committee for Aeronautics; tests of airplane frames, wing fabrics, and engines for the U.S. Army Signal Corps; tests into the chemical, physical and structural properties of metals for use in ammunition shells for the Army; development of concrete cargo ships for the Shipping Board; ensuring the availability of precision gages for ordnance production; experiments into substitutes for leather and woolen products for the Council of National Defense, the War Department, and Army Quartermaster Corps; and, a study of dental amalgams at the request of the Surgeon General of the Army (Sangster 1975:D-19; Cochrane 1966:159-186, 271).

The NBS campus in D.C. was expanded to include nine additional acres. The number of NBS staff rose to 517 in 1917 and to 1,117 in 1918 (Cochrane 1966:165, 167; NIST 2000:n.p.).

The first women were employed at NBS during World War I to replace male employees who joined the military. While many of the nearly 100 women were clerks and secretaries, women also joined the agency as researchers. In 1918, Joanna Busse began her career at NBS as a researcher in thermometry. Dr. Louise McDowell, who held a Ph.D. degree in physics, joined the staff in 1918 to assist in the preparation of a handbook on radio. Dr. Mabel Frehafer, Ph.D., joined the colorimetry section in 1919 (Cochrane 1996: 54, 170).

3.3 The NBS During the 1920s and 1930s

Between 1920 and 1940, the NBS continued to grow and mature as an organization. Projects undertaken during this time reflected political priorities. During the 1920s, NBS staff worked more closely with projects designed to benefit industry under the leadership of Secretary of Commerce Herbert Hoover. During the 1930s, the Great Depression directly impacted the agency. The agency's basic scientific programs returned to prominence.

Between 1921 and 1928, Herbert Hoover served as the Secretary of Commerce. Hoover redirected the focus of the NBS to support domestic economic recovery following World War I through his programs for standardization, specifications, and simplification. In particular, the NBS worked with industry to reduce "waste in manufacture and distribution through the establishment of standards of quality, simplification of grades, dimensions, and performance in non-style articles of commerce; through the reduction of unnecessary varieties; through more uniform business documents such as specifications, bills of lading, warehouse receipts" and to develop "pure and applied scientific research as the foundation of genuine labor-saving devices, better processes, and sounder methods" (Sangster 1975:C-21; Cochrane 1966:254). While fundamental research continued, new areas of research emerged to support industry, including investigations into standardized radio frequencies to support the popularization of the home radio; investigations to standardize building construction materials and codes to support Hoover's home building program; publication of a popular handbook for perspective home buyers; development of methods to test the fire endurance of buildings; development of standards for fuel economy and automobile safety; and, development of a radio guiding system for aircraft. Other areas of research included standardization of color, development of improved dental materials, research into textiles, and standardization of screw threads (NIST 2000:n.p.; Sangster 1975:D-21). Between 1913 and 1932, the NBS also supported crime detection. Wilmer Souder, employed at the NBS between 1913 and 1954, became a noted criminal investigator. By the early 1930s, Souder routinely participated in between 50 to 75 criminal investigations per year. In 1932, Souder's handwriting analysis of the ransom note in the Lindbergh kidnapping case contributed to the conviction of Bruno Hauptmann. Forensic investigation at the NBS dwindled after the Federal Bureau of Investigation established its scientific laboratory in 1932 (NIST 2000:n.p.).

The depression years of the 1930s resulted in curtailed research activities of the NBS. Staffing was reduced from 1,066 in 1930 to 668 by 1935, and total funding from all sources decreased to $1.9 million (Cochrane 1966:558, 563). The NBS was refocused on "maintenance and improvement of standards of measurement; calibration and certification of measuring instruments … [to ensure] that accurate and uniform standards of measurement would be used throughout the nation; development of improved methods of measurement for use in industry, engineering, and scientific research; determination of physical constants and essential data on the properties of materials or physical systems; [and] serving… as a centralized physical research laboratory for governmental agencies" (Sangster 1975:D-22; Cochrane 1966:323-324).

Some basic research programs at NBS did continue. The NBS continued studies into all aspects of radio transmission and receiving. In fact, NBS scientists established a WWV radio station at Beltsville, Maryland, in 1923 to transmit standard radio frequencies and time (NIST 2014b). Radio research also included the study of layers in the upper atmosphere that interfered with radio waves. Radio expert Dellinger conducted research that linked interruptions in long-distance radio transmissions to sun eruptions. As a result of Dellinger's research, NBS initiated monthly forecasts of ionospheric and radio conditions in 1937 (Cochrane 1966:350-353).

NBS researchers also conducted studies on X-rays and radium, and began projects in atomic physics. In 1931, Harold C. Urey, associate professor of chemistry at Columbia University, sought to prove the existence of a heavy isotope of hydrogen. Urey sought to isolate the hydrogen isotope. Fred L. Mohler of the NBS atomic physics section suggested that Urey work with Ferdinand Brickwedde of the NBS cryogenics laboratory. Their collaboration resulted in the identification of deuterium, i.e., heavy water, for which Urey won the Nobel Prize in chemistry in 1934. Though Urey received the award, he acknowledged the contribution of Brickwedde at NBS and shared the prize money with him (Cochrane 1966:358-359; Martin and Frederick-Frost 2014). NBS scientists from the cryogenics program worked with deuterium and the development of the atomic and hydrogen bombs during World War II and the early Cold War (NIST 2000:n.p.).

NBS scientists were involved in early research in the U.S. to split the atom and to develop the atomic bomb. In 1939, President Roosevelt established an Advisory Committee on Uranium headed by then NBS Director, Dr. Lyman Briggs. NBS scientists contributed critical initial research, including determining the purity of uranium, providing radioactivity measurements, and establishing safety procedures for bomb materials. When the Manhattan Project was transferred to the Army Corps of Engineers, NBS remained a "central control laboratory for determining the purity of uranium" and other materials. Some NBS scientists undertook temporary assignments at Oak Ridge, Tennessee, and Los Alamos, New Mexico, the two major atomic research centers (Cochrane 1966:361-364, 377; NIST 2000:n.p.; Sangster 1975:D23).

3.4 World War II and the Postwar Period

This section describes the range of projects conducted by the NBS scientists during World War II. By 1943, all research conducted at the agency supported the war effort; most work was classified. Following the war, the NBS was reorganized to meet post-war scientific needs of the atomic age and the space age.

The beginning of World War II ushered in a period of explosive growth for NBS. From a staff numbering below 1,000 in 1939, the personnel level rose to 1,204 and was supported by a budget of $3.37 million by December 1941. By 1945, the staff had increased to 2,206 and the budget had risen to $9.7 million (Passaglia 1999:16; Cochrane 1966: 558, 563).

NBS scientists were involved in many significant projects, such as the radio proximity fuse, which contained a tiny radio that transmitted waves towards a target and controlled detonation to inflict maximum damage. This development increased the effectiveness of antiaircraft shells, rockets, and bombs (Briggs and Colton 1951:770). NBS scientists also developed a fully automated guided missile, known as the "Bat," that was used in the last months of the war against Japanese land and sea targets (Sangster 1975:D-23; NIST 2000:n.p.). Radio research focused on improving radio direction finders, studying radio propagation phenomena, and supporting aerial navigation, radio-telephony, radio-telegraphy, and radar. An outgrowth of this radio research was the establishment at NBS of the Interservice Radio Propagation Laboratory (IRPL) in 1942. The objective of the IRPL was to centralize data on the behavior of transmitted radio waves for dissemination to all military services. NBS investigations also were conducted to develop methods to conserve petroleum, to manufacture optical glass, and to investigate a broad range of substitute materials, such as synthetic rubber, quartz crystals, and plastics (Sangster 1975:D-23).

The experiences of World War II resulted in a dramatically changed scientific landscape. Technological advances made during the war posed the potential for immense changes in all areas of life. Development of the atomic bomb ushered in the atomic age, followed, in 1957, by the beginning of space age with the launch of Sputnik by the U.S.S.R.

The role of NBS in this new world of science and technology was a topic of discussion during the late 1940s. In 1950, the Secretary of Commerce proposed new enabling legislation to codify activities assigned to the NBS by "supplementary legislation, executive orders and customary procedure" (Passaglia 1999:149-150). The legislation, enacted in 1950, defined NBS functions as:

> (a) The custody, maintenance, and development of the national standards of measurement, and the provision of means and methods for making measurements consistent with those standards, including the comparison of standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the government.
> (b) The determination of physical constants and properties of materials when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere.
> (c) The development of methods for testing materials, mechanisms, and structures, and the testing of materials, supplies, and equipment, including items purchased for use by government departments and independent establishments.
> (d) Cooperation with other government agencies on scientific and technical problems.
> (e) Advisory service to government agencies on scientific and technical problems.
> (f) Invention and development of devices to serve special needs of the government (Passaglia 1999:616).

The act also identified research to support government agencies, scientific institutions, and industry in the following select areas: investigation and testing of railroad track scales and other scales in weighing commodities for interstate shipment; the preparation of standard samples for use in checking chemical analysis, temperature, color, viscosity, heat of combustion, and other basic properties of materials; development of chemical analysis and synthesis of materials, including rare substances; the study of radiation and x-rays; the study of atomic and molecular structure of chemical elements; broadcasting of radio signals for standard frequency; investigation of conditions which affect the transmission of radio waves; and, the determination of properties of building materials, including fire resistance. In addition, the NBS was tasked with compiling, publishing, and disseminating scientific and technical data resulting from its research for public use (Passaglia 1999:616-617). The new law vested authority for the NBS in the Secretary of Commerce and gave the U.S. President the ability to appoint all future NBS directors (Passaglia 1999:151).

In 1950, the role of NBS organization was described as:

> … the principal agency of the Federal government for basic and applied research in physics, mathematics, chemistry, and engineering. In addition to its general responsibility for basic research, the Bureau undertakes specific research and development programs, develops improved methods for testing materials and equipment, determines physical constants and properties of materials, tests and calibrates standard measuring apparatus and references standards, develops specifications for Federal purchasing, and serves the government and the scientific institutions of the Nation in an advisory capacity on matters relating to the physical sciences. The Bureau also has custody of the national standards of physical measurement, in terms of which all working standards in research laboratories and industry are calibrated, and carries on necessary research leading to improvement in such standards and measurement methods (Passaglia 1999:23).

In 1950, personnel employed at NBS numbered 3,100 (Passaglia 1999:15). The organization had grown to fifteen research divisions containing 107 sections. The NBS divisions reflected its research areas: Electricity, Optics and Metrology, Heat and Power, Atomic and Radiation Physics, Chemistry, Mechanics, Organic and Fibrous Materials, Metallurgy, Mineral Products, Building Technology, Applied Mathematics, Electronics, Ordnance Development, Central Radio Propagation Laboratory (CRPL), and Missile Development. Support divisions included Budget and Management, Personnel, Plant, and Shops (Passaglia 1999:17-18; Science and Engineering at NBS 1953).

In 1950, the NBS budget totaled $20 million; 43 per cent of the budget was authorized directly by the U.S. Congress, while 57 per cent of the budget came from government agencies, primarily the military, to underwrite specific projects (Passaglia 1999:15). Research was conducted at the main campus Washington, D.C., and at Corona and Los Angeles, California. The master scale depot was located in Clearing, Illinois, and materials testing was performed in Allentown, Pennsylvania; Seattle, Washington; Denver, Colorado; and, San Francisco, California. Radio propagation field stations numbered eleven and were distributed in the following places: Virginia (2), Maryland (1), Colorado (1), Panama Canal Zone (1), Puerto Rico (1), Hawaii (1), Guam (1), and Alaska (2) (Science and Engineering at NBS 1953).

Research projects conducted at the NBS included both basic research in physics, mathematics, electronics, chemistry and metallurgy and work in the fields of electronic, electrical, mechanical, hydraulic, and structural engineering. A sample of projects included the installation of the NBS Eastern Automatic Computer (SEAC) in 1950; studies in low temperature physics; the development of an omegatron to determine constants such as the faraday and magnetic moment of the proton; studies in electron optics to determine electric-field distribution and space-charge density within a magnetron; X-ray radiation protection studies; research to expand electronic memories in computers; carbohydrate studies; and, preparation of pure iron. In the field of engineering, studies were conducted in oil flow in plain journal bearings; aircraft materials; methods of measuring large currents and voltages; cement and concrete; and, in the engineering properties of specific building materials and entire structures, from residences to skyscrapers to dams. Projects that resulted in more precise measurements included the development of atomic clocks; development of a set of primary atomic standards; the development of improved reference standards for electrical units; and, the development of standards for the uniform measurement of light and illumination (Science and Engineering at NBS 1953).

In 1953 at the request of the Secretary of Commerce, the NBS underwent a thorough review of its organization and activities, which was conducted by the Ad Hoc Committee for the Evaluation of the Present Functions of the National Bureau of Standards. The committee's report contained ten recommendations, including: refocusing NBS on basic scientific research; modernizing facilities and increasing space; improving the NBS organizational structure; transferring military work to the Department of Defense; increasing support of standard samples program; and, decreasing repetitive test operations (Passaglia 1999:173-174).

One of the ad hoc committee's recommendations was implemented almost immediately. The NBS ordnance and guided missile work located in Corona, California, was transferred to the Department of Defense in September 1953 (Passaglia 1999:176). The remaining recommendations from the ad hoc committee were implemented gradually and shaped the evolution of the agency for the next two decades.

During the late 1950s, the NBS scientists and researchers developed new methods to measure time and length. Before 1956, the length of a second was based on the earth's rotation as 1/86,400 of a mean solar day and was the basis for Universal Time. The length of a second was accurate to one part in a million (Briggs and Colton 1951:759). In 1960, NBS adopted a new atomic definition of the second as 9,192,631,770 oscillations of the cesium atom. This measurement was accurate to within one second per 30,000 years. Scientists at both the D.C. and Boulder campuses worked on this project. This new definition of the second became the international standard in 1964 (National Bureau of Standards [NBS] 1966d:5; Passaglia 1999:373; Schooley 2000:104).

A new definition of length also was studied by NBS scientists who experimented with ways to define length based on a wavelength of light from a suitable element. Three elements were proposed for study: mercury-198, the orange-red line from krypton-84 or krypton-86, and cadmium-114. NBS scientists conducted studies of all three. Ultimately, in 1960, a new definition of a meter as 1,650,763.73 wavelengths of krypton-86 was accepted as the international standard (Passaglia 1999:349-350).

In 1955, Tsung Dao Lee and Chen Ning Yang at Columbia University wrote a paper entitled "Question of Parity Conservation in Weak Interactions." This paper presented the theory that "there was no evidence that parity was conserved or not conserved in weak interactions" (Passaglia 1999:207-208). Parity was a long-held belief that the human world would be indistinguishable from its mirror image (NIST 2014b). Lee and Yang's theory was proven experimentally in 1956 by NBS researchers Ernest Ambler, Raymond W. Hayward, Dale D. Hoppes, and Ralph P. Hudson using the using the low temperature laboratory on the NBS Washington DC campus. Lee and Yang won the Nobel Prize in Physics in 1957 (Martin and Frederick-Frost 2014).

3.5 Need For A New Campus

This section describes the initial plans to construct a new campus to accommodate the expanding research programs at NBS. Since 1903, the NBS headquarters was located on the west side of the intersection of Connecticut Avenue and Van Ness Street in northwest Washington, D.C. Originally eight acres, the campus had grown to sixty-eight acres by 1950. The D.C. campus was overcrowded with 93 buildings, a third of which were temporary buildings constructed during World War II. Buildings 1 through 9 were constructed around a quadrangle, while other buildings were sited on the property as need arose and with no overall plan (Figure 3.1). Often personnel and equipment associated with a single research division were dispersed between several buildings. Typically, one research division housed personnel in eight separate buildings. Maintenance of the laboratories was expensive due to their age and condition. Upgrades to meet contemporary research programs and operating requirements, such as increased access to electricity, heating and air conditioning, were prohibitively expensive (U.S. Department of Commerce 1961; Passaglia 1999:475).

The developing residential areas of Washington, D.C., surrounding the campus restricted future expansion of NBS. One research area that was especially hampered was radio research conducted by the CRPL, formerly known as the IRPL. Scientists assigned to the CRPL performed research on line-of-sight microwave propagation and research into new ranges of radio frequencies. The NBS D.C. campus could not accommodate ongoing radio research (Passaglia 1999:182).

In 1949, the U.S. Congress authorized $4.4 million for land acquisition for a new radio laboratory to support NBS programs in radio propagation and standards research (Passaglia 1999:612). Congress specified that the new laboratory be located outside of Washington, D.C., and the NBS administration began a nationwide search for a suitable location (NBS 1967:6). Site selection criteria included sufficient area to allow long-distance, line-of-site transmissions; lack of radio interference from nearby communities; and, accessibility and proximity to a university that possessed strong programs in electrical engineering. Twenty-eight sites were examined, including Boulder, Colorado (Passaglia 1999:182-183). The citizens of Boulder, Colorado, began a concerted campaign to attract the new NBS radio laboratory and its projected $2 million payroll. The Boulder Chamber of Commerce located a tract of land adjoining the city's southern boundary, secured a purchase option, and offered the tract to NBS. The NBS administrators accepted the land offer and selected Boulder as the new location of the new CRPL. The radio laboratory, Building 1 at Boulder, was completed in 1954 (Passaglia 1999:183).

In mid-1955, Assistant Secretary of Commerce for Administration James Worthy asked Director Astin to consider a new NBS headquarters to support efforts to relocate Federal agencies outside of D.C., which was considered a high-potential target for enemy attack during the Cold War. Astin accepted the offer and initiated the process to find a new headquarters for NBS. In a memo dated 15 July 1955, Astin summarized the reasons for relocation:

> 1) The age of NBS buildings and facilities, and the concomitant extraordinary costs needed to maintain those structures;
> 2) The uneconomical and inefficient space arrangements to accommodate the present organization;
> 3) The urgent requirement to act now in implementing plans for possible emergencies; and,
> 4) The need to find an area sufficiently distant from populated communities to im-

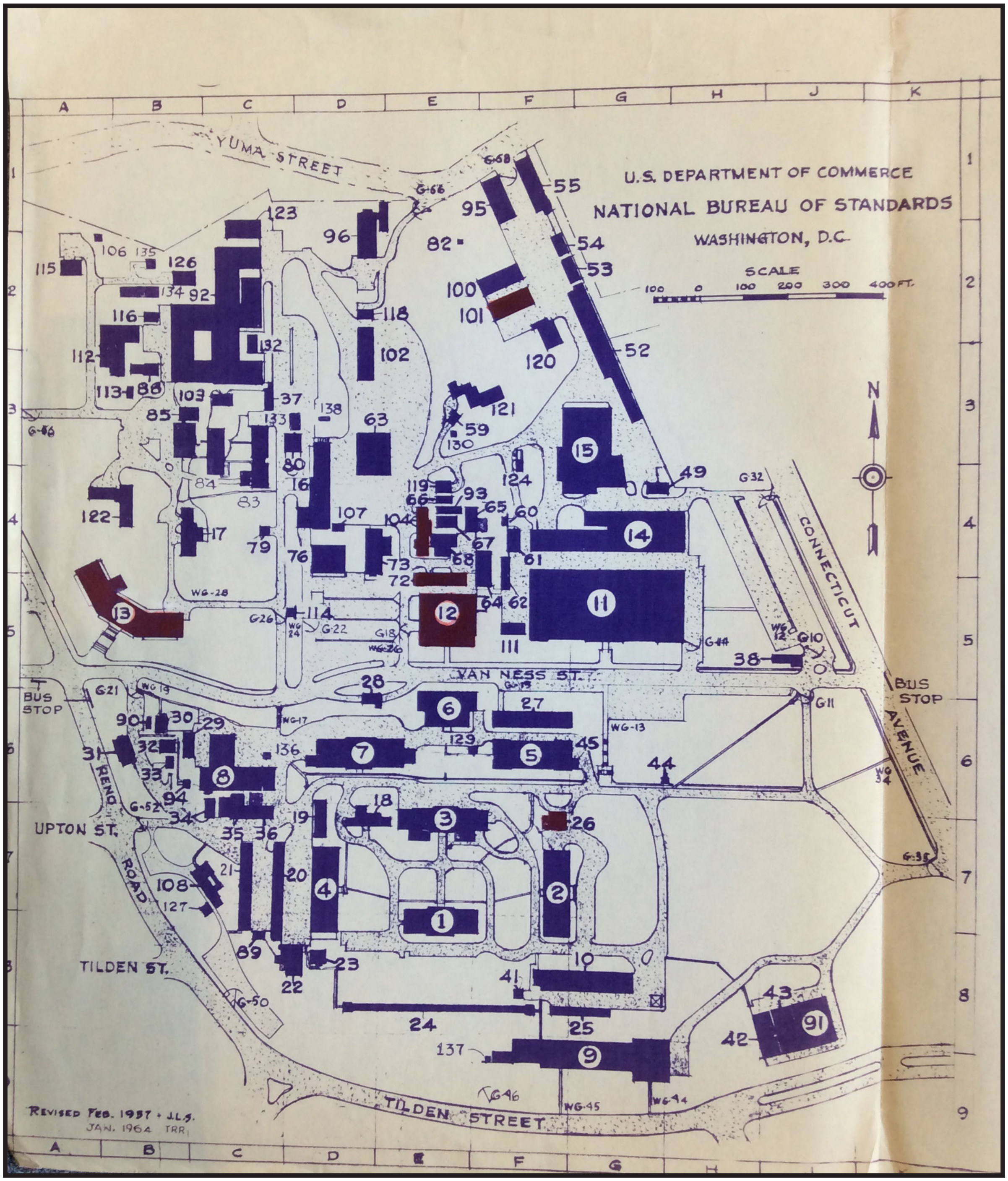

Figure 3.1 National Bureau of Standards, Washington, D.C. Campus, ca. 1964 (Source: NIST Library Vertical Files).

> prove and expand certain urgent scientific programs (Astin 1955).

Astin had only two weeks to obtain a cost estimate for the relocation before the submission of the President's budget for fiscal year (FY) 1957. He approached the GSA to prepare the cost estimate. GSA cost estimators calculated $40 million for the relocation, which was based on the construction of a single, six-story building containing 1 million square feet, several support buildings, roads, walkways, and GSA construction supervision costs. The estimate assumed a ratio of 70 per cent office space to 30 per cent support space, which proved unrealistic for laboratories. The actual space ratio for laboratories was 50 per cent of laboratory space to 55 per cent service space. GSA's initial $40 million cost estimate proved ultimately to be far too low and did not include costs for equipping the buildings or moving the staff (Passaglia 1999:475-476, 478, 481).

As passed, the FY1957 Congressional appropriation included $930,000 for site acquisition and for the preparation of plans and detailed cost estimates for the new NBS headquarters (U.S. Department of Commerce 1961). However, the appropriation was contingent on immediate site selection (Passaglia 1999:477; Summary of Files on Gaithersburg 1958:2.2, NIST Library). Astin and GSA selected 575 rural acres near Gaithersburg, Maryland, and the GSA began site acquisition in July 1956 (U.S. Department of Commerce 1956).

In the FY1959 supplemental appropriation, NBS received $3 million to cover design costs for the new NBS headquarters. The architectural firm of Voorhees Walker Smith Smith & Haines was awarded the architectural design contract (U.S. Department of Commerce 1961; NBS 1966a:6). In FY1961, Congress appropriated $23.5 million to begin construction at the Gaithersburg campus (U.S. Department of Commerce 1961). Official groundbreaking ceremonies were held at the site of Building 202 on June 14, 1961. Secretary of Commerce Luther H. Hodges commented that "it was typical of the NBS dedication to accuracy to hold the ground breaking on the exact site of the Engineering Mechanics Laboratory in spite of the remote location" (Ground Broken for Gaithersburg Laboratories n.d., NIST Library vertical file). Dedication ceremonies occurred in November 1966, followed by a two-day symposium entitled "Technology and World Trade" (Passaglia 1999:488-489).

3.6 Late Twentieth and early Twenty- First Century Administrative History

This section details the administrative history of the NBS and its transformation into NIST. Throughout this period, the agency was tasked with an increasing number of projects and directed research into a wide variety of new areas. After the 1988 reorganization, NIST focused on applying the science of measurements and technology to benefit U.S. industry.

In January 1964, the NBS was reorganized radically while the new campus was under construction. The twenty-three NBS divisions that traditionally were organized by laboratory, were structured under four institutes (Passaglia 1999:342, 344). The purpose of the institute structure was to facilitate a "systems approach to problems by grouping related programs under unified direction and by decentralizing management to permit closer evaluation and direction of program progress" (NBS 1966b:3). Prior to this change, division directors reported directly to the NBS director. After the establishment of the institutes, division directors reported to their institute director, who then reported to the NBS director. The institutes were:

- Institute for Basic Standards;
- Institute for Materials Research;
- Institute for Applied Technology (NBS 1966a:1); and,
- The CRPL in Boulder, Colorado (Passaglia 1999:343).

Each institute was assigned responsibility for specific research areas. Individual institutes were not assigned to a specific building, rather, the divisions typically were located in different buildings. The Institute for Basic Standards was tasked with the standards program for physical measurements, coordination with international measurement systems, calibration of a wide variety of measuring devices, and data dissemination of the fundamental properties of matter. This institute comprised divisions located in the Engineering Mechanics, Metrology, Physics, Chemistry, Radiation Physics, and Administrations buildings at Gaithersburg; work for the Institute for Basic Standards also was completed by some divisions located at the Boulder, Colorado, campus.

The Institute for Materials Research conducted research on methods to improve the understanding of the basic properties of materials for industry and on measurement techniques to determine those properties. This institute comprised divisions located in the Metrology, Physics, Chemistry, Materials, and Polymer buildings in Gaithersburg. The cryogenics division in Boulder also was assigned to this institute.

The Institute for Applied Technology's primary function was the development of criteria and the evaluation of the performance of technical products and services to support the Federal government and industry. This institute comprised divisions located in the Instrumentation, Building Research, and Administration buildings in Gaithersburg (NBS 1966a:1).

The reorganization was implemented as the NBS staff moved from the D.C. campus into the new facilities in Gaithersburg, Maryland. The reorganization fostered cross-disciplinary research. Divisions assigned to the institutes were dispersed among the general purpose laboratories (GPL). A sample of the equipment capabilities, calibration services, and research topics associated with the GPLs and the special purpose laboratories at the Gaithersburg campus in 1966 are summarized in Table 3.1.

Other organizational structural changes followed the move to Maryland. Some research functions, such as product testing and vehicle safety, long associated with NBS, were transferred to other agencies. Since 1904, NBS had served as a primary laboratory to test products purchased by the Federal government. Routine tests were conducted on such products as batteries, lamps, security cabinets, chemicals, and concrete. The NBS also conducted mechanical and soil testing. In 1969, Director Astin facilitated the transfer of these activities to the GSA (Passaglia 1999:380).

The Office of Vehicle Safety was not moved to Gaithersburg. Scientists in the Office of Vehicle Safety conducted research to establish the technical basis for Federal safety standards for motorized vehicles and equipment. Research was focused on tire systems, braking systems, and occupant restraint systems. The Office of Vehicle Safety operated out of the old Industrial Building at the D.C. campus until the section was transferred to the Department of Transportation in 1972 (Schooley 2000:47, 130).

Organizational changes also occurred at the NBS facility in Boulder, Colorado, during the 1960s. In 1962, the NBS and the University of Colorado at Boulder collaborated on the establishment of the Joint Institute for Laboratory Astrophysics (JILA). The new institute was founded to support space science and to research questions in plasma physics and astrophysics, combining studies in astronomy and astrophysics with atomic and molecular physics (Passaglia 1999:322-329). In 1966, a ten-story building was constructed on the University of Colorado Boulder Campus to house JILA (Schooley 2000:164-165).

The CRPL, which was planned as the fourth NBS institute, in Boulder was reorganized during the mid-1960s. A review of the environmental programs within the Department of Commerce led to the establishment of the Environmental Science Services Administration (ESSA) in July 1965. In October 1965, the staff of the CRPL were transferred administratively to ESSA, but physically remained in Building 1 at Boulder. Building 1 was occupied jointly by personnel from both NBS and ESSA, consequently, the name of the campus was changed to the U.S. Department of Commerce Boulder Laboratories (Passaglia 1999:493).

In August 1969, long-time Director A.V. Astin retired. The next two directors, Lewis Branscomb (1969-1972) and Richard Roberts (1973-1975), served relatively short terms, but both directors left enduring impacts on NBS research programs. Both directors stressed the connection between NBS research programs and national

Table 3.1 GPL Equipment Capabilities, Calibration Services, and Research Topics

Building No.	Name	Selected Laboratories/Research Facilities	Calibration Services	Selected Research projects 1968	Selected Research projects 1969-1975
101	Administration	Computer, applied mathematics, statistical engineering laboratory, Computer Center for Sciences and Technology, UNIVAC 1108/418	Standard reference material for magnetic tape	General purpose program for manipulating formatted data, five utility computer programs to make overall changes in existing data sets; studies using the methods of mathematics to assist in the development of new measurement techniques and to evaluate results of measurement; statistical analysis of consumer trends, cost-benefit analysis, computer graphing, electronic printing, fingerprint identification	Evaluations of magnetic tape, consultations, three-dimensional imaging on computer; applied mathematics handbook, random ordering of the draft for 1970, modeling flow of truck traffic in congested parts of New York City, modeling air traffic to optimize the assignment of transponder codes
202	Engineering Mechanics	Precise strain measurements, measuring large forces, vibration test room, large mass lab, acceleration of gravity, fatigue lab, 12 million pound force Universal Testing Machine installed in 1971	Calibration for hardness, load cells, proving rings, and elastic force, vibration measuring devices, railroad track scales	Development of standards of force, special standards for vibrating-measuring devices; performance of structures and strain measurements at room and high temperatures; operation of high-performance aircraft; development of missiles and space vehicles; tests of beams, creep and stress relaxation of metal at high temperatures; examination of hardware used by electric power and telephone utilities	Calibration of NASA's rocket engines
220	Metrology Building	Density laboratory, mass laboratory mass measurement process, capacitance and induction measurements, NBS electrical standards, high pressure measurements, national standard of voltage, measurement of light sources, color standards, measurement of viscosity, gear measurements, lasers for precise length measurement, volumetric laboratory	Provided electrical calibration services for electrical instruments; electrical resistance, induction, capacitance, and electromotive force (emf), voltage ratios; calibration for photometry, image optics and photography, aerial cameras, spectrophotometry, length, engineering metrology (length, diameter, end standards, step gages, threads and gears, spherical diameters, calipers, flatness, straightness, optical reflecting planes, roundness, surface texture)	Studies to improve the measurement of the electric charge, including the Faraday, capacitance standards and voltage standards; comparisons between ac and dc voltages; laser wavelength comparisons, review of procedures for accurate mass measurements; improved accuracy of line measurements using 633 nm helium-neon laser; studies of microfilm storage for Library of Congress; ongoing research in color vision; temperature-dependent properties of materials, new standard for dc and low-frequency ac calibrations	Study of lunar rock samples; comparisons of Josephson junctions with voltages obtained from standard chemical cells using a new type of potentiometer, superconductors, temperature studies with superconductors, noise thermometry experiments, improved measurement of viscosity, analysis of high-intensity electric fields
221	Physics	High-temperature calibration of optical pyrometers, high resolution electron spectroscopy, acoustical thermometer for very low temperatures, research on laser stability, spectroscopy laboratory	Temperature (liquid-in-glass), thermocouple, resistance thermometers); cryogenic resistance thermometers; radiation thermometers and standard lamps; radiometers;	Development of low temperature scale based on the saturated vapor pressure of liquid hydrogen; behavior of paramagnetic materials at low temperatures; thermodynamic properties of ammonia; superconductor properties of SrTiO3; temperature reference for 1083C; new tungsten-filament lamp standard for total irradiance replacing the 50 W carbon-filament lamp standard; laser research	Monograph on paramagnetic materials in low-temperature physics research

Building No.	Name	Selected Laboratories/Research Facilities	Calibration Services	Selected Research projects 1968	Selected Research projects 1969-1975
222	Chemistry	Nuclear magnetic resonance in chemical analysis, growth of crystals in solution, preparation of iron and steel standards, field emission spectroscopy, surface studies of metals, radioisotope tracer techniques, electron probe microanalyzer, mass spectrometry, Mossbauer spectroscopy	Development and production of standard reference materials	Research in the fields of radiochemistry, spectrochemistry, electrochemistry, analytical coordination chemistry, microanalysis, mass spectrometry, organic chemistry, separation and purification; analysis of high-purity materials, optical spectrometry, gravimetry, titrimetry, analysis of gases in metals, ion exchange, ultrapure reagents, crystallization, acidity measurements, solvent effects in electrolyte processes, mass spectrometry; absolute isotopic abundance ratios of high-purity elements important in science and industry, microanalysis using an electron microprobe X-ray emission spectrometer, ionization constant of deuterium oxide near room temperature, acid-base behavior in aprotic organic solvents, crystal studies	Studies to detect impurity elements at concentrations at parts per billion; chemical analysis with flame spectroscopy; studies to handle liquid sodium safely; studies on reactive molecules; olefin reactions at low temperatures; ion exchange resins in small spherical particles as mass standards
223	Materials	Soft X-ray spectroscopy, structure of crystals, materials research, properties of semiconductors, chemistry of materials at high temperatures, mechanical properties of brittle materials, nuclear magnetic resonance in metals, special purpose glasses, Mossbauer spectroscopy, ferromagnetic nuclear resonance	Development and production of standard reference materials	Thermodynamic properties of materials; corrosion study of galvanic pitting in metallic coatings; interface kinetics and stability of the shape of a solid sphere growing from the melt; studies of the field emission microscopy; mechanical behavior of metals, diffusion in refractory metals, deformation and fracture of ionic crystals, optical constants of titanium, x-ray powder patterns, optical properties of $SrTiO_3$, ceramics	Study of crystal structures under high pressure, thermophysical properties research on conductive refractory materials
224	Polymer	Dental research, polymer research		Dielectrics, chemistry and physics of polymers, molecular and thermophysical properties; polymer crystallization, polymer properties, dental materials	Polymer crystallization, nucleation theories for chain-folded polymers, dental amalgams, instruments used in dental research
225	Instrumentation (Technology)		Evaluation of electronic instrumentation, maintained standard reference materials for rubber and paper	Automated systems and services, development of measurement techniques and test methods for technical materials, research on plastics and textiles, fibrous systems, viscoelastic materials, paper evaluation, and fabric flammability; semiconductor measurements	Improved methods of preparing low-resistance contacts on semiconductors, research on defective bonding of wire leads to metallized semiconductors, research on defects of lithium-compensated germanium gamma ray detectors

Building No.	Name	Selected Laboratories/Research Facilities	Calibration Services	Selected Research projects 1968	Selected Research projects 1969-1975
226	Building Research	Environmental engineering, structural testing, accelerated weathering, building component testing laboratory		Reorientation of research program from building components and materials to behavior of entire buildings systems, assisting governmental analysis of building problems/failures, participation in National Conference of States on Building Codes, fire studies, materials durability and analysis, environmental engineering	Pilot study surveying two large office buildings, evaluating live floor loads and fire loads; natural disaster damage assessments for 1971 San Fernando Valley, CA, earthquake, Texas tornado in 1970; improvements to building design to prevent damage from high winds; testing and evaluation of 22 manufactured housing systems as part of HUD "Project Breakthrough" focused on performance criteria; evaluated new public buildings using performance criteria; update estimates of live loads for office buildings, including weights of occupants, stored materials, and furnishings; update of fire loads in office buildings, continued work on building codes, evaluation of holding strength of inserts embedded in concrete, testing to destruction of 100 types of masonry walls to establish their strength under axial, transverse, and diagonal loads
233	Sound	Large anechoic chamber, reverberation chamber	Acoustics	Opened in 1968	Noise level of trucks at Wallops Island, VA; nose levels of mowers; hearing aid investigations, quality of microphones, loudspeakers, and other audio equipment; hearing protectors at firing ranges; acoustical properties of Juilliard String Quartet instruments; acoustical absorption of architectural materials
235	Neutron Studies		Calibration of neutron sources, instrumentation, irradiation of neutron foils	Neutron studies, backscattering of alpha particles, interactions of nuclei with electromagnetic fields	

Building No.	Name	Selected Laboratories/Research Facilities	Calibration Services	Selected Research projects 1968	Selected Research projects 1969-1975
245	Physics	X-ray machines, production of neutrons, four million volt electron accelerator, calibration of neutron sources, standards of radioactivity, 100 million volt linear accelerator, synchrotron	X-ray calibrations, radioactive samples, beams of x-rays, gamma rays, and electrons, dosimeters, measuring instruments	Atomic spectroscopy, scattering theory, irradiation processing of foods including radiation sources and dosages	Handling of hot accelerators, measuring radioactive doses
231	Industrial	Special equipment for the study of paper making and textiles			
230	Fluid Mechanics	Laboratory to research large air meters and water meters, aerodynamics laboratory to study laminar and turbulent air flow, subsonic and super-sonic wind tunnel, water tunnel	Calibration of large air and water meters, fluid meters, hydraulics, aerodynamics	Specialized studies of the flow characteristics of a variety of fluids; turbulent fluid fields	

(Sources: NBS 1966a; NBS 1966c; Schooley 2000) need and the role of NBS as a consumer-oriented, problem-solving institution. Director Lewis Branscomb created a Program Office that was assigned the tasks of developing policy, analyzing programs, tracking funding sources, ensuring that NBS research programs were related justifiably to national needs, and formulating budgets (Schooley 2000:171). Director Roberts strengthened this trend by instituting program reviews and continuing to streamline the organization (Schooley 2000:333, 337).

Director Branscomb also initiated problem-solving groups within the NBS. For example, when the problems of air and water pollution surfaced as national issues during the 1960s, Branscomb established a new office, Measures for Air Quality. Scientists from several divisions collaborated to identify existing NBS programs capable of measuring various aspects of air pollution, particularly automobile emissions. NBS scientists conducted research to identify the key components of air pollution and prepared standard reference materials for the gases to support compliance with auto emission laws (Schooley 2000:173-174).

Director Branscomb continuously emphasized the relevance of NBS research programs to solving national problems when testifying in budget hearings before Congress. By 1974, the NBS codified specific budget areas to describe its programs. The budget areas were scientific and technical measurements, use of science and technology, equity in trade, public safety, technical information, central technical support, and the experimental technology incentives program specifically requested by the Nixon White House (Schooley 2000:172, 185-186).

Director Branscomb also sought to educate Congressional members about the NBS programs. He invited the House Committee on Science and Astronautics to conduct an in-depth review of NBS, its goals, structure, operations, and programs. The Congressional Research Service (CRS) prepared a comprehensive report on NBS, which in 1970 employed 4,053 persons, including a staff of 650 at Boulder. The CRS researchers acknowledged the "difficulty in 'getting a grip' on the Bureau because…outsiders knew relatively little about its work" (Schooley 2000:189, 193). During his tenure, Director Roberts continued the work initiated under Director Branscomb to increase the visibility and public image of the NBS and to tie NBS research programs to consumer-related areas (Schooley 2000:337, 339).

In 1977-1978, Acting Director Ernest Ambler (1976-1978, then Director 1978-1989) implemented another NBS reorganization. Ambler's vision for NBS was to "undertake programs to foster the delivery of technology to the industrial, intergovernmental and international sectors" (Schooley 2000:452). Ambler appointed a steering committee and five task forces to guide the transition to the new organizational structure. The institutes established in 1964 were abolished. Research programs were realigned into the National Engineering Laboratory (NEL), the National Measurement Laboratory (NML), the Institute for Computer Sciences and Technology, the NBS/Boulder Laboratories, two National Centers for Cooperative Technology, and Administrative and Information Systems (Schooley 2000:452-453).

The NEL comprised the Center for Fire Research, which included the Fire Science and Fire Safety Engineering divisions; the Center for Electronics and Electrical Engineering; the Center for Mechanical Engineering and Process Technology, which was divided in 1981 into the Center for Manufacturing Engineering and the Center for Chemical Engineering; the Center for Building Technology; the Center for Consumer Product Technology; the Center for Applied Mathematics; and, a new Center for Chemical Engineering. The instrument shops were assigned to the NEL. The NML was assigned the traditional measurement standards, physics, and chemistry activities. These research activities fell under the Center for Absolute Physical Quantities, the Center for Radiation Research, the Center for Thermodynamics and Molecular Science (later the Center for Chemical Physics), the Center for Analytical Chemistry, and the Center for Materials Science. The Institute for Computer Science and Technology established in 1966 remained a separate entity. The new organizational structure was in effect until 1988 (Schooley 2000:453-457).

The implementation of the new NBS organizational structure coincided with President Carter's efforts to reform the civil service, and intense efforts under President Reagan's administration to reduce the size of government, particularly in areas that could be served by the private sector. During 1982-1983, the NBS budget was targeted for potential cuts by the Grace Commission. The Grace Commission projected potential savings of $45 million over three years from eliminating the centers in chemical engineering, manufacturing engineering, fire research, building technology, analytical chemistry, and materials science.

A second panel, the White House Science Council Federal Laboratory Review Panel, visited NBS in 1982 to review the agency and its research. The NBS was one of 16 laboratories selected to represent the 700 Federal laboratories operated for, or by, the Federal government. The panel recommended that NBS clearly define its mission, revise personnel policies, work to secure multi-year funding, incorporate peer review of laboratory management and operations, and increase collaboration with universities and industry. Director Ambler chose to adopt the recommendations of the second panel by defining the NBS mission as assisting U.S. industrial goals, strengthening ties to academia and industry, and emphasizing outside review of NBS research. In 1981, the NBS was required to reduce its work force by 10 percent (approximately 300 employees) under President Reagan's reduction in force program (Schooley 2000:463-467, 472, 478). As NBS was under pressure to reduce personnel and costs, Congress passed legislation that assigned new and additional responsibilities. Despite pressures to downsize, Director Amber secured increased funding and larger NBS budgets during his tenure as director (Schooley 2000:469, 479).

In 1988, the Omnibus Trade and Competitiveness Act (Public Law 100-418) redefined the roles and mission of the NBS. The NBS was renamed the National Institute of Standards and Technology (NIST) to reflect its new responsibility: to play a major role in revitalizing U.S. trade in the face of Japanese and German technological superiority. The drafters of Public Law 100-148 both acknowledged the traditional NIST research areas and defined its important future role:

> The National Bureau of Standards since its establishment has served as the Federal focal point in developing basic measurement standards and related technologies, has taken a lead in stimulating cooperative work among private industrial organizations in efforts to surmount technological hurdles and otherwise has been responsible for assisting in the improvement of industrial technology. It is the purpose of this Act to rename the National Bureau of Standards as the National Institute of Standards and Technology and to modernize and restructure that agency to augment its unique ability to enhance the competitiveness of American industry while maintaining its traditional function as lead national laboratory for providing the measurements, calibrations, and quality assurance techniques which underpin United States commerce, technological progress, improved product reliability and manufacturing processes, and public safety (Schooley 2000:615).

Director Ambler, who was soon to retire, commented on the new focus of NIST: "We now have a direct, unambiguous charge to work closely with industry on the development and use of new technologies that U.S. companies need to stay competitive in the world marketplace" (Schooley 2000:635).

The new NIST essentially retained the same organizational structure implemented in 1978 with one addition. The Industrial Technology Services was formed to include the Advanced Technology Program, the Manufacturing Technology Program, and the offices of Standards Services, Technology Commercialization, Industrial Extension Services, and Measurement Services. The purpose of the Advanced Technology Program was to assist technology transfer to industry for quick commercialization of economically viable scientific discoveries and improvement of manufacturing technologies (Schooley 2000:632, 636, 638).

In 1990, John Lyons became the new NIST Director (1990-1993) and began to adapt the NIST organizational structure to his vision for the agency and to meet the goals of supporting industry. The new organizational structure formally was implemented in 1991 (Schooley 2000:645). The 1991 NIST organization comprised the following laboratories:

- Electronics and Electrical Engineering Laboratory (Electricity, Semiconductor Electronics, Electromagnetic Fields, and Electromagnetic Technology divisions) located in Buildings 220 and 225 and Boulder, Colorado;
- Manufacturing Engineering Laboratory (Precision Engineering, Automated Production Technology, Robot Systems, Factory Automation Systems, and Fabrication Technology divisions) located in Buildings 220, 225, 244, and 245;
- Chemical Science and Technology Laboratory (Biotechnology, Chemical Engineering, Chemical Kinetics and Thermodynamics, Inorganic Analytical Research, Organic Analytical Research, Process Measurements, Surface and Microanalysis Science, and Thermophysics divisions) located in Buildings 222, 221, 230, 220, 235 and Boulder, Colorado;
- Physics Laboratory (Electron and Optical Physics, Atomic Physics, Molecular Physics, Radiometric Physics, Quantum Metrology, Ionizing Radiation, Time and Frequency, Quantum Physics, and Radiation Source and Instrumentation divisions) located in Buildings 221, 220, 245, and Boulder, Colorado;
- Materials Science and Engineering Laboratory (Office of Nondestructive Evaluation, Ceramics, Materials Reliability, Polymers, Metallurgy, and Radiation divisions) located in Buildings 224, 223, 235, and Boulder, Colorado;
- Building and Fire Research Laboratory (Structures, Building Materials, Building Environment, Fire Science and Engineering, and Fire Measurement and Research divisions) located in Buildings 226 and 224;
- Computer Systems Laboratory (Information Systems Engineering, Systems and Software Technology, Computer Security, Systems and Network Architecture, and Advanced Systems divisions) located in Buildings 225 and 223; and,
- Computing and Applied Mathematics Laboratory (Applied and Computational Mathematics, Statistical Engineering, Scientific Computing, Computer Services, Computer Systems and Communications, and Information Systems) (Schooley 2000:635, 976-987; NIST 1996).

In February 1991, Director Lyons and NIST senior managers prepared a 10-year strategic plan. Among the priorities identified in the strategic plan was doubling laboratory budgets and modernization of laboratory facilities. The NIST facilities, then approaching thirty years old, required modernization and upgrades particularly in the areas of laboratory environmental controls, such as temperature, humidity, vibration, air filtering; safety systems; and, utilities. Director Lyons testified before Congress in 1992 that "many of the NIST laboratory buildings were no longer equal to modern scientific demands. Such problems as ubiquitous dust - let alone a lack of critical services - rendered some of the laboratories unfit for specialized investigations" (Schooley 2000:650-651, 653, 655). However, funding for new buildings was not forthcoming until the end of the 1990s and into the early 2000s.

In 1993, President Clinton appointed the first woman director of NIST, Arati Prabhakar, who came to the organization from the Microelectronics Office of the Defense Advanced Research Project Area (Schooley 2000:656). Prabhakar directed an organization that employed about 3,300 scientists, engineers, technicians and support personnel with a budget of $810 million supported by Congressional appropriations, project funding from other agencies, user fees, and sales of SRMs and publications. Publications numbered more than 480 per year and included reports on standards, research results, catalogs of products and services, and technical handbooks (NIST 1996:n.p.). One important element of public outreach was the dissemination of the 1996 Guide to NIST. The document was a consumer-oriented publication, providing an overview of research programs and available research facilities for the seven operating laboratories and their associated departments. By this time, the two computer laboratories were combined into the Information Technology Laboratory (NIST 1996:147).

The NIST organization evolved as research areas continually were aligned to meet national research priorities. In April 2007, two new research centers were formed: the NCNR and the Center for Nanoscale Science and Technology. The Center for Nanoscale Science and Technology formerly had been a division within the Materials Science and Engineering Laboratory. By 2009, NIST comprised ten laboratory programs: Building and Fire Research, Center for Nanoscale Science and Technology, Chemical Science and Technology, Electronics and Electrical Engineering, Information Technology, Manufacturing Engineering, Materials Science and Engineering, NCNR, Physics, and Technology Services (Martin and Silcox 2010:139-140).

In 2010, NIST's research programs again were realigned from a laboratory-based to a mission-based structure fostering interdisciplinary research groups collaborating on projects. The new organization replaced a single deputy director with three associate directors and reduced the number of laboratories to six. The laboratories comprised Material Measurement Laboratory, Physical Measurement Laboratory, Engineering Laboratory, Information Technology Laboratory, Center for Nanoscale Science and Technology, and NCNR (NIST 2010b). By 2014, the Communications Technology Laboratory in Boulder became the seventh operating unit (NIST 2014c).

The Department of Commerce is tasked with encouraging and prompting the economic growth of the United States. Through its collaboration with private-sector industry and businesses, universities, and local governments, the department helps to promote job creation and sustainable development. The 12 bureaus, including NIST, that fall under the Department of Commerce, collectively assist that Federal department with fulfilling its mission. NIST's location within the Department of Commerce helps ensure that new products and services are developed and improved for use in commercial applications. Further, NIST assists the department by facilitating development of new technologies and innovations that can be adopted by the private sector (U.S. Department of Commerce 2014).

Chapter 4.0

Historic Context: Design of the NIST Gaithersburg Campus

The previous chapter explored the NBS administrative history from its establishment to the present. This chapter explores the design and construction of the Gaithersburg campus. The chapter includes a summary of construction at the campus over time and profiles the architecture and engineering firms responsible for the design of the Maryland facility.

4.1 The Move to Gaithersburg

By the 1950s, the NBS had outgrown its Washington, D.C. facilities. The D.C. campus comprised over 90 buildings in a sprawling campus. Many of the buildings were ill suited to conducting the research needed to fulfill the agency's mission. In addition, the expanding residential areas of Washington, D.C., had encroached on the NBS campus, resulting in interference with the work conducted by the CRPL, including line-of-sight microwave propagation, and research into new ranges of radio frequencies (Passaglia 1999:182). The agency was in desperate need of room and modern facilities.

A campaign to relocate the NBS began during the mid-1950s when James Worthy, Assistant Secretary of Commerce for Administration, approached NBS regarding relocation as part of an effort to disperse Federal agencies outside the District of Columbia, which, during the height of the Cold War, was considered a high potential target area. NBS director A.V. Astin accepted the offer, and thus began the multi-year NBS relocation process. Director Austin coordinated with the GSA to prepare a construction budget, which was submitted to Congress for approval, and ultimately, the appropriation of funds. While the GSA acted in a construction management capacity, the agency did not assume operational and management responsibility for the buildings once they were completed. Rather, the new campus and buildings became part of the NBS real property inventory.

Many factors were considered in site selection. Agency requirements for acreage and distance from the nation's capital established basic criteria for potential locations. The new site needed to encompass a large area, ideally 500 or more acres, and to be located approximately 15 to 20 miles outside the District of Columbia, but not in the Baltimore-Washington corridor. Future expansion also was a key consideration in site selection. The site of the new home for the NBS needed to be large enough to accommodate the construction of additional buildings.

Isolation from population centers and the associated mechanical, electrical, and atmospheric disturbances that could interfere with the agency's precise scientific measurement and research programs was paramount. In addition, the site needed to be accessible to NBS scientists; access to downtown Washington, D.C., and proximity of the site to where Bureau scientists lived were imperative (Voorhees Walker Smith Smith & Haines 1961b:1). Like with other research facilities constructed during the period, project planners sought a site that was located outside the city center in a suburban location that would be convenient for NBS employees. In addition, NBS maintained strong working relationships with research institutions and other government agencies. The ability to continue those relationships from the new location was important to administrators and scientists.

In May 1956, Director Astin was shown a site that appeared to meet the agency's requirements. The Gaithersburg, Maryland, location comprised 575 acres in rural Montgomery County and was accessible by rail and road. Final site selection set in motion land acquisition and the preparation of plans and cost estimates.

In selecting a firm to design the new campus, the Federal government sought an established company experienced in the design of research facilities meeting exacting requirements. Specifically, NBS officials wanted a team with: "the experience, competence, and the size necessary to accomplish the planning for a large research facility like the National Bureau of Standards" (NBS 1966a:3). The selected firm, Voorhees Walker Smith Smith & Haines, had extensive technical expertise in designing laboratory space.[1] Indeed, the decision to select the design team was well-considered. Since World War II, the firm had designed and constructed approximately 10 million square feet of laboratory space for such clients as DuPont, Ford, General Electric, and IBM, in addition to the Bell Telephone Laboratories (NBS 1966a:3). The firm concurrently designed research laboratories for NASA's Goddard Space Flight Center in nearby Greenbelt, Maryland.

In December 1956, GSA contracted with the New York City-based architectural firm to initiate preliminary studies for the new NBS facility. Their assignment was "to determine the number, size and type of structures required, to develop a fundamental site development plan as a basis for final designs, and to prepare cost estimates. Basic requirements for the exploratory study were to consolidate the Bureau's various operating divisions into the smallest practicable number of buildings; to provide mechanical and electrical facilities that would serve the laboratories…; to plan the buildings for a limited increase in the future work load and site addition of further research facilities as required" (Voorhees Walker Smith Smith & Haines 1961a:1). HLW International was awarded the architectural design contract in 1959 (U.S. Department of Commerce 1961; NBS 1966a:6).

[1]The architectural firm that designed the Gaithersburg campus, Voorhees Walker Smith Smith & Haines, underwent a number of name changes since it was established. A change in name also occurred during the design and construction of the NIST campus. For simplification and to avoid confusion, HLW International (the firm's current name) will be used for all future references to the original design team. Chapter 6 provides a summary history of the firm and identifies all iterations of its name.

Design of the new campus was conducted simultaneously with the land acquisition process. The first land acquisition was completed during 1958. Additional parcels were acquired between 1959 and 1962. In all, 565.3 acres were acquired from nine owners. The smallest parcel was 1.7 acres, while the largest parcel was 260.2 acres. The remaining 14.6 acres were purchased from four owners between 1967 and 1986 (NIST n.d.a).

When the Gaithersburg campus was planned, three institutes were scheduled to move to the new facility: the Institute for Basic Standards, the Institute for Materials, and the Institute for Applied Technology. Public and private-sector employees participated in discussions regarding the new campus (NBS 1966a:1). The new campus would house the world's largest physical science laboratories "designed to meet the varied environmental and space requirements of many kinds of specialized equipment and delicate, highly precise measuring instruments" (NBS 1966a:3).

4.2 Designing the Gaithersburg Campus

Upon selection of the design team, the first major decision confronting the designers was the issue of the type of research facility envisioned: a single-structure plan versus a multiple-building campus. The GSA preferred a single building option, as a measure to contain construction costs. NBS administrators and scientists preferred a campus setting with multiple buildings and landscaped grounds, reminiscent of the D.C. campus. The architects prepared a variety of options, submitting one multiple-building plan and three single building plans (Figure 4.1, Figure 4.2, Figure 4.3, and Figure 4.4). Ultimately, the architects recommended the multiple-building plan because it offered maximum flexibility and minimal restriction in planning the varied research programs conducted at NBS (Voorhees Walker Smith Smith & Haines 1961b:1-2; NIST 1958:3:21-1-2) Figure 4.5. Additionally, the nature of some testing required isolation from other laboratories to eliminate environmental interference. The architects determined that the one-building scenario for accommodating all of the employees slated to move to Gaithersburg and that could also meet the necessary required vibration and noise toler-

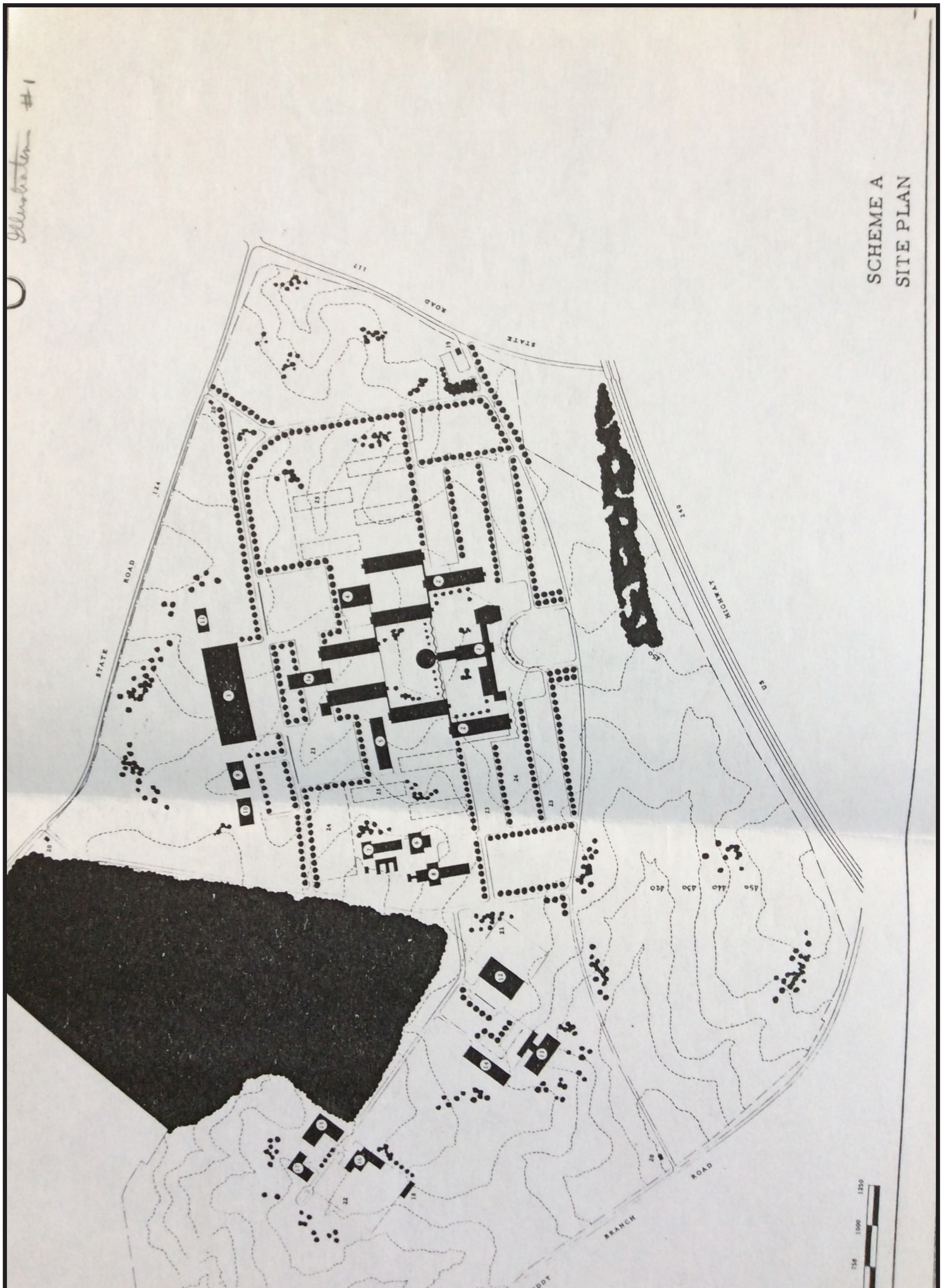

Figure 4.1 Proposal for NBS Gaithersburg Campus, Scheme A (Source: NIST Library Vertical Files).

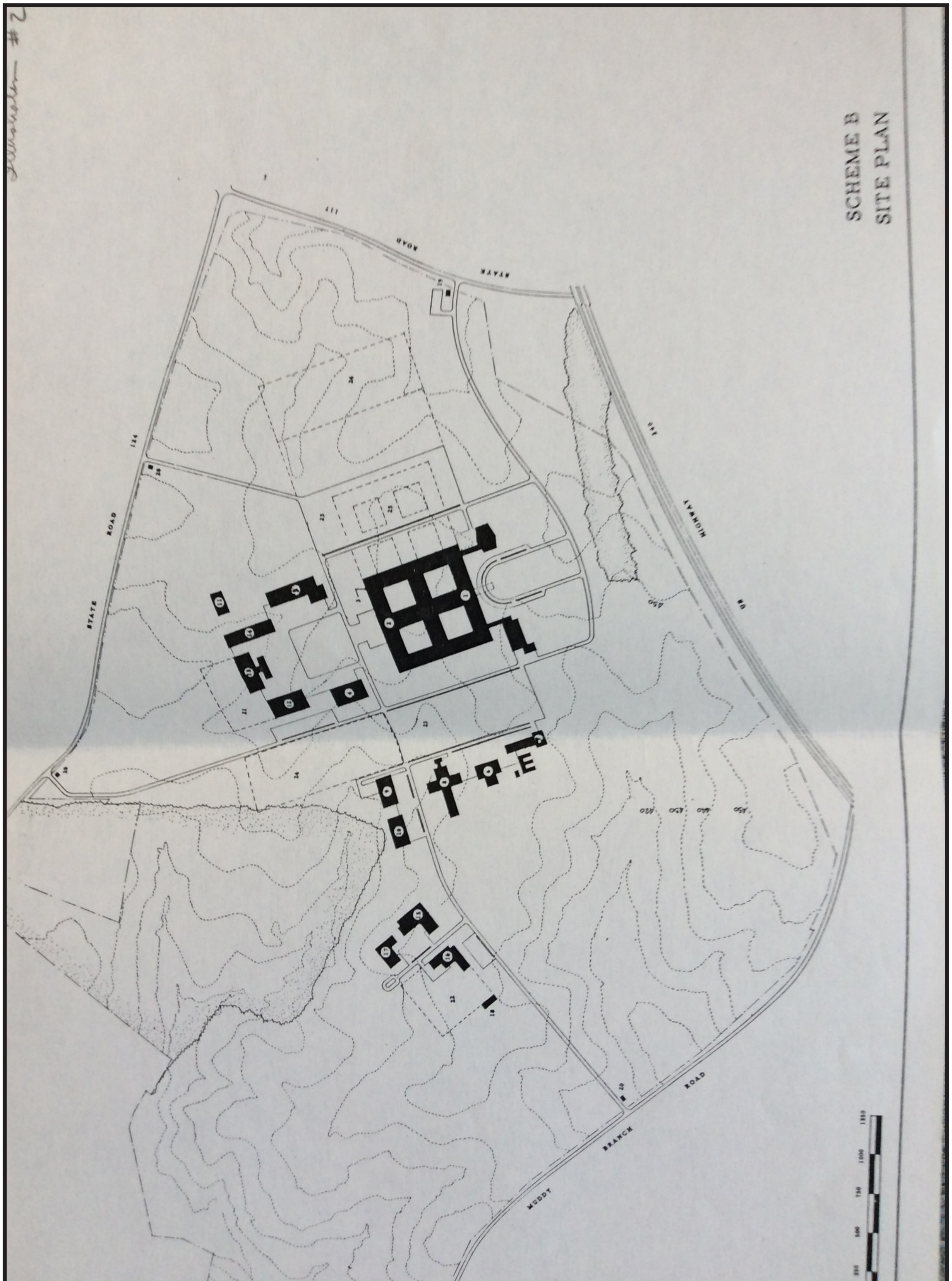

Figure 4.2 Proposal for NBS Gaithersburg Campus, Scheme B (Source: NIST Library Vertical Files).

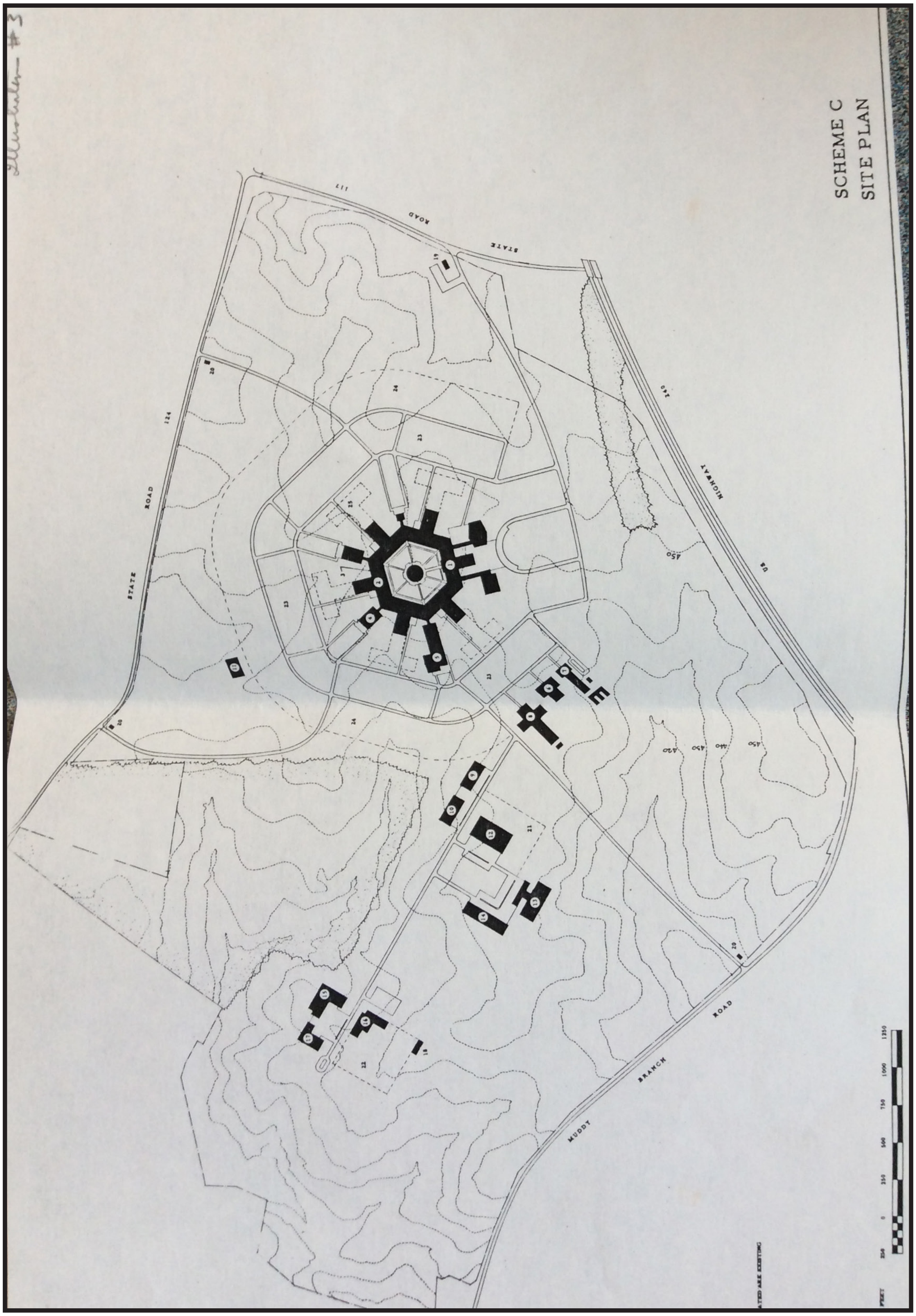

Figure 4.3 Proposal for NBS Gaithersburg Campus, Scheme C (Source: NIST Library Vertical Files).

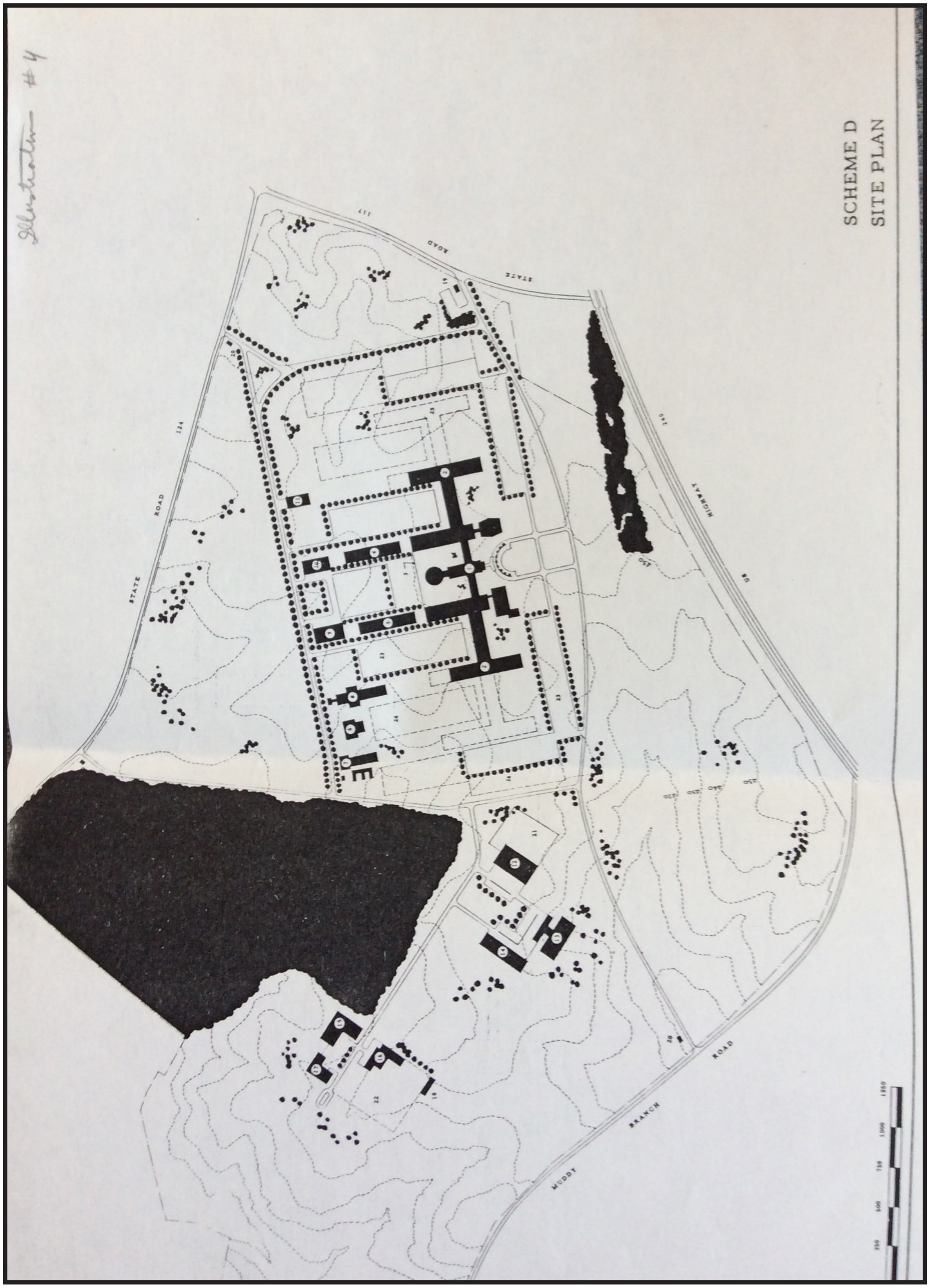

Figure 4.4 Proposal for NBS Gaithersburg Campus, Scheme D (Source: NIST Library Vertical Files).

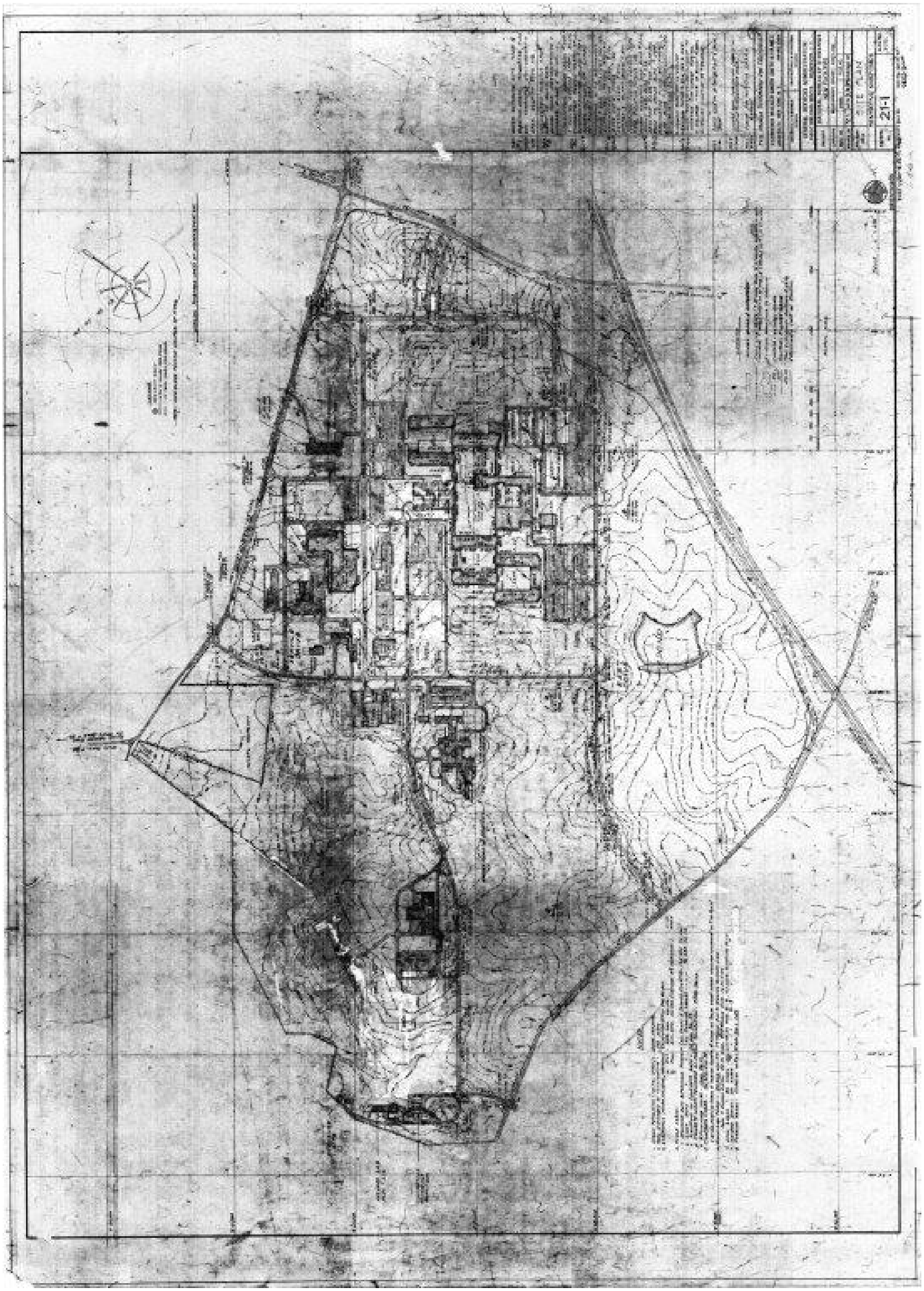

Figure 4.5 Early Site Plan, NBS Gaithersburg Campus (Source: NIST Office of Facilities & Property Management)

ances was not practical. Two types of laboratories would be needed: one type of laboratory for general purposes and another type that would be isolated from other buildings and where highly technical testing could be conducted absent environmental interference.

Once the decision on the type of facility was resolved, design of the new facility began in earnest. An intense collaborative relationship developed among the NBS scientists, administrators, and the design team. As part of this collaboration between the government client and architectural firm, a multi-pronged approach to the design process was developed. This process included site visits to other research laboratories for comparative research into similar facilities, the creation of a planning committee, and the construction of scale models.

Part of the collaborative design philosophy included input from scientists at other research institutions. To accomplish that goal, NBS administrators and scientists and representatives from the architecture firm visited many of the nation's noted research laboratories to solicit advice and opinions from associates at similar laboratories. Facilities visited included DuPont, Bell Telephone Laboratories, Argonne National Laboratories, Midwest Research Institute, Lincoln Laboratories, Westinghouse Corporation, General Electric Research Laboratory, General Electric Measurements Lab, IBM, General Motors, National Carbon Company, and Franklin Institute (Passaglia 1999:481; Laboratory Planning Committee 1957:4). Two of the research campuses, Bell Telephone Laboratories and Argonne National Laboratories, were designed by HLW International. The purpose of these visits was to gather data on the functionality and organization of the physical plant that could be incorporated into the design of the new NBS headquarters (NIST 1958:3.21-4).

The NBS established a process for agency employees to offer input on the design of the new campus. The Laboratory Planning Committee, comprising a cross-section of scientists, was created to seek input from NBS colleagues, to liaise between the administration and the architects, to identify key laboratory requirements, and to offer feedback on the design of the campus in general, and laboratories specifically. The Committee developed recommendations, which were then presented to the architects. The Committee adopted five concepts to assist with its task:

- All designs must take into account that scientists complete "the basic mission of the Bureau". To that end, the design should address the needs of the scientists.
- Management decisions regarding the design and allocation of laboratory and office space should be based on need and performance, or as the Committee called it, "intelligent management" rather than inflexibility in design of the facilities.
- The research, tools, and programs the NBS implements to complete its mission are dynamic. The Committee noted, "we must have a flexible and highly adaptable laboratory module, as well as a situation where interconversion between offices…., laboratories, and office-laboratories is readily achieved. The need for increased flexibility provides the major impetus for moving the entire NBS operation to the new site."
- The design of the campus should encourage communication between people and of goods, equipment, materials, and supplies.
- The Committee recognized that funding for future projects may be limited. Therefore, "basic provisions," i.e., air conditioning and adequate wiring in case of future expansion, are planned at the outset because the likelihood of such modifications being implemented at a later date was remote. Along the same lines, the Committee suggested that future expansion of existing buildings be taken into consideration to avoid haphazard expansion of the buildings (Laboratory Planning Committee 1957:1-3).

The Committee played a key and influential role in both the design of the campus and the inclusion of select features in the research buildings. The Committee advised on building programs and office/laboratory space parameters. Through the Committee, NBS scientists identified the following minimum uses to be housed on the campus: auditorium, shops, storerooms, library, and cafeteria (Laboratory Planning Committee 1957:5). Committee members provided suggestions for the location of campus services and building programs. A review of the drawings prepared by the project architects indicates that some of the Committee's recommendations were integrated into the design. For example, the Committee recommended easy access to the library; siting it on the roof of the major administrative building, as depicted in preliminary designs, was discouraged (Laboratory Planning Committee 1957:5).

NBS scientists who were not members of the planning committee also influenced laboratory design. Examples of NBS scientists expressing design preferences include discussions on the inclusion of windows in laboratory buildings and the minimum size requirements for individual laboratory spaces. The merits of natural versus artificial lighting were debated intensely between scientists and the architects. While employees expressed little disagreement on the inclusion of windows in the office spaces, they expressed strong opinions on whether windows should be included in the laboratories. Each NBS division was asked to provide an opinion on whether windows should be included in the laboratories in an attempt to develop consensus. Many sections preferred windowless labs, particularly those sections engaged in projects requiring periods of darkness (Associate Director for Administration 1956:1). In other divisions, the decision to exclude windows generated widespread displeasure, with some scientists threatening to quit if windows were excluded from work spaces (Associate Director for Administration 1956:2). Ultimately, those who advocated the exclusion of windows prevailed. The GPLs were designed without windows in the laboratory spaces.

Prospective design flexibility, both in the future development of the campus and in the interior configuration of individual buildings, was a programming priority. Workspace flexibility was paramount, generating significant discussion among the Committee, the administration, and the architects, and intense focus and study by the design team. The Committee strongly supported the concept of the "modular" laboratory. Scientists working at the Bell and Westinghouse laboratories cautioned their NBS colleagues that while modular design offered maximum flexibility in the configuration of research spaces, such design also resulted in "rigidity because of inevitable overstandardization" (Laboratory Planning Committee 1957:11). Based on advice from Bell and Westinghouse scientists, the NBS Laboratory Planning Committee strongly recommended that the Bureau avoid rules on the location of plumbing and electrical equipment to allow maximum flexibility in the reconfiguration of laboratory space (Laboratory Planning Committee 1957:11). Restrictions on the type and location of services could impact the size of laboratory modules and reduce flexibility.

While Committee members agreed that modular design afforded maximum flexibility, they disagreed on the optimal size and shape of the basic module, with scientists initially preferring a 12 x 24 or 12 x 26-foot size module (Laboratory Planning Committee 1957:11). To assist the staff in visualizing the proposed modular laboratory space, a modular space with removable walls spaced at 10 feet, 11 feet, and 12 feet was set up on the D.C. campus. Ultimately, NBS administrators chose the 11 foot width module for the Gaithersburg campus (Voorhees Walker Smith Smith & Haines 1961:2).

The need for two types of laboratories, general laboratories and facilities for highly-technical research, was recognized early in the design process. The highly-specialized nature of some of the research programs required the construction of purpose-built buildings isolated from the general laboratories. However, the overwhelming majority of scientific investigation would occur in the GPL, which were intended to "be suitable for most of the work performed within NBS laboratories" (NBS 1966a:5). The GPLs were easily adaptable. A chemistry lab easily could be converted for use as an electronics laboratory (NBS 1966a:7).

Buildings for highly-specialized research also were designed. Some of the work completed by the Bureau required very specialized facilities that could not be accommodated in the GPLs. (Voorhees Walker Smith Smith & Haines 1961b:3). Special purpose laboratories were those that required: laboratory space larger than the standard module, precise temperature control, special ventilation, or excessive floor loading (Voorhees Walker Smith Smith & Haines 1961b:3). Due to the nature of the testing and experimentation that was to be conducted in the buildings, these laboratories could not be designed with adaptability and flexibility in mind (NBS 1966a:7). These specialized and technical facilities included:

- Tape Calibration Facility;
- Photometric Range;
- Spectascopy Area;
- Neutron research facility; and,
- Building Research Special Areas
    - Environmental Engineering Laboratory and
    - Structural Test Laboratory (NBS 1966a:10, 11).

Applying the knowledge gained through collaboration with the NBS, the architects developed a design concept. A scale model of the multi-building Gaithersburg campus was unveiled at the Project Design Review Meeting on 1 June 1960. The model was viewed by representatives of GSA, NBS, U.S. Department of Commerce, and the Bureau of the Budget. Photographs of the model appeared in local newspapers shortly thereafter (Passaglia 1999:483; The NBS Standard, June 1960). Once the basic design of the campus and individual buildings had been completed, the NBS issued a document akin to design guidelines, which outlined basic building provisions (NBS 1961). The document codified construction materials for the GPLs and established the dimensions of the demountable steel partitions used for the configuration of the interior modules. Flooring materials were specified and air conditioning, exhaust systems, and mechanical and electrical service were identified (NBS 1961).

4.3 Construction of the Campus

The final design of the Gaithersburg facility incorporated prevailing architectural design theories and tenets for successful research campuses. These tenets included: suburban siting; general research labs and highly specialized laboratories; flexibility in design to facilitate reorganization of spaces; and adequate acreage to accommodate future expansion. Productive collaboration among colleagues was among the goals in the construction of postwar research campuses. Creating an environment conducive to collaborative interaction among scientists was a key consideration in the design of the NBS facilities.

Ideally, the most cost-effective approach to establishing a collaborative work environment was to minimize the number of buildings constructed. Two options were considered: the construction of one large building, or limiting the number of buildings constructed through the consolidation of uses. The administration and the architects determined the former option ineffectual.

In consultation with NBS administration, the architects designed the facility based on the campus design approach. Rather than designing a large building housing the majority of the components NBS needed, the architects and top administration officials deemed the construction of several buildings was a more appropriate solution. Administrative, service buildings, special laboratories, and general laboratories were planned (Voorhees Walker Smith Smith & Haines 1961b:2).

The site plan for the Gaithersburg campus grouped the buildings into three general areas: the GPLs and the principal administration building were grouped together. Service and support functions generally were located west of the GPLs and the specialized, special purpose buildings generally were located south of South Drive. The architects planned to incorporate extensive landscaping (Voorhees Walker Smith Smith & Haines 1961b:6). They intended that most of the roads would be tree lined (Voorhees Walker Smith Smith & Haines 1961b:6).

The central focus and dominant building of the complex was the Administration Building (Building 101), which was linked by enclosed passageways to low scale buildings, including seven GPLs and the Instrument Shops Building (Building 304). The Administration Building housed all common facilities and public spaces, such as a variety of dining facilities; a library; and meeting rooms of various sizes, including an 800-seat auditorium, a 300-seat auditorium, three

100-seat, one 50-seat, one 25-seat, and two 12-seat lecture rooms (NBS 1966a:5). The executive offices for the agency director also were housed in the building (Figure 4.6).

The GPLs were identical in exterior design with minor differences. Three of the seven buildings were constructed with basements. All seven buildings rise three stories above the ground level. The GPLs were designed to house approximately 1,500 scientists, engineers, and support staffs. The seven GPLs represented a consolidation of research activities. At the Washington, D.C. site, the same number of scientists and their support staffs were housed in 48 buildings (NBS 1966a:7). The laboratories were classified as "general purpose" because of their flexible interior design, but were assigned originally to specific research areas. The siting of the GPLs allowed for the addition of up to seven additional buildings, while retaining the original hierarchical plan of connected buildings.

The plant support area was located west of the Administration Building and the GPLs and contained the boiler and refrigeration plant, the Potomac Electrical Power Company substation, the supply and plant warehouse, and the motor pool. The other buildings in this area were specialized laboratories, such as the Engineering Mechanics Laboratory and the Physics Laboratory. A group of laboratories constructed for the Building Research Division were located at the south end of the property. These laboratories contained fire research and concrete material testing. These facilities were isolated from the main administration and laboratory complex due to the type of work conducted, the size of the equipment, and specialized research requirements. Exterior materials were used to delineate function in the design. Primary research buildings typically were faced in light beige brick, while support buildings were faced in red brick (Voorhees Walker Smith Smith & Haines 1961b:6; NBS 1966a:6; Susan Cantilli personal communication 12/3/2014).

New research requirements were assigned to NBS requiring new and expanded facilities even as the new facilities at Gaithersburg were being programmed and designed. For instance, the Engineering Mechanics Laboratory (Building 202) was not included in the initial plans for the research campus. The Engineering Mechanics Laboratory was designed to house several compression and tension testing machines, including a 12 million-pound universal testing machine and a 1 million-pound deadweight force-calibrating machine. The urgency for research requiring these new machines was due to the new emphasis on space sciences in response to the U.S.S.R. launch of its sputnik satellite in 1958. NASA enlisted NBS assistance to calibrate a load cell capable of measuring up to 1.5 million lbs to support the man-in-space project. NBS did not possess the machinery to accomplish the task. Buildings at the D.C. campus could not accommodate the massive testing equipment and no additional acreage was available at the facility to construct a purposely designed building. Consequently, a new building at the Gaithersburg campus was designed and constructed to house this important new program (NBS 1966a:18-22; Passaglia 1999:482).

Two additional buildings also were planned for the campus to accommodate special research requirements. These were a specialized physics building (Building 245) and the neutron studies building (Building 235). The physics building was specifically designed to house high-energy particle accelerators, specifically the linear accelerator (LINAC) (no longer extant), two Van de Graaff accelerators, and X-ray machines for use in "developing radiation standards and measurement methods and by obtaining basic data on the interaction of radiation with matter" (NBS 1966a:14). The neutron studies building was used to test the effects of neutron beams on materials of all kinds, including the structure of solids and liquids, aspects of crystal structure, and generating radioisotopes (NBS 1966a:11). Funding to construct the neutron studies building was a separate Congressional appropriation (U.S. Department of Commerce 1961).

4.4 Architectural Vocabulary Employed in the Construction of the NIST Campus

The Modern architectural style was adopted extensively by the Federal government during the mid-twentieth century for the construction of new buildings. The Modern style blurred or redefined public and private space. Public spaces, such as

National Bureau of Standards

The National Bureau of Standards was established in 1901 to provide technical assistance to industry, Government, and educational institutions. This assistance involved the development, maintenance, and dissemination of fundamental standards of physical measurement, and the systematic and accurate determination of physical constants and important properties of matter and materials.

Today, in addition to providing a central base for a consistent and compatible system of physical measurement, NBS serves as a focal point within the Federal government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. To accomplish these objectives, the Bureau conducts research and provides central national services in three broad program areas: basic measurement standards, materials research, and engineering standards and applied technology.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States for a complete and consistent system of physical measurement, coordinates the system with the measurement systems of other nations, and furnishes essential services, including measurement and dissemination of fundamental properties of matter, leading to accurate and uniform physical measurements throughout the nation's scientific, industrial, and commercial communities. The Institute is composed of a series of divisions, each serving such classical subject matter areas of science and engineering as electricity, metrology, heat, mechanics, applied mathematics, atomic physics, cryogenics, astrophysics, radio physics, and radio engineering.

An additional important responsibility of the Institute is the operation of the Office of Standard Reference Data which coordinates the National Standard Reference Data Program and provides a central national file of critically evaluated data in the physical sciences.

THE INSTITUTE FOR MATERIALS RESEARCH assists and stimulates industry through research to improve understanding of the basic properties of materials, and contributes to the National Standard Reference Data Program by developing data on the bulk properties of materials and devising measurement techniques for determining these properties. The divisions in this Institute are organized primarily by technical field and include such areas as analytical chemistry, polymers, metallurgy, inorganic materials, and physical chemistry. Each division is responsible for the development of methods of measuring the properties of materials within its particular area and the accumulation of data on the properties of these materials.

The Institute also contains the Office of Standard Reference Materials. This office evaluates the requirements of science and industry for carefully characterized reference materials, stimulates the Bureau's efforts to develop methods for production of needed reference materials, and directs their production and distribution.

THE INSTITUTE FOR APPLIED TECHNOLOGY provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government. The main functions of the Institute are: find and help overcome obstacles to technical innovation, provide bases for evaluation of technological products and services, cooperate with public and private organizations in development of standards, codes and methods of test; and disseminate technical information. The Institute also provides advice and services to Government agencies for increased economy of program operation, design of information systems, and utilization of automatic data processing.

THE CENTER FOR RADIATION RESEARCH conducts programs important to the Nation in basic standards, materials research, and applied technology utilizing radiation and nuclear scientific techniques. The staff and facilities of the center are available to all segments of NBS, other agencies, industry, and universities, for the purpose of performing allied and other institutional work utilizing radiation techniques. The Center consists of a group of divisions organized according to type of radiation resources.

U. S. DEPARTMENT OF COMMERCE / National Bureau of Standards

Figure 4.6 National Bureau of Standards Information Sheet (Source: NIST Library Vertical Files).

grand lobbies and entrances often were eliminated in favor of sweeping plazas, and functionalism became the prevailing consideration (GSA 2005:30). Extensive use of new materials and technologies were key. Steel, reinforced concrete, plastic, and glass were used in innovative ways (GSA 2005:30). Style was expressed through the use of innovative materials and the exposure of structural systems that previously were hidden beneath a decorated skin. Government agencies, with their desire to minimize taxpayer expense, readily embraced the Modern style because it was cost effective to construct (GSA 2005:31).

While Modern buildings had cheaper initial construction costs than buildings constructed in earlier styles, their expected service life was considerably shorter. Gordon Bunshaft of Skidmore, Owings & Merrill, a leading practitioner of the Modern movement, stated:

> It seems to me that the greatest change that is occurring in this country is that buildings are no longer being built to last five hundred years…. Today the economics of our civilization and the increasing requirements of comfort demanded by the people are making buildings obsolete in twenty to twenty-five years…As far as the technical aspects of development, there is no question that we must develop a method of building these buildings precisely, lightly, and quickly, and this, of course, leads to prefabrication (GSA 2005:31).

The GSA developed design standards for the construction of Federal buildings. The Public Buildings Service, charged with overseeing design and construction management activities for Federal agencies, issued guidelines in 1959. Private-sector architects and engineers could be retained to design Federal projects. However, such firms were required to complete projects within fixed government estimates. These estimated costs included site acquisition; design, construction, and interior design and furnishings for the buildings; as well as the administrative and supervisory costs incurred by the government (GSA 2005:62). A policy on material, systems, and equipment selection was developed. The GSA prescribed buildings that were "functionally efficient and economical in construction, operation, and maintenance" (GSA 2005:62).

In 1962, the GSA again issued guidelines for the construction of Federal buildings under its management. The new guidelines encouraged maximization of net useable space, flexibility in space assignment, and economy. The guidance also encouraged designs that would promote high employee morale and that were conducive to the protection of life and property (GSA 2005:62). The GSA continued to modify its guidelines and issue revisions throughout the 1960s and early 1970s. The 1962 GSA guidelines were issued after the design and construction of the NBS campus was underway. In an effort to be prudent with taxpayer funds, the GSA emphasized economy and expediency in Federal construction projects. NBS management, in contrast, were concerned that too great an emphasis was placed on minimizing costs at the potential expense of long term functionality. The timing of the issuance of the first formal GSA guidelines in 1959, some of which codified requirements that NBS officials found objectionable, suggests the guidelines may have been in development during the design phase of the NBS project and did not apply to the Gaithersburg project.

When designing the NBS campus, the architects selected the International Style, a substyle of the Modern aesthetic movement and which was then-popular for the construction of commercial buildings. Coined in 1932 in *The International Style* by Henry-Russell Hitchcock and Philip Johnson, which was published in conjunction with the "Modern Architecture: International Exhibition" at the Metropolitan Museum of Art, the style did not gain popularity in the United States until after World War II. The work of European architects, including Le Corbusier, Walter Gropius, and Mies van der Rohe introduced the style to an American audience. Hitchcock and Johnson identified three characteristics of the style: "architecture as volume, regularity, and voiding the application of ornament" (McAlester 2013:617).

A major feature of the style was the use of curtain-wall construction. The postwar increase in the availability of steel resulted in the construction of light-weight buildings that were taller than their predecessors and that could incorporate an abundance of windows. Cladding materials were smooth and unadorned. Additional character-defining features include clean geometrical forms, flat roofs, a lack of ornamentation, asymmetrical facades, and cantilevered projections (Pennsylvania Historical & Museum Commission n.d.).

While it use was not uncommon in residential applications, the style more commonly was applied to commercial office buildings. Indeed, it became popular in the design of skyscraper office towers and corporate and research campuses as well as low-scale commercial buildings. In some cases, such as the General Motors Technical Center in Warren, Michigan, and the Seagram's Building in New York City, the style became an expression of corporate image.

4.5 Campus Landscape Design

A contemplative environment was seen to support productive scientific research and investigation. Postwar research campuses frequently were located in suburban environments and an abundance of well-designed and manicured greenspace was common. Formal landscape designs were used to enhance research "campuses" by defining vehicular and pedestrian circulation patterns, reinforcing connectivity between buildings, creating informal gathering points for professional interaction, and establishing an idyllic environment with minimal urban distractions.

The GPLs and the Administration Building are clustered at the eastern edge of the campus. Concourses connect the laboratory buildings to one another. The buildings are aligned along an east/west access with mowed lawn between the buildings. Parking lots, which are arranged along a north/south access, are regulated to the periphery of the GPL complex. In general, parking lots were sited to allow for future building expansion (Voorhees Walker Smith Smith & Haines 1961b:6).

The support buildings and some of the special purpose laboratories generally are located west of Research Drive. Buildings requiring isolation are sited south of South Drive. The buildings at the southern end of the campus are isolated from the main concentration of buildings clustered north of South Drive as well as isolated from each other. Large expanses of mowed lawn define the southern end of the campus. Roads generally are aligned along a north/south access. The road network provides efficient vehicular circulation; sidewalks accommodate pedestrian circulation.

Landscaping to support the campus site plan at Gaithersburg was extensive. By 1966, 3,000 trees and shrubs had been planted (NBS 1966a:6). Two existing wood lots were integrated into the design. One was converted into a glade with grass and light shade; the other wood lot was an "open flowering woods with winding paths and azaleas" (NBS 1966a:6). The interior courtyard of Building 101 was landscaped extensively and included benches, specimen trees, and a water feature.

A well-developed landscape plan was not a unique feature to NIST. Many Federal agencies constructing buildings during the postwar years took landscape design into consideration in comprehensive site development. Indeed, "the landscapes of Federal buildings and complexes were also prominent components of many Modern buildings. Landscaped plazas and courtyards were often executed as part of original building plans" (GSA 2005:9).

4.6 Architect and Engineering Firms Working at NIST

Architectural and engineering firms experienced in designing extremely specialized buildings generally were selected to design the research campuses. The design teams working at NIST had particular expertise in the design of laboratories, research facilities, and research campuses. For example, HLW International, the principal architects for the campus were nationally known for their specialization in research campuses, whereas Burns and Roe Associates, the firm responsible for the initial design of Building 235 had particular experience in designing energy facilities for public and private-sector clients.

Construction at the Gaithersburg campus was initiated after Congress appropriated $23.5 million in 1961 (U.S. Department of Commerce 1961). The new NBS campus was a major undertaking and construction activities were divided among numerous builders. Funds to build the HLW International-designed campus in its entirety were not appropriated in a single funding package. Consequently, buildings included in the original campus design were completed in phases as funds were appropriated and construction contracts were awarded. Annual funding and the agency's prioritization of building need dictated construction order. HLW International designed all the buildings completed under the initial construction period (1961-1969).

Development of the campus can be divided into three broad periods: Initial Construction (1961-1969), Second Period (1970-1999), and Third Period (2000-2015). The first period of construction (Initial Construction) is further divided into five phases coinciding with Congressional funding and the awarding of construction contracts. Twenty-six buildings were constructed during this period. Twelve buildings were constructed during the Second Period of construction. Two buildings, Building 102 (the original gatehouse) and Building 310 (a townhouse) were demolished. The current gatehouse replaced the original when the existing building was constructed in 2009. The date of demolition for Building 310 is unknown. Sixteen buildings were constructed during the Third Period of construction. One building, Building 308, predates the campus. Building 308 is a dwelling constructed during the early 1950s. Select projects are discussed in additional detail below.

4.6.1 Initial Construction Period (1961-1969)

Phase I of the Initial Construction Period comprised initial site work and construction of the Engineering Mechanics Laboratory (Building 202) and the power plant (Buildings 302 and 305). The contractor for Phase I was Paul Tishman Co., Inc., from New York, New York (Voorhees Walker Smith Smith & Haines 1961c:2). Official groundbreaking ceremonies were held at the actual site of the Engineering Mechanics Laboratory on June 14, 1961.

Phase II construction comprised the Radiation Physics Laboratory (Building 245), Administration Building (Building 101), Supply and Plant Building (Building 301), Automotive Service Building (Building 303), and the Instrument Building (Building 304). The contractor for Phase II was Blake Construction Company, Inc., from Washington, D.C. A neutron testing facility (Building 235) was constructed during Phase III. The construction contractor for the building was Blount Brothers Corporation (NBS 1966a:6).

Phase IV construction comprised the seven general purpose laboratories: Metrology (Building 220), Physics (Building 221), Chemistry (Building 222), Materials (Building 223), Polymers (Building 224), Technology (Building 225), and Building Research (Building 226). Phase V comprised the special purpose laboratories for Sound (Building 233), Hazards (Building 236), Industrial (Building 231), and Concrete Materials (Building 206). The contractor for both construction Phases IV and V was J.W. Bateson Co., Inc., from Dallas, Texas (NBS 1966a:6; Voorhees Walker Smith Smith & Haines Contract Kits 1961c; NIST 1997). The archival record is unclear regarding the end date of Phase V. Some sources include the construction of Buildings 230, 237, and 238 under Phase V, while other sources do not (NIST 1996a:6; NIST 1997; Passaglia 1999:487).

HLW International was the architecture firm responsible for the overall design of the campus and designing the original buildings. Architects at the firm were noted specialists and national leaders in the design of postwar research campuses. The firm developed innovations in the design of research laboratories. Those innovations were applied to the NBS buildings. The firm is discussed in greater detail in Chapter 6.

In addition to HLW International, a second New York City-based firm also designed buildings constructed during the Initial Construction phase. Burns and Roe Associates designed the original portion of Building 235, which was completed in 1965. Burns and Roe Associates was established in 1932 (Bloomberg Business n.d.a). As an engineering firm, Burns and Roe Group, Inc., as the company later was known, provided desalination, air quality and pollution control, and advanced nuclear technology services, among others, to private and public-sector clients (Bloomberg Business n.d.a). POWER Engineers acquired Burns and Roe in 2014 (Rubin 2014).

Power plant personnel were the first staff to move to the campus in March 1962. In October 1963, the Office of Weights and Measures and the Engineering Mechanic Section staff occupied Building 202. The Administration Building was occupied in July 1965; NBS Director Astin moved into the completed headquarters building in September 1965. The GPLs were occupied during 1966; dedication ceremonies were held in November of that year (Passaglia 1999:488-489). Figure 4.7 depicts construction completed during the Initial Construction Period.

4.6.2 Second Period (1970-1999)

The Second Period of development at the Gaithersburg campus was modest. Buildings constructed were associated with expanded missions or new assignments. Building 307 (completed in 1971), Building 205 (completed in 1975), Building 309 (completed in 1976), Building 311 (completed in 1990), and Building 312 (completed in 1996) were constructed during the time period. Additional chemistry facilities were added to the campus with the construction of Building 227 in 1999. However, the majority of major construction projects comprised improvements or additions to existing buildings. Buildings 205 and 235 were expanded during this period.

Building 205 was constructed to support new testing demands in an existing research program, fire research. The architectural firm of Fry and Welch designed the building, which was completed in 1975. The firm was established in 1954 by Louis Fry, Sr. and John Welch (Tuskegee University 2010:3). Early during its history, the practice specialized in campus construction and was responsible for the design of buildings at Prairie View A & M University, Texas; Tuskegee University, Alabama; Lincoln University, Pennsylvania; Howard University, Washington, D.C., and Morgan State University, Maryland, among others (Fry and Welch Associates, P.C. n.d.). The firm also undertook government projects as well as commercial commissions (Fry and Welch Associates, P.C. n.d.). During the first decades of the twenty-first century, the practice refocused on schools, small businesses, and residential design (Fry and Welch Associates, P.C. n.d.). Company co-founder, John Welch, later became the Dean of the Tuskegee Architecture Program (Tuskegee University 2010:4). The firm is one of the oldest African-American architectural practices in the country. Building 205 was expanded in 2014.

Building 235 also was expanded in 1988 to accommodate the growing program in cold neutron research (Rush and Cappelletti 2011:27). The 1988 addition was designed by NUS Corporation. Originally Nuclear Utility Services, Inc. NUS Corporation was an engineering consulting firm specializing in nuclear engineering, water management, and environmental safety (Nelkin 1974:31). Today, the company, Halliburton Nus Corporation, is a subsidiary of Halliburton Company (Bloomberg Business n.d.b).

A major expansion to Building 302 was completed in 1996. The addition to the building was designed by the Cleveland, Ohio-based Austin Company. The Austin Company was an early pioneer in the design of corporate campuses. The firm, under the leadership of company founder, Samuel Austin, designed the industrial research campus for the National Electric Lamp Association (NELA), a predecessor to General Electric in 1911 (The Austin Company n.d.:2). The company undertook the design of lamp manufacturing plants and other projects in the Midwest as well as the east and west coasts (The Austin Company n.d.:2). During World War I, the Austin Company completed projects for the defense industry, designing the Curtiss Aeroplane and Motor Company's manufacturing facility (The Austin Company n.d.:3). The company again turned to designing airplane manufacturing facilities during World War II. Today, the firm provides design services for projects ranging from office and commercial development to health care and hospitals, to facilities for information processing and communications technology.

During the late 1980s, NIST administrators regularly requested Congressional appropriations for upgrades to the facility. To prioritize these requests, Congress directed NIST to prepare a ten-year plan for anticipated capital improvement projects. This request was formalized under Public Law 102-245 enacted in 1992, which mandated that the NIST director submit a report on projected renovations and upgrades for the upcoming decade to the appropriate Congressional committees. The report was to prioritize facility needs, estimate costs, and include plans for meeting identified needs (United States Code 1992).

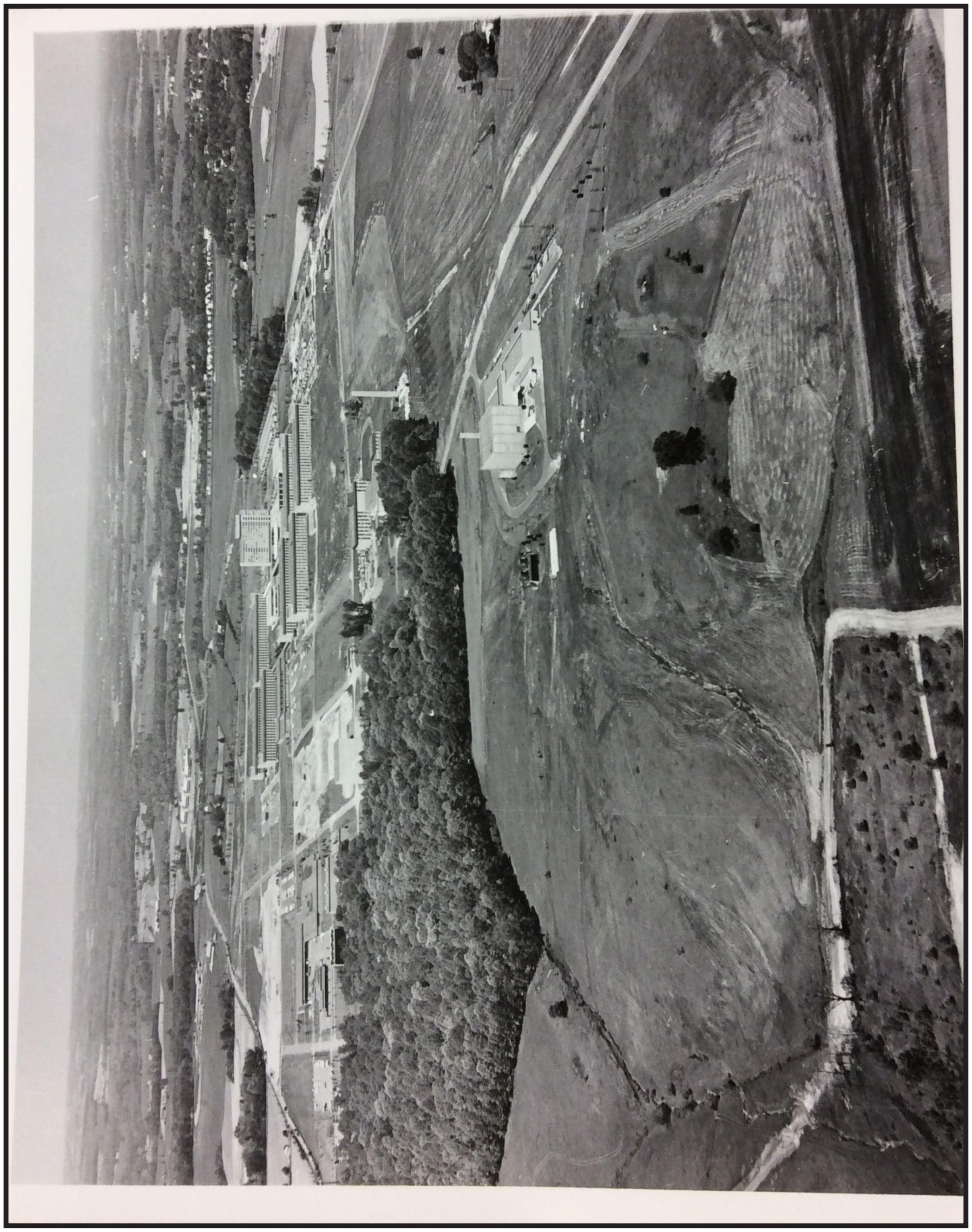

Figure 4.7 Initial Construction Period ca. 1966 (Source: Montgomery County Historical Society, Rockville, Maryland).

4.6.3 Third Period (2000-2015)

The agency's mission and priorities continued to evolve during the first decade of the twenty-first century. Additional buildings were constructed to meet changing needs. New additions were constructed to expand selected buildings during the time period.

A major construction program was initiated to erect a five-building complex to support the Advanced Measurements Laboratory. This program included Buildings 215, 216, 217, 218, and 219 which were designed in 2000 by HDR Architecture, Inc. The firm was established in Omaha, Nebraska, in 1917 and expanded through the mid-twentieth century. HDR Architecture, Inc. originally specialized in municipal engineering services. Early commissions included designing water and sewer systems in the Midwest (HDR Inc. n.d.). By the 1960s, the firm expanded into the healthcare industry, designing several medical facilities throughout the country. Engineering expertise was provided through HDR Engineering and HDR Architecture provided design services. The firm's range expanded during the late twentieth and early twenty-first centuries to include environmental, transportation, water, and science and technology services (HDR, Inc. n.d.). Buildings in the NIST complex designed by HDR Architecture feature state-of-the-art laboratories, NanoFab laboratory space, and a cleanroom (NIST 2013). The buildings offer rigorous air quality, temperature, vibration, and humidity control (NIST 2013). The complex was constructed to support measurement research in a variety of different areas, including measuring electrical current, "distances in increments tinier than the radius of an atom," and molecules (NIST 2013).

STV Architects, Inc. of Douglassville, Pennsylvania, designed the chiller addition to Building 302 in 2009. STV, Inc. is an engineering firm with a national practice with experience in multiple fields including, aviation, military, capital improvement programs, tunnels, and data centers, among others. The firm is a conglomeration of several engineering firms, the earliest of which, Elwyn E. Seeyle, was established in 1912. Major projects include renovations to Grand Central Terminal, design of the corporate headquarters for Shire Pharmaceuticals, rail transportation projects for municipalities across the country, the Nets Arena, the USAMRIID Containment Laboratory at Fort Detrick, Maryland, and RCA manufacturing facilities (STV, Inc. n.d.).

Smaller projects completed during the period include construction of Buildings 320 and 207. Designed by Colimore Thoemke, construction of the CCC (Building 320) was completed in 2010. Building 207 (Robot Test Facility) was designed by Colimore Architects and completed in 2012. Established in 1973 by John A. Colimore, Jr., Colimore Architects specializes in commercial, industrial, educational, and institutional projects for public and private-sector clients (Colimore Architects, Inc. n.d.). Table 4.1 presents the architecture and engineering firms that designed the buildings constructed during the third period of construction.

This chapter explored the reasons for the agency's move to suburban Montgomery County and discussed the architectural influences in the design of the campus. Key architects were identified. HLW International designed the majority of buildings constructed during the first period of construction and provided the architectural framework and vocabulary for the campus. The firm's work was supported by other architectural firms having specialized expertise in the design of highly-technical scientific buildings. The following chapter summarizes some of the many scientific investigations that were conducted at the Gaithersburg campus and identifies influential scientists.

Table 4.1 Architect and Engineering Firms – Third Period Buildings and Additions

Bldg #	Building Name	Architect
203	Standard Reference Materials Facility	MTFA Architecture Inc. (Sub) with McMullan & Associates, Inc. (Prime)
205 Addition	National Fire Research Lab - 2014 Addition to Large Fire Facility	Colimore Thoemke Architects
207	Robot Test Facility	Colimore Thoemke Architects
208	Net-Zero Energy Residential Test Facility	Building Science Corporation (BSC)
235 Addition	NCNR -2009 Addition	HDR
103	Visitor Center and Gate A	Martin Reddy Architects (Sub) with Holbert Apple Associates, Inc. (Prime)
318	ES Facility	Colimore Thoemke Architects
320	CCC	Colimore Thoemke Architects
301 Addition	Supply & Plant Bldg – 2013 Addition	Colimore Thoemke Architects

Chapter 5.0

Theme: Science and Technology

The NBS underwent a series of administrative reorganizations following the move from Washington, D.C. to its new Gaithersburg, Maryland, campus. The agency's mission also changed as a result of Congressional action. These changes were explored in detail in Chapter 3. New missions often required the creation of new programs and the realignment of existing research programs to meet new national priorities. The impact of these mission changes on programs and selected highlights of the agency's projects and accomplishments are explored in the following chapter. Major references consulted to compile this summary include *Responding to National Needs* by James F. Schooley (2000); the publication *NIST at 100* (2000); and the NIST website. Contributions of key scientists are identified. The agency is referred to as NIST throughout this chapter for clarity.

5.1 Standards and Measurements

Advancing the science of metrology, the study of weights and measures, is central to the NIST mission. From its founding, NIST has established national measurement standards and safeguarded uniform, compatible, and reliable measurements. Basic measurements include mass, length, time, temperature, electric current, resistance, and chemical composition. Maintaining national measurement standards is not a static mission. Over time, requirements for measurements have become exacting and far exceed the level of precision previously accepted. For example, the original platinum-iridium bar that defined the meter was replaced by a more precise measurement based on the wavelength of krypton-86 in 1960. Large force measurements are required to support rockets for the space program or measure large beams used in skyscrapers, while measurements of atoms are required for nanotechnology. Greater precision in measurement has led to the development of a variety of new and more rigorous measuring devices. Measurements are a requisite to new technologies, and scientific research is required to advance the precision of the science of measuring.

As NIST developed new programs in response to new legislation and policy priorities, it continued to make advances in measurement. The following paragraphs illustrate a few of the measurement advances completed at NIST since 1966. These include advances in the areas of electrical charges, the speed of light, atomic particles, photomask linewidths, and quasicrystals.

In 1968, NIST scientists Walter Hamer, Richard Davis, and Vincent Bower examined the basic measurement for the electric charge by testing five different solutions. The results of the testing led to improved measurement of the faraday, the basic unit of electric charge (Schooley 2000:83). In 1985, Clark Hamilton, Richard Kautz, and Frances Lloyd with the Electromagnetic Technology Division at Boulder succeeded in developing the world's first practical superconducting voltage standard for 1 volt. The team connected 1500 Josephson junctions in a series array. The new array remained stable despite temperature fluctuations. This achievement led to a variety of new and more precise voltage measurements. In 1986, a 10-volt standard was released using 20,000 Josephson junctions (Schooley 2000:669; NIST 2014b; NIST 2000:n.p.). In 1989, Edwin R. Williams, P. Thomas Olsen, Marvin Cage, Ronald Dzuiba, John Shields, and Barry Taylor were awarded a Department of Commerce Gold Medal for their research on "the time-dependence of the NBS ohm and the …volt representation, as well as the low-field proton gyromagnetic ratio." Their work was credited with contributing valuable information supporting the 1990 international adjustment of electrical units (Schooley 2000:525).

During the early 1970s, two groups of NIST scientists worked independently to advance precise measurement for the speed of light. Two teams, Roger Barger, Bruce Danielson, Gordon Day, Kenneth Evenson, John Hall, F. Russell Petersen, and Joseph S. Wells at Boulder and Gabriel Luther and Zoltan Bay at Gaithersburg, researched how to provide a more precise measurement for the speed of light. In Gaithersburg, Bay and Luther in the Quantum Metrology Section of the Optical Physics Division measured light based on the 633 nm line of a helium-neon laser using microwaves. The Boulder group used a methane-stabilized laser of known frequency and wavelength to measure the speed of light. The new measurement of the speed of light at 299,792,456.2 +/- 1.1 meters per second was 100 times more accurate than previous measurements. Both values were published in 1972 within months of each other (Schooley 2000:363-364, 369-370; NIST 2014b).

Between 1969 and 1971, NIST physicist Russell Young built the topografiner, a new type of microscope that scanned and mapped surfaces at a level approaching individual atoms. The topografiner demonstrated the operating principle used in the later scanning tunneling microscope. The IBM inventors of the scanning tunneling microscope based in Zurich were awarded the Nobel Prize in Physics in 1986. The Nobel committee noted the important contribution of Young to the work: "The first to succeed in doing this [building an instrument that operated on the principle of maintaining a small constant distance between the sample surface and a sharp mechanical stylus] was the American physicist Russell Young at the National Bureau of Standards in the USA. He used the phenomenon known as field emission…However, Young realized, that it should be possible to achieve better resolution by using the so-called tunnel effect" (Schooley 2000:423-434; Martin and Frederick-Frost 2014).

In 1979, NIST scientists issued a new measurement system with the first photomask linewidth standard. The tiny ruler was developed to measure integrated circuits for the semiconductor industry. NIST continued to refine accurate methods of measurements for smaller and smaller dimensions approaching one-tenth of a micrometer or less. Methods to measure the spacing between crystalline silicon atoms was under investigation in 2000 (NIST 2000:n.p.).

In 1984, NIST scientist John Cahn was among the team of scientists that announced the discovery of a new material, quasicrystals, comprised of metallic particles. Guest researcher Dan Shechtman of the Israel Institute of Technology grew the crystals in Building 231 at the Gaithersburg campus. In 2011 Dan Shechtman won the 2011 Nobel Prize in Chemistry for this discovery. John Cahn won the National Medal of Science for his lifetime contributions to the fields of materials science, solid-state physics, chemistry, and mathematics (NIST 2000:n.p.; Martin and Frederick-Frost 2014).

The production and distribution of standards and measurements for the general public, government, and industry have been ongoing NIST programs since the founding of the agency. Standards and measurements are distributed through calibration services for measuring equipment and devices and through publications, including standard reference data, reports, journal articles, and conference materials. A popular standard reference data was the more than 1,000-page *Handbook of Mathematical Functions,* which was first published in 1964. The handbook was reprinted in 1965 and most recently in 1999. The handbook has been converted to a digital format (NIST 2000:n.p.).

One important means of distributing standards to the public is through the NIST Standard Reference Materials (SRMs) program. Under the SRM program, compounds, pure materials, chemicals, and other substances are certified for their physical properties and provided as standards to industry. This program originated in 1905 with the development of standard samples for the composition of steel, concrete, glass and ceramics. The program has expanded exponentially over NIST's history. NIST has prepared over 4,900 SRMs. The current inventory contains approximately 1,300 SRMs and contains a wide variety of samples beyond the original physical master samples (Watters and Parrish 2006:1-7). A sample of SRMs that have been developed since 1966 includes SRMs to measure cholesterol and aerosols, and several SRMs produced to support law enforcement activities.

In 1967, NIST developed an SRM for cholesterol, which was distributed as a pure, crystalline material. This SRM marked the first SRM issued by NIST for medical use. Since 1967, NIST has developed more than 60 chemistry SRMs for use in medical laboratories, including those for measuring lead and glucose levels in blood (NIST 2000:n.p.).

In 1982, NIST produced an SRM comprising polystyrene spheres to measure smoke and aerosols and to calibrate instruments used in the medical, environmental, and electronics professions. The spheres also could be used to count and measure the shape of blood cells. NIST collaborated with NASA to have billions of the tiny spheres fabricated in space where the low gravity ensured that the materials were true spherical forms (NIST 2000:n.p.; Schooley 2000:508).

The NIST Office of Law Enforcement Standards produced several SRMs to support law enforcement agencies. In 1993, the Justice Department requested that NIST produce a SRM for DNA profiling. The study took two years and resulted in a SRM to test "every step of the restriction fragment length polymorphism analysis method" for forensic DNA analysis (NIST 2014b). In 1998, NIST started to develop a SRM for bullet casings, which was issued in 2006. Other SRMs developed to support law enforcement include materials for measuring blood-alcohol levels, for verifying drug detection in hair and urine, and for identifying residues in smokeless gunpowder and residues of ignitable liquids in arson (Watters and Parrish 2006:1-7).

The ongoing development of measurements and standards is central to NIST's current programs and is conducted at the Material Measurement Laboratory (MML) and the Physical Measurement Laboratory (PML); both laboratories have divisions in Gaithersburg and Boulder. The MML serves as the national reference laboratory in chemical, biological and material science. The divisions within the MML are Applied Chemicals and Materials, Biomolecular Measurement, Biosystems and Biomaterials, Chemical Services, Materials Measurement Science, and Materials Science and Engineering. The research conducted in this laboratory includes applied research on the composition, structure, and properties of environmental, industrial, and biological materials and processes, as well as development and distribution of tools and reference data. Areas of research include advanced materials; fossil and alternative fuels; measurement of environmental pollutants; food safety and nutrition; health care; infrastructure; manufacturing; and safety and forensics (NIST 2015a).

The PML "develops the national standards of length, mass, force and shock, acceleration, time and frequency, electricity, temperature, humidity, pressure and vacuum, liquid and gas flow, and electromagnetic, optical, microwave, acoustic, ultrasonic, and ionizing radiation." Divisions in the PML comprise Electromagnetics, Quantum Electronics and Photonics, Quantum Measurement, Quantum Physics, Radiation Physics, Semiconductor and Dimensional Metrology, Sensor Science, Time and Frequency, and the Office of Weights and Measures (NIST 2015b).

Two other shared-use facilities for measurement located at NIST Gaithersburg are the Center for Nanoscale Science and Technology and the NCNR, both established in 2007 (Martin and Silcox 2010:iii). The Center for Nanoscale Science and Technology supports the "U.S. nanotechnology enterprise from discovery to production" in diverse fields, including "electronics, computation, information storage, medical diagnostics and therapeutics, and national security and defense" (NIST 2014d). The NCNR, which encompasses previous NIST divisions associated with neutron research, offers a broad range of instruments and capabilities for the study of both hot and cold neutrons (NIST 2015c).

5.2 Testing and Evaluation

NIST scientists conduct research in several programs that support the Federal government and industry in testing and evaluation. Many of these programs are assigned to the current NIST Engineering Laboratory. As constituted in 2015, the Engineering Laboratory comprises six divisions: Materials and Structural Systems, Energy and Environment, Fire Research, Intelligent Systems, and Systems Integration and the offices of Applied Economics, the Smart Grid Program, the National Earthquake Hazards Reduction Program, and the National Windstorm Impact Reduction Program (NIST 2014e).

The following sample of NIST's testing and evaluation programs illustrates the agency's accomplishments since moving to the Gaithersburg campus. The discussion is not comprehensive, but selected from the research areas of fire, building materials, structure and building failures, energy, environment, and law enforcement.

Flammability and fire research is one important research area in the Engineering Laboratory. Fire research is a program historically associated with the agency. NIST undertook fire research almost from its establishment. A major impetus for research into the flammable properties of clothing was the passage of the Flammable Fabrics Act of 1953, which was enacted following a series of children's deaths linked to highly flammable clothing, such as brushed rayon sweaters and cowboy outfits. Following passage of this legislation, NIST developed a standard flammability test. Any fabric that burned faster than the standard could not be sold and marketed between the states (Schooley 2000:497-499).

In 1967, Congress expanded the provisions of the Flammable Fabrics Act to include paper, plastic, and foam used in clothing and interior furnishings. The legislation instructed the Secretary of Commerce to conduct research into the flammability of products, fabrics, and materials; conduct feasibility studies to reduce the flammability of these items; and develop flammability test methods. The Secretary of the Department of Commerce assigned these tasks to NIST. Tasks included research to determine the products of fabric combustion, calorimetry of fabric combustion, laboratory burning of fabrics, analysis of burn cases, study of flame retardants, controlled burning of full-scale household furnishing, and study of heat transfer from burning fabrics. Studies conducted at NIST investigated the flammability of carpets, mattresses, children's sleepwear, and blankets.

In 1972, the legal responsibility for continuing the mandates under the Flammable Fabrics Act was transferred to the Consumer Product Safety Commission. The Commission continued to fund fire research at NIST. For example, NIST was requested to devise a test to minimize the probability of ignition in fabrics. Emil Braun, John Krasny, Richard Peacock, and Ann Stratton completed the project by 1975. Braun's group later evaluated the effectiveness of protective clothing worn by firefighters and industrial workers exposed to high temperatures. Vytenis Babrauskas and William Twilley developed a cone calorimeter to measure the changing mass of a specimen during fire tests. The cone calorimeter won an award in 1988 from *Research and Development Magazine* (Schooley 2000:497-500).

The Fire Research and Safety Act of 1968, followed by the Federal Fire Prevention and Control Act of 1974 resulted in the establishment of the Center for Fire Research. John Lyons was appointed the first Chief of the Division. The Secretary of Commerce was assigned the tasks of creating "a national fire research and safety program, including the gathering of comprehensive fire data; a comprehensive fire research program; fire-safety education and training program; and demonstrations of new approaches and improvements in fire prevention and control; and, reduction of death, personal injury, and property damage" (Schooley 2000:225-226). Since its establishment, the Center for Fire Research has operated a robust research program into all aspects of fire, including fire retardants, smoke, soot formation, toxicology, materials combustion, and combustion of furnishings and room interiors. Scientists have been called into examine causes and effects of fire disasters (Schooley 2000:499-510). In 1997, NIST scientist Gregory Linteris traveled on the space shuttle to conduct a NIST-designed, low-gravity combustion experiment (Schooley 2000:519). The focus of the current research program is fire detection, fire-fighting technologies, fire materials research, fire measurements, and fire computer modeling (NIST 2014f).

Fire performance standards for smoke detectors were one valuable product resulting from the agency's fire research Work in this area was begun in 1974 by Richard Bright. NIST also developed recommendations on the number, type, and locations for the installation of home smoke detectors. These recommendations were incorporated into building and fire codes and were credited with a 50 per cent reduction of death by fires in 1997. In 1980, Irwin Benjamin conducted a similar study of the design of smoke detectors used in large buildings (NIST 2000:n.p.; Schooley 2000:507).

In 1972, the Center for Building Technology was established at NIST at the direction of the Secretary of Commerce. The new center contained three divisions: Building Environment; Structures, Materials and Life Safety; and, Technical Evaluation and Applications. The new center had a staff of 250 and engaged in a wide range of projects. Some projects included the development of computer models to predict the dynamic thermal performance of houses in winter and summer weather cycles, investigations into failed heat pumps, development of a device to measure the dew point in sealed glass envelopes to evaluate the moisture content in double-pane glass, measurement of the thermal resistance of building insulation, development of a systematic method to predict the service lives of buildings materials, and development of standard test methods for solar energy collectors and thermal storage systems. Work also progressed towards developing a performance-based building code to specify desired attributes of building materials, components, or systems to satisfy the intended user (Schooley 2000:392-395). Building research continues at NIST in the research areas of construction integration and automation, cybernetic building systems, net-zero and high-performance buildings, and sustainable infrastructure materials (NIST 2015d).

Special studies were conducted into the causes of building and structure failure. In 1967, NIST scientists evaluated the collapse of the Silver Bridge in Point Pleasant, West Virginia. Their investigation revealed that the cause of the collapse was a microscopic pit in the surface of a single I-bar that connected the deck to the suspension chain. In 1982, investigations were undertaken to identify the cause of the collapse of suspended walkways in a hotel in Kansas City, Missouri. NIST scientists traced the failure to the box beam-hangar rod connections (NIST 2014b). NIST scientists have continued investigations of building failures to the present. One of the most high-profile cases was NIST's participation in the investigation of World Trade Center buildings 1, 2, and 7 conducted between 2001 and 2008. The purpose of the investigations was to "investigate the building construction, the materials used, and the technical conditions that contributed" to the collapse of the buildings following the initial impacts of the aircraft into Buildings 1 and 2 (NIST 2011). NIST scientists also routinely are called upon to evaluate damage to buildings and structures caused by hurricanes, tornadoes, and other natural disasters (NIST 2015d).

NIST scientists also researched and published design and evaluation criteria for energy conservation for the construction industry. Application of the criteria by the construction industry is voluntary. The design and evaluation criteria were designed to reduce energy consumption by over 50 per cent in new buildings. In a separate study, NIST scientists developed testing and rating procedures to evaluate energy consumption in household appliances (NIST 2000:n.p.). In 1976, NIST signed a Memorandum of Understanding with the Electric Power Research Institute to support the institute in the areas of equipment, power generation, measurement of electrical and electromagnetic quantities, evaluation of devices and control systems, and energy conservation (Schooley 2000:462). Ongoing NIST projects related to energy include the research areas of alternative energy; electric power metrology; energy conservation, energy conversion, storage, and transport; fossil fuels; and, sustainability (NIST 2015e).

NIST environmental research programs were developed to measure pollutants in air, water, and soil and toxicity in organisms. New equipment was devised to measure pollutants, such as a portable meter to measure microscopic air particles. Standards were developed for fuel economy and automobile emissions. A computer model was developed to allocate salmon catches to support salmon fishery regulations. NIST, in cooperation with the U.S. Environmental Protection Agency (EPA), established a biomonitoring specimen bank that contains thousands of biological specimens preserved in liquid nitrogen to assist in the comparative study of chemical and pollutant exposure. As a result of the specimen bank, NIST scientists developed procedures and protocols for proper handling of environmental samples that have been adopted by environmental laboratories worldwide. One special project undertaken by NIST was the review of the organic chemical analysis in the 1982 EPA study of Love Canal. Another study was to characterize the damage to the earth's ozone layer caused by chloroflourocarbons from aerosol propellants and refrigerants (NIST 2000:n.p.). NIST current areas of research in the environmental field include climate science measurements, environmental technologies, marine health, and pollution/indoor air quality (NIST 2014g).

Testing and evaluation activities are conducted by NIST's Law Enforcement Standards Laboratory (LESL) established in 1971 to support law enforcement programs. NIST staff assigned to LESL identified problems with equipment and armament of police departments. LESL staff began studies that resulted in standards programs for vehicles, communications equipment, security systems, concealed-object detectors, protective equipment and clothing, emergency equipment, police weaponry, and building systems for law enforcement. Research projects carried out by NIST staff included improvements to body armor, helmets, and face shields; studies of the composition and color of paint for cars; gunpowder analysis; handcuffs; burglar alarms; and, window locks. LESL was not assigned its own laboratory but "purchased" research and development from existing NIST groups or outside contractors (Schooley 2000:266-267, 353-354, 355-357). Research to support law enforcement activities is an ongoing program in the MML. Current research areas include ballistics, biometrics, communications, forensics, and weapons and protective systems (NIST 2014h).

5.3 Technology

NIST has invested time and money to support improved technology in manufacturing and computers, both hardware and software. NIST built its first computer, known as SEAC, in 1950. Since that time, the agency has continued research into computer development. In 1965, a new Center for Computer Sciences and Technology was formed at NIST (NBS 1966b:2). Under the Brooks Act of 1972, NIST was charged with providing technical support to standardize the government use of computers and to increase the cost effectiveness of government expenditures for equipment. Currently, computer research is under the NIST Information Technology Laboratory. This laboratory has six divisions: Applied and Computational Mathematics, Advanced Network Technologies, Computer Security, Information Access, Software and Systems, and Statistical Engineering (NIST 2015f).

Software improvements included the development in 1966 of the Omnitab software, an early spread sheet. Omnitab was written to automate handling of data input and output, and the production of graphs. In 1977, NIST issued the first publicly available data encryption standard (DES). By 1997, approximately 50 per cent of U.S. cryptographic products implemented DES (NIST 2000:n.p.). In 2001, NIST released the Advanced Encryption Standard (NIST 2014b).

NIST scientists routinely developed computer applications for statistical analysis. In 1969, the Selective Service System requested assistance to make the 1970 military draft a truly random selection. Joan Rosenblatt and colleagues developed a methodology that used a selection of random calendars and priority permutations to accomplish the task. Her success on this and other projects earned Rosenblatt the Federal Woman's Award in 1971 (NIST 2014b).

Since the early 1970s, NIST scientists have been involved in automated manufacturing research through the design of computer-controlled manufacturing machines, or robots. Ernest Ambler, while Director of the Institute of Basic Standards, promoted the idea of automating the gear calibration process by combining the metrology division with the atomic physics program that linked three-dimensional coordinate measuring machines, mini-computers, laser interferometers, and robotics from the Institute for Computer Sciences and Technology. The result was the establishment of the Automated Manufacturing Research Facility in 1980 that operated until 1995. As part of the program Jim Albus, a leading robotics researcher, developed NIST's real-time control system, a system that "creates an efficient organization for knowledge-based intelligent control of complex systems" (NIST 2000:n.p.). In 1991, NIST unveiled a floor-cleaning robot that used the real-time control system. The system also was used in shipbuilding, hospitals, and in land mine clearance (Schooley 2000:618-621, 625; NIST 2000:n.p.; Zenzen 2001:1-8). A robotics program continues at NIST in 2015 under the NIST Engineering Laboratory. Research areas in this program comprise bomb-disposal robots, mobility, manipulation, and urban search and rescue robots (NIST 2015g).

5.4 Select NIST Scientists

Thousands of scientists have worked at NIST since the move to the Gaithersburg campus. Some scientists have made their careers at NIST; others have launched their careers at NIST, then transferred to work in academia or at industrial laboratories. NIST scientists have won recognition for their work from professional organizations in their respective fields, as well as from the Department of Commerce and NIST. The Department of Commerce Award program was begun in 1949 to recognize distinguished and exceptional performance. Three to four NIST scientists and one group routinely have won Department of Commerce Gold Medals in the years between 1966 and 2009.

In 1980, NIST scientists, along with ABC and PBS, won an Emmy award for closed captioning. In 1976, the Federal Communications Commission approved closed captioning for use with television transmission. Closed captioning evolved from NIST's TvTime program that was a method of broadcasting time and frequency over television airwaves. TvTime was developed by Dicky Davis, James Jesperson, and George Kamas. The first use of closed captioning was an episode of the Mod Squad. By 1979, closed captioning was being used by all the major networks. The Emmy is located at NIST Boulder (NIST 2000:n.p.; NIST 2014b).

Among the most prestigious award in science is the Nobel Prize. NIST scientists historically have made scientific advances and had executed experiments that have supported scientists in academia and other institutions in discoveries that have won Nobel prizes. These contributions are discussed in the overall historic context and above. Between 1997 and 2012, four NIST scientists were awarded Nobel prizes for their work conducted at NIST:

- In 1997, William Phillips of NIST shared the 1997 Nobel Prize in Physics for successfully developing the technique of laser cooling and trapping of atoms. This technique has the potential to build a new kind of atomic clock that will be more accurate than what currently is used. This work was undertaken from 1985-1988 on the Gaithersburg campus (Martin and Frederick-Frost 2014; NIST 2014b).
- In 2001, Eric Cornell of NIST/JILA and his colleagues shared the Nobel Prize in Physics for creating the first Bose-Einstein Condensate, "a new state of matter that emerges at just a few billionths of a degree above absolute zero." Scientists have incorporated this finding into their routine work to support research in quantum mechanics. This work partly took place on the Boulder campus from 1990-1995 (NIST 2000:n.d.; Martin and Frederick-Frost 2014; NIST 2014b).
- In 2005, John Hall of NIST/JILA shared the Nobel Prize in Physics for his "contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique." Frequency combs have the potential to increase the precision of a broad array of measurements in the future. This work partly took place on the Boulder campus around 1984 (Martin and Frederick-Frost 2014; NIST 2014b).
- In 2012, David J. Wineland of NIST shared the Nobel Prize in Physics for "ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems." The research helped lay the groundwork towards building a computer using quantum physics and for a potential new time standard. This work took place between 1995-2005 on the Boulder campus (Martin and Frederick-Frost 2014; NIST 2014b).

NIST scientists have made important contributions to a broad variety of scientific and technological fields. Their cutting-edge work in measurement science and in the development and use of standards has led to great advances in science and technology that underpin the advances in U.S. industry and contributed to consumer safety. NIST scientists strive to continue to be a world leader in creating critical measurement solutions and promoting equitable standards.

Chapter 6.0

Theme: Postwar Research Campus Design

Construction of the Gaithersburg campus of NIST followed a postwar trend in office development. A number of factors influenced the decisions of corporate leaders to relocate their headquarters or research divisions to suburban, if not rural, locations. This chapter explores the factors contributing to those trends and provides a framework for understanding the philosophies influencing the design of the NIST campus. Maximum flexibility in the configuration of research space and an aesthetically pleasing environment were hallmarks of the development pattern.

6.1 Early Precedents in Research and Corporate Campus Design

Two closely related property types developed during the years following the end of World War II: the corporate campus and the research campus. These property types emerged during the second quarter of the twentieth century as corporations began moving their research divisions out of central cities. Corporate headquarters soon joined the migration from urban areas. Corporations left the cities with their noise, congestion, buildings with small footprints, and challenges to expansion. Suburban settings were seen as affording greater amenities than their urban counterparts.

Corporate campuses differed from the research campuses in the amount of administrative space. The research campus, in contrast, provided facilities for corporate scientists to conduct experiments in rigidly controlled environments. Research and development branches emerged as distinctive entities from administrative and manufacturing arms of business and advanced technologies necessitated controlled environments. One building integrating management, research, and manufacturing functions, the common pattern during the nineteenth century, no longer was practical. By the early twentieth century, businesses increasingly began to separate the three functions into separate facilities.

Municipalities encouraged industry in the migration. Zoning ordinances that regulated land use were introduced during the first two decades of the twentieth century. As industry was reaching the pragmatic conclusion that research could not adequately be undertaken adjacent to heavy manufacturing due to noise, health, and safety reasons, local governments enacted legislation mandating the separation of manufacturing, commercial, and residential uses for some of the same reasons. In some cases, corporations seeking to keep its research functions in the center city were prohibited by zoning. Land use ordinances helped give rise to the construction of corporate and research campuses in suburban settings. These factors contributed to the development of the two types of campuses, which exhibited a common design aesthetic but differed in function.

The suburbs afforded space for the development of multi-building corporate and research campuses. In this new paradigm low-scale, sprawling buildings could be separated from one another by winding paths, lawn, and trees (Mozingo 2011:50). Zoning, however, was not the only impetus for corporations to move their administrative or research operations to the suburbs. Corporate management and academics felt that pastoral environments with designed landscapes emphasizing access to nature would improve scientific discovery and facilitate productivity.

The corporate and research campus was purpose-built and combined large, landscaped acreage with generally, low-rise buildings (Mozingo 2011:105). The design and quality of facilities of these pastoral campuses were used by business, industry, academia, and government to compete for a limited pool of scientists. Bucolic, tranquil landscapes were seen as key to attracting select qualified personnel. Aside from an idyllic environment, these new corporate campuses offered expansive parking and on-site cafeterias (Mozingo 2011:110). Other amenities included health facilities, gift shops, and walking trails (Dunham-Jones and Williamson 2011).

The research facilities developed for Bell Telephone Laboratories established an early precedent in the separation of research functions from manufacturing. The new facility, completed in 1939, introduced innovative ways of approaching the design of research facilities. Bell Telephone Laboratories set the standard for the design of postwar research campuses. The successful design of the facility established the reputation of its architectural designers, who eventually became leaders in the niche field of research campus design. NBS administrators and scientists selected demonstrated experts in the design of state-of-the-art institutions for the development of the Gaithersburg campus.[1]

6.1.1 Research Campuses

Bell Telephone Laboratories was located on Manhattan's lower west side prior to the move to New Jersey in 1939. The company required additional space to conduct highly-sensitive research in strictly-controlled environments. Expansion within Manhattan was not feasible because urban noise, electrical intrusion, and traffic vibrations would interfere with the accuracy of experimental measurements (Mozingo 2011:54). The company's research needs led to the construction of the first corporate research campus. The design of the project was initiated in 1930 by the architectural firm, Voorhees, Gmelin and Walker; however, the Great Depression delayed realization of the plan until 1939 in Murray Hill, New Jersey. By that time, the architects of record were the reorganized firm of Voorhees, Walker, Foley, and Smith (now HLW International) (Mozingo 2011:57).[2] Historians have noted that "Bell Labs invented the fundamentals of the corporate campus." The integrated plan featured:

- green space, centrally located at the site;
- flexible laboratory space incorporating specialized utilities;
- ample parking and truck access;
- underground utilities;
- fenced property;
- three-story height limits; and
- generous landscape setbacks (Mozingo 2011:63).

Two key innovations of the Bell campus were generous site plans and the use of moveable walls in the laboratory spaces (Rankin 2013:54). As the largest of research facilities constructed during the period, the Bell facility became the prototype for future research laboratory construction. By the conclusion of World War II, the advantages of flexible space and site isolation had led to their adoption as accepted design practice. Architectural magazines, trade journals for the research-management field, and specialized laboratory-design handbooks extolled the benefits of the features first introduced at Bell Telephone Laboratories (Rankin 2013:54).

The vanguard architectural firm, HLW International, continued to integrate the innovations first introduced in the design of the Bell Telephone Laboratories in their commissions for the design of research campuses through the 1960s (Rankin 2013:54). The innovations first applied in the Bell campus were developed in direct response to the client's need for an economic solution and maximum flexibility (Haines 1951:337).

The resulting prototype for laboratory buildings integrated flexible laboratory space with common support space, such as cafeterias and libraries. Large-scale testing and research facilities, such as wind tunnels and nuclear reactors, were housed in separate, dedicated buildings (Rankin 2013:55). Laboratory buildings comprised flexible spaces, or modules, arranged in double-loaded corridor plans that could be modified, i.e., expanded or contracted, to suit research needs. The use of such flexible plans became universally accepted practice during the postwar period.

Notwithstanding the modular design standard for general research laboratories, research campuses were unique and sophisticated complexes requiring a broad-range of building types

[1] During the planning phases of construction of the Gaithersburg campus, the agency was called NBS. The change in name to NIST did not occur until 1988. To avoid confusion NBS will be used for the remainder of this chapter.

[2] As discussed in greater detail later in this chapter, Voorhees, Walker, Foley, and Smith underwent a number of name changes. HLW International will be used to avoid confusion.

and specialized equipment. In addition, designs often included provisions for specialized service requirements and required sophisticated engineering to address such factors as fluctuating building loads. Safety features were major components of the design and might include safety showers, additional exits, and special grounding devices (McCulley 1968:10).

Modern laboratories necessitated increasingly sophisticated technical facilities and complex mechanical equipment. The sensitivity of testing equipment demanded buildings systems that controlled humidity, temperature, and air quality (McCulley 1968:65). Finishes that could be easily cleaned, yet were resilient to damage from testing or chemicals, were installed (McCulley 1968:66).

6.1.2 Corporate Campuses

By the 1940s, an architectural image emerged for corporate headquarters: sweeping entry drives, gently rolling grassy topography, and ample parking lots (Mozingo 2011:105). Changes in corporate architecture and setting were adopted for economic as well as for aesthetic reasons. The exodus for the suburbs continued through the 1950s. As *Business Week* noted in an article published during the early 1950s, firms were leaving New York for exurban locales because of increasing rent and a lack of office space in urban centers. The magazine article went on to state that it was increasingly difficult to attract "first class personnel to work in some of the more unsightly, congested New York areas" and "management thinks workers will be happier looking at trees instead of grimy buildings and listening to birds instead of honking taxis" (Mozingo 2011:105).

During the postwar period, many major corporations adopted the corporate campus as the architectural expression of new headquarters. Companies with household names including GE, GM, and IBM had adopted the model (Rankin 2013:52). Universities and government agencies quickly followed the precedent established by large corporations (Rankin 2013:52).

The rise in popularity of the corporate campus facilitated the postwar move of businesses from the traditional urban core to the suburbs. Businesses moved their research and development departments to suburban campuses; corporate headquarters soon followed suit (Mozingo 2011:98). One result of the move of corporations to the suburbs was the relocation of white collar jobs from the urban core to the outskirts of the city limits. Increased automobile ownership and the construction of the interstate highway system facilitated the rapid movement of employees from the central cities to jobs in the new suburbs (Dunham-Jones and Williamson 2011:n.p.). Sophisticated corporations chose well-known "celebrity" architects to design new corporate campuses. Principal buildings symbolized corporate status and prestige.

General Foods was the first Fortune 500 company to leave Manhattan for the suburbs. The company chose Voorhees, Walker, Foley, and Smith (HLW International) and Olmsted Brothers, landscape architects to design its new facility (Mozingo 2011:98; 107). The design and construction of the General Foods corporate headquarters in White Plains, New York, in 1954, introduced design elements that were later seen in the NBS campus: "architectural restraint, central courtyard, and self-contained site planning" (Mozingo 2011:110). With its rural siting, the General Foods campus became an architectural focal point, visible to commuters traveling along the expressway (Mozingo 2011:111).

6.2 Innovations in Research and Corporate Campus Design

During the construction of postwar corporate and research campuses, architects and designers, in collaboration with administrators and scientists, undertook extensive architectural programming studies. Comparable research laboratories were explored and full-scale models of proposed designs were constructed and refined (Rankin 2013:56). Collaboration among the architects and the scientists on the design for research laboratories was not uncommon. The Bell Telephone Laboratories researchers played a prominent role in the design of the Murray Hill facility (Knowles and Leslie 2013:255). They provided insights and critiques regarding the pragmatic and functional proposed designs based on their experience and from observations after touring other research facilities (Knowles and Leslie 2013:255). The design developed for Bell Telephone Laboratories was presented in a full-scale, fully-functional model composed of five modules (Knowles and Leslie 2013:266). While critics faulted the facility's austere and "bland" exterior, the labs received high praise for the then-novel use of movable panels (Knowles and Leslie 2013:256). As a Bell Telephone Laboratories executive later observed "It has been so successful a model that scarcely any large industrial laboratory has subsequently been built without taking ideas from it and some laboratories are fairly close copies of it" (Knowles and Leslie 2013:256). The long halls, at once derided by scientists, were also praised because they facilitated collaboration. Researchers, forced to walk long distances, would meet their colleagues in the halls and walk past laboratories and offices, and thereby would learn about projects in other departments (Knowles and Leslie 2013:259). This objective of using physical design to foster collaboration also was employed later for the new NBS campus.

In depth analysis conducted by the Nuffield Foundation, a British charitable organization, during the mid- and late 1950s presented findings on the designs of the most efficient laboratories. The organization's analysis concluded that "requirements for space and services were found to vary only between scientists and assistants, not between disciplines" (Rankin 2013:57). In other words, the spatial needs for a chemist, biologist, or physicist were the same; however, the spatial requirements between the scientists and their assistants were different, with assistants requiring more space due to the nature of work they performed, i.e. less reading and writing than their scientist peers (Rankin 2013:57). The study also recommended that research campuses should include "amenities that would be used for only one percent of a researcher's tasks" (Rankin 2013:57). Designers and scientists agreed that high morale fostered scientific creativity; a properly designed work environment, one that encouraged collaboration, contributed to scientific productivity (Rankin 2013:58).

By 1951, Ralph Walker, principal in the New York City-based firm Voorhees, Walker, Foley & Smith, developed a methodology for designing corporate laboratories. Two steps he thought important included early discussions with key personnel regarding the location of mechanical and electrical services and the size of the module. Questionnaires also were a useful tool for soliciting feedback on design solutions and space allocation (McCulley 1968:11). In addition, Walker advocated the preparation of a full-scale model to help employees visualize the size and scale of the module as well as to allow plumbing, electrical, and other contractors an opportunity to view the project before submitting an estimate (Walker 1951a:149). The firm pioneered this approach with the design of Bell Telephone Laboratories and applied it later in the development of the NBS.

Key to the design of an effective laboratory was the incorporation of the "module". Walker's use of "module" was not to denote standardization; rather, he defined the module as "a unit of work space determined by human needs. It is dimensional only through its use factors. … The character of the research carried on, the need for safety considerations in the width of aisles, for example, each determines the final result" (Walker 1951a:149). He further stated, "In the development of a module's dimensions there is no general standard and each research group should indicate for itself the size and character of its working conditions" (Walker 1951a:149). Collaboration in design was key. The module was an effective use of research and office space because "the chief advantage of the module system is the known repetitive position of services and therefore the lack of interference between one laboratory at work and another in preparation for a new project requiring special and additional services" (Walker 1951a:150). Concepts that were considered new and novel during the 1950s became accepted practice. By the mid-1960s, they had become industry standard, with the expectation that one fifth of the partitions in any laboratory would move once a year (McCulley 1968:15).

The necessity for windows also was discussed in a 1951 article by Walker. He noted that windows may have become superfluous during the age of modern air conditioning and fluorescent lighting; however, in spaces deeper than 15', their inclusion may be desirable as "a wholly psychological device permitting the mind to relax" (Walker 1951a:150). The necessity for windows was the subject of heated debate during the design of the NBS campus. Walker acknowledged that workers may state that they did not want windows; however, in practice, this was not the case, especially as research facilities moved to rural settings in part, to provide esthetically pleasing environments (Walker 1951a:150).

6.3 Landscape Design

By the 1950s, design professionals and corporate leaders recognized the connection between the work environment and productivity. In considering a proposed research or corporate campus, Walker acknowledged the benefits of selecting a site that could accommodate up to three times the scale of expected future expansion, a high-quality facility in terms of design and construction, and access to amenities (Walker1951b:139). Easy access to major roads was important. Walker encouraged scientists and management to visit other research facilities. This practice was followed for the NBS. He developed a checklist to aid in facility development and site selection.

As Walker stated in an industry publication, *Laboratory Design*, issued by the National Research Council in 1951, landscaping is "worthwhile in consideration of amenity value" (Walker 1951b:148). Walker cautioned against designing a facility with "advertising features such as useless and strident towers;" rather, he endorsed a design that resembled a college campus because "the longer will be its term of esteem in the minds of both the worker and the public" (Walker 1951b:148).

Competition was heavy for well-trained, highly-educated scientists following the end of World War II. Universities, government, and large corporations competed for a limited number of employees. Efforts to make the work environment attractive and inviting were seen as effective tools for attracting and keeping qualified scientists. These efforts included designing research campuses with extensive landscaping. Buffers and landscaping separating laboratories from their adjacent neighborhoods were deemed important in site selection (McCulley 1968:12). Suburban locations were desirable because management thought such locations would facilitate retention of highly-educated residents (McCulley 1968:13). An esthetically pleasing work environment was seen as important factor in retaining highly trained professionals; a site that afforded a pleasant work environment was worth any potential higher costs and in some circumstances was given greater consideration than higher cost finishes and sites (McCulley 1968:63).

Jonas Salk, in his collaboration with Louis Kahn in the design of the research institute that bears his name, encouraged Kahn to design a space that would "provide a welcoming and inspiring environment for scientific research" (Salk Institute for Biological Studies n.d.). To that end, Kahn designed laboratories with an abundance of natural light and a travertine marble courtyard (Salk Institute for Biological Studies n.d.). I.M. Pei also took the environment into consideration when designing the Mesa Laboratory for the National Center for Atmospheric Research in Boulder, Colorado. The building was designed so that most offices would have a view of the Rocky Mountains (McCulley 1968:63). The building also was designed with unique spaces to facilitate the scientists' ability to "think" and maze-like corridors that would encourage casual meetings (McCulley 1968:63; National Center for Atmospheric Research n.d.).

6.4 Profile of a Leading Architectural Firm in the Design of Corporate and Research Campuses

The architectural firm that designed the first period of construction at NBS was a leader in the field. Voorhees, Walker, Smith, Smith, & Haines, the firm that would become HLW International, had developed a specialization in the design of research campuses. The firm's first research campus was completed in 1941 for Bell Telephone Laboratories. Some of the firms' cutting-edge innovations included the design of laboratories with moveable partitions. Architect Ralph Walker, who becomes a partner in the firm, advocated the use of moveable partitions in numerous articles he wrote during the 1950s.

Throughout the 1930s, the firm designed a number of prominent buildings in New York City in the Art Deco style. These buildings included the Western Union Building (1930) and the Irving Trust (1932) (Vosbeck et al. 2008:86). Additional works include projects completed for the Department of the Army and ten projects for the 1939 World's Fair in New York City. During World War I, the firm designed Army hospitals and during World War II, the firm designed military facilities in the United States and the Caribbean (Moore et al. 2010:142). The U.S. Army War College at Carlisle Barracks, Pennsylvania, and the Night Vision Laboratory at Fort Belvoir, Virginia, were designed during the Cold War period (Moore et al. 2010:142).

Walker found employment with the firm McKenzie, Voorhees & Gmelin upon his discharge from the Army following the end of World War I. The firm's name changed to Voorhees, Gmelin & Walker in 1926 when he was made partner. The firm underwent another name change after 1939 when it became Voorhees, Walker, Foley and Smith. As Voorhees, Walker, Foley and Smith, the firm developed a national specialization in the design of corporate campuses. Selected projects included Bell Telephone Laboratories, Murray Hill, New Jersey; General Foods, White Plains, New York; IBM Research Center, Poughkeepsie, New York; and Argonne National Laboratories, Chicago, Illinois (Vosbeck et al. 2008:86). Walker served as president of the American Institute of Architects between 1949 and 1951 (Vosbeck et al. 2008:85).

Walker, both with the firm and individually, published articles on the design of postwar corporate campuses. These publication included two articles in *Laboratory Design* (1951), *Laboratories* (1961), "*Ralph Walker, Architect, of Voorhees, Gmelin, and Walker; Voorhees, Foley, and Smith; and Vorhees, Walker, Smith & Smith* (1957), and contributions to *The Fly in the Amber* (1957).

The firm continues today as HLW International. Established in 1974, the firm has offices in New York, New York; Madison, New Jersey; Los Angeles, California; London, England; and Shanghai, China. In addition to architectural and engineering services, services expanded to include interior design, sustainability, and planning, across a broad spectrum of sectors, such as, media and entertainment, hospitality and retail, and science and technology, among others (HLW International n.d.). Table 6.1 summarizes the firm's various name changes.

Table 6.1 Predecessor Firms to HLW International

Name of Firm	Years in Operation
Cyrus L.W. Eidlitz	Ca. 1885-1900
Eidlitz & McKenzie	Ca. 1900-1910
McKenzie, Voorhees & Gmelin	1910-1926
Voorhees, Gmelin & Walker	1926-1939
Voorhees, Walker, Foley & Smith	1939-1954
Voorhees, Walker, Smith & Smith	1955-1959
Voorhees, Walker, Smith, Smith, & Haines	1959-1964
Smith, Smith, Haines, Lundberg & Waehler	Ca. 1964-1966
Haines, Lundberg & Waehler	1968-1974
HLW International	1974-present

Source: Moore et al. 2010:141.

Chapter 7.0

Property Types and Summary of Architectural Data

This chapter presents a summary of previous architectural investigations at NIST, a summary of the current architectural inventory, and discusses issues of integrity.

7.1 Previous Investigations

Due to its recent development, the NIST campus has been subject to one previous architectural investigation focused on the identification of historic properties. In 2014, cultural resources investigations were completed in support of the *Corridor Cities Transitway Bus Rapid Transit Build Alternative* project pursuant to Section 106 of the NHPA. The investigations were completed by RK&K on behalf of the Maryland Transit Administration in cooperation with the Federal Transit Administration (RK&K 2014:S-1). The NIST campus was one of four properties identified in the project's Area of Potential Effects (APE). The report preparers recommended that an NRHP-eligible historic district was present at the NIST campus. The recommended district included the entire 579.5 acres associated with the campus and identified the following seven resources located with the project APE as contributing to the NRHP-eligible historic district: Building 233; Building 301; Building 303; Building 306; a concrete culvert; campus hardscape, including roads (Bureau, North, Sound, Research, Steam, South, Service, and West drives), parking lots, the driveway to Building 306, and service yards; and designed and natural landscapes (Tamiguchi 2014).

The district was recommended eligible for its association with the growth and evolution of a government agency having an important role in the development of American science and industry (Criterion A) and for "exemplifying the Modernist design philosophy, making effective use of modern materials, components, noteworthy landscaping, and site design" (Criterion C) (RK&K 2014:S-2). The report further recommended that the Administration Building (Building 101), which was located outside the project APE, is individually eligible for inclusion in the NRHP as "a successful example of the GSA's application of the International Style" (Criterion C) (RK&K 2014:S-2). Individual evaluations of the other resources located outside the project APE were not provided. In correspondence dated 12 January 2015, the MHT concurred with the recommendation that the NIST parcel is eligible for inclusion in the NRHP under Criteria A and C and further "accepted the results and conclusions presented in FTA/MTA's survey documentation" (Hughes 2015:2).

7.2 Property Overview

NIST is located in Gaithersburg, Maryland, a suburb of Washington, D.C. Major roads, consisting of I-270 to the east, Muddy Branch Road to the southeast, and Quince Orchard Road to the west, separate the campus from the surrounding commercial and residential development constructed during the late twentieth century. A single-family and townhouse neighborhood abuts the campus to the southwest. Commercial development consists of strip malls, big-box retailers, and office buildings. Residential neighborhoods are located adjacent to the campus.

NIST comprises multiple buildings located on a formally landscaped campus organized by a grid network of internal roads. Large-scale, multi-story, monumental buildings separated by parking and mowed lawn define the campus. The internal road network consists of roads running in north/south and east/west directions. The publically-restricted road network creates large superblocks occupied by research buildings. Parking is expansive. The primary research areas are clustered around the Administrative Building (Building 101) and the GPLs. Two smaller research areas south of the campus center are accessible from Center Drive.

Principal north/south roads include East, West, and Center drives. Center Drive provides access to the southern portion of the campus. North and South drives provide east/west access. Access to the support buildings is via Sound, Research, and Steam drives, and Service Drive, which runs in a north/south direction. No distinction in terms of design, landscaping, or road width is made between the service roads and the principal roads.

The main laboratory complex falls between North and South drives and East and West drives. Isolated laboratory complexes are located south of South Drive and are accessible from Center Drive. Service and support buildings generally are located along the west side of West Drive. The topography is relatively flat. Formal landscaping includes specimen trees and mature coniferous trees.

Building hierarchy is denoted through building materials. The Administration Building, GPLs, and Special Purpose Laboratories are executed in beige; support buildings are completed in red brick. The buildings are monumental in scale; occupy irregular, sometimes complex footprints; and terminate in flat roofs. Fixed-sash, single-light metal window are common. With the exception of the Administration Building, public space and ornamentation, both interior and exterior, are absent.

An extensive landscape plan prepared by HLW International was implemented for the NIST campus. Large expanses of lawn buffer the campus from the main thoroughfares. A large wood preserve is located between Quince Orchard Road and Buildings 202 and 235. Three stormwater management ponds of various sizes are located along the eastern and southwestern edges of the campus. Specimen and ornamental trees are planted throughout the campus. The Newton apple tree, which is derived from cuttings of the Newton apple tree in England, is planted in the courtyard between Building 101 and Building 225. Building 101 features an inner courtyard with flowering shrubs and trees. A water feature, benches, and a sun dial also are located in the courtyard.

A review of architectural drawings and conversations with NIST staff suggest that the resources located at NIST have undergone a continuous program of modification and alteration. Changes to building interiors are particularly common as laboratory and testing spaces have been altered to make the spaces relevant in the face of ever-changing research needs. Other building modifications include the construction of additions. Again, such modifications are necessary in order for the buildings to meet contemporary research requirements. In some cases, the additions are larger than the original building.

The core campus reflects the unified campus design developed by HLW International. The firm designed many of the buildings and prepared the campus landscape plan. Other architectural and engineering firms with expertise in the design of specialized, scientific buildings also have contributed to the evolution of the campus.

A total of 74 buildings, structures, objects, sites, and landscapes were systematically surveyed in December 2014 and January and March 2015 (Table 7.1). Surveyed buildings are presented on Figures 7.1-7.5. A discussion of buildings by property types, including representative examples highlighting key characteristics, is presented below. Property types are based on function at the time of building construction and not on current building use. Evaluations of resource significance and integrity are presented in Chapter 8 of this report. The appendix of this report includes an MIHP form, with detailed resource descriptions, and the DOE form.

7.3 NIST Property Types and their Associated Themes

7.3.1 <u>NIST Property Types</u>

The historic context presented in Chapters 3 and 4 of this report identifies the historic patterns and trends through which the facility's cultural resources are understood and important associations with history clarified. Chapters 5 and 6 present specific historical themes important to understanding the development and evolution of the Gaithersburg campus. Key dates in the agency's

Table 7.1 Surveyed Resources at NIST

Building Number	Building Name	Construction Date
101	Administration Building	1962-1965
103	Visitor's Center and Gate House	2009
B	Gate House	ca. 2009
C	Gate House	ca. 2009
F	Gate House	ca. 2009
202	Engineering Mechanics	1961-1963
203	Standard Reference Materials Facility	2012
205	Large Fire Facility	1973-1975; 2014
205E	Emissions Control Electrical	ca. 2000
205M	Emissions Control Mechanical	ca. 2000
205E#2	Emissions Control Electrical	ca. 2014
205M2	Emissions Control Mechanical	ca. 2014
2	Hopper	ca. 2014
3	Hopper	ca. 2000
206	Concrete Materials	1966-1968
207	Robot Test Facility	2012
208	Net-Zero Energy Residental Test Facility	2012
215	Nanofabrication Facility	2002-2004
216	Center for Nanoscience & Technology (Instrument East)	2001-2002
217	AML Instrument West	2002-2004
218	AML Metrology East	2000-2004
219	AML Metrology West	2000-2004
220	Metrology	1963-1966
221	Physics	1963-1966
222	Chemistry	1963-1966
223	Materials	1963-1966
224	Polymer	1963-1966
225	Technology	1963-1966
226	Building Research	1963-1966
227	Advanced Chemical Sciences Laboratory	1999
230	Fluid Mechanics	1967-1969
231	Industrial	1966-1968
233	Sound	1965-1968
235	NCNR	1963-1967
236	Hazards	1966-1968
237	Non-magnetic Laboratory	1964-1968
238	Non-magnetic Laboratory	1964-1968
245	Radiation Physics	1962-1964
301	Supply and Plant	1962-1964; 2013
302	Steam and Chilled Water Generation Plant	1961-1964; ca. 1990s; ca. 2010
303	Service	1962-1964
304	Shops	1962-1964

Building Number	Building Name	Construction Date
305	Cooling Tower	1961-1964; 2011
306	Potomac Electric Power Company (PEPCO) Electrical Substation	ca. 1970
306A	PEPCO	1961-1964
306B	PEPCO	1961-1964
307	Hazardous Chemical Waste Storage	1970-1971
308	Bowman House	1952-1953
309	Grounds Maintenance	1974-1978
310	Hazardous Materials Storage	1986-1987
311	Grounds Storage Shed	1990
312	Materials Processing Facililty	1996
313	Site Effluent Neutralization	1996
314	Backflow Preventer Building	1998
315	Backflow Preventer Building	1998
316	Electrical Service Building	1998
317	Cooling Tower	2010
1	Building associated with 317	2010
318	ES Consolidated Facility	2014
319	ES Storage Building	2014
320	CCC	2013
321	Liquid Helium Recovery Facililty	Under construction
Baseball Field 1		Late 1990s
Baseball Field 2		Late 1990s
Volley Ball Court		ca. 2009
Picnic Area		Late 20th centurty
Campus Landscape Plan (including Newton apple tree)		1961-1969; 1966
Stormwater Mangement Pond 1		ca. 1965
Stormwater Mangement Pond 2		ca. 1965
Stormwater Mangement Pond 3		ca. 2006
Flag pole		1965
Entrance Gates		1976
Masonry Test Wall		1977

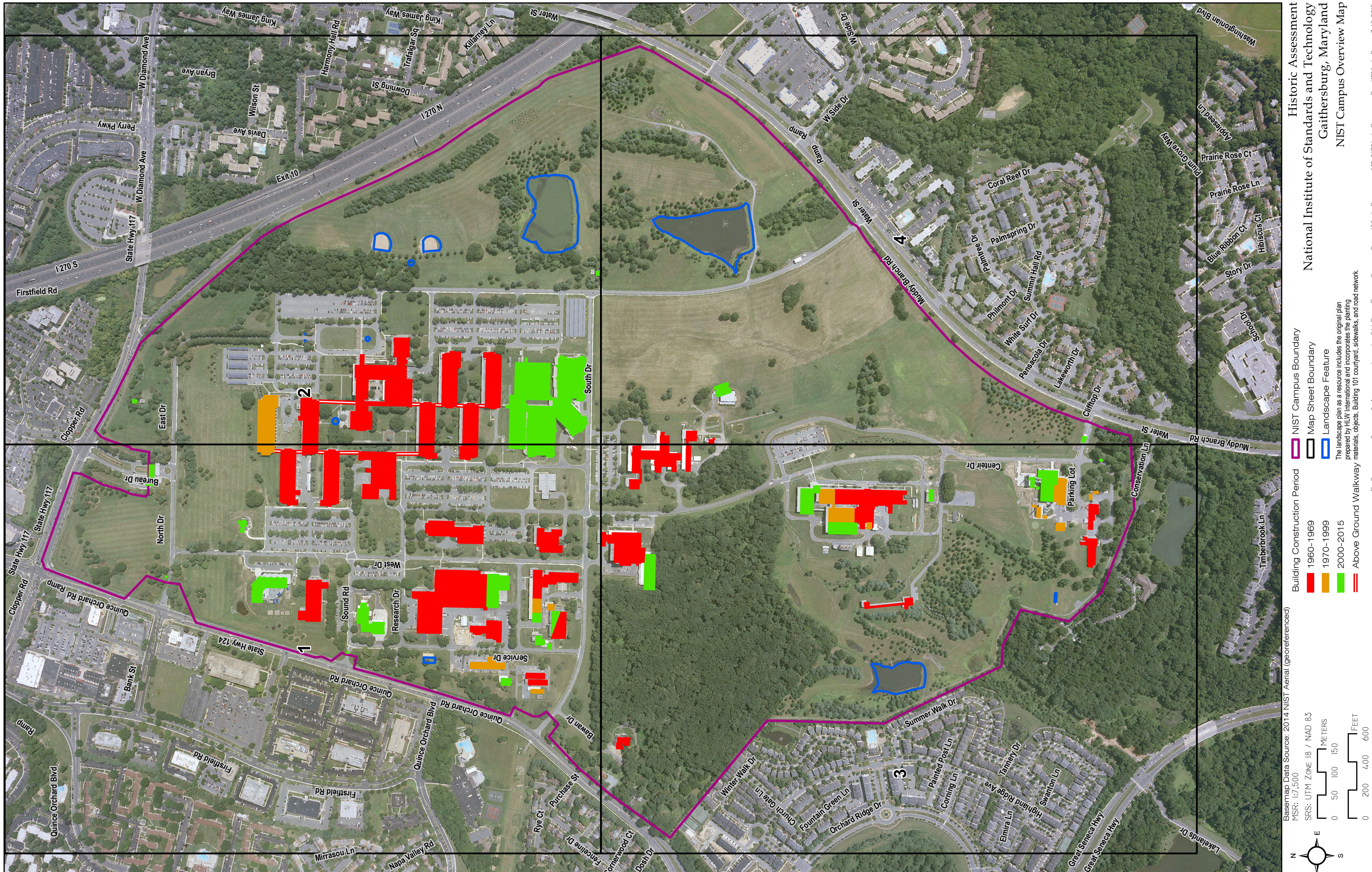

Figure 7.1 NIST Campus – Overview Map, (Source: RCG&A 2015).

Figure 7.2 NIST Campus – Detail Map 1, (Source: RCG&A 2015).

Figure 7.3 NIST Campus – Detail Map 2, (Source: RCG&A 2015).

Figure 7.4 NIST Campus – Detail Map 3, (Source: RCG&A 2015).

Figure 7.5 NIST Campus – Detail Map 4, (Source: RCG&A 2015).

history and their relationship to broader events in American history are identified. Themes are examined and their connections to buildings necessary for conducting research, testing, and evaluation are discussed. For the NIST property subject to this current investigation, the principal themes related to significance are:

- Science and Technology during the Cold War era through the present (1961 to 2015) and
- Postwar Research Campus Design (1940-1970).

Property types establish the link between the historic themes identified in the historic context and the NIST real property inventory. Property types include classes of resources constructed by NIST in support of its mission that are related to the Science and Technology theme and class of resources related to the theme of Postwar Research Campus Design.

The real property inventory at NIST can be categorized into five major property types:

- Administrative Buildings/Laboratories,
- Special Purpose Laboratories,
- Utility and Support Facilities,
- Recreational Facilities, and
- Domestic Architecture.

These property types briefly are described below.

Administrative functions often are combined in the same building with laboratory, testing, and evaluation functions. HLW International designed all but one (Building 227) of the GPLs and the Administration Building. The firms responsible for the design of selected Special Purpose Laboratories and the support buildings are discussed briefly in the preceding chapter. Chapter 6 also includes a detailed discussion of the key principles and concepts for Postwar Research Campus Design.

7.3.2 <u>Administrative/Laboratory Buildings</u>

Administrative/laboratory buildings represent a nine-building complex. The administrative/laboratory buildings are connected, monumental buildings faced in beige-colored brick, with the exception of the Administration Building, which is faced in stone and beige brick. The GPLs rise three stories in height. The Administration Building features a monolithic, 11-story tower and projecting wings housing the campus library, auditoriums, and cafeterias. In contrast to the horizontal emphasis seen in the design of the GPLs, the design of the Administration Building tower emphasizes verticality through scale and the use of extruded aluminum mullions. The height, materials, and orientation of the Administration Building establishes it as the dominant and central design focus of the complex.

Administrative/laboratory buildings terminate in flat roofs. Single-light, fixed-sash windows in metal frames are common. Metal spandrels visually divide the buildings into horizontal and vertical bays. With the exception of Building 227, which was constructed in 1999, the administrative/laboratory buildings were built during the initial period of campus construction (1961-1969). The buildings representing the GPLs are general research laboratories and testing facilities that did not require specialized construction to accommodate highly-specialized testing and evaluation programs. The spatial requirements for research conducted in Building 220 (Metrology), for example, did not differ from those of Building 223 (Materials). In keeping with the original design intent, the GPLs have been subject to regular interior reconfiguration using moveable partitions, as labs and offices were changed to accommodate spatial requirements in support of project-specific research needs (Figure 7.6).

In general, the exterior and interior designs of the buildings reflect their function. The exterior or interior ornamentation is minimal, reflecting Modern design aesthetics as well as the desire by NIST management and the GSA contract manager to control costs. The limited interior public spaces are confined to building lobbies.

The GPLs are large-scale beige-brick buildings that rise three stories in height and terminate in flat roofs. Original drawings reference grey face brick suggesting building color might have changed between the time the drawings were prepared and the time the buildings were constructed. Buildings 220, 221, and 225 were constructed with basements to house specialized research

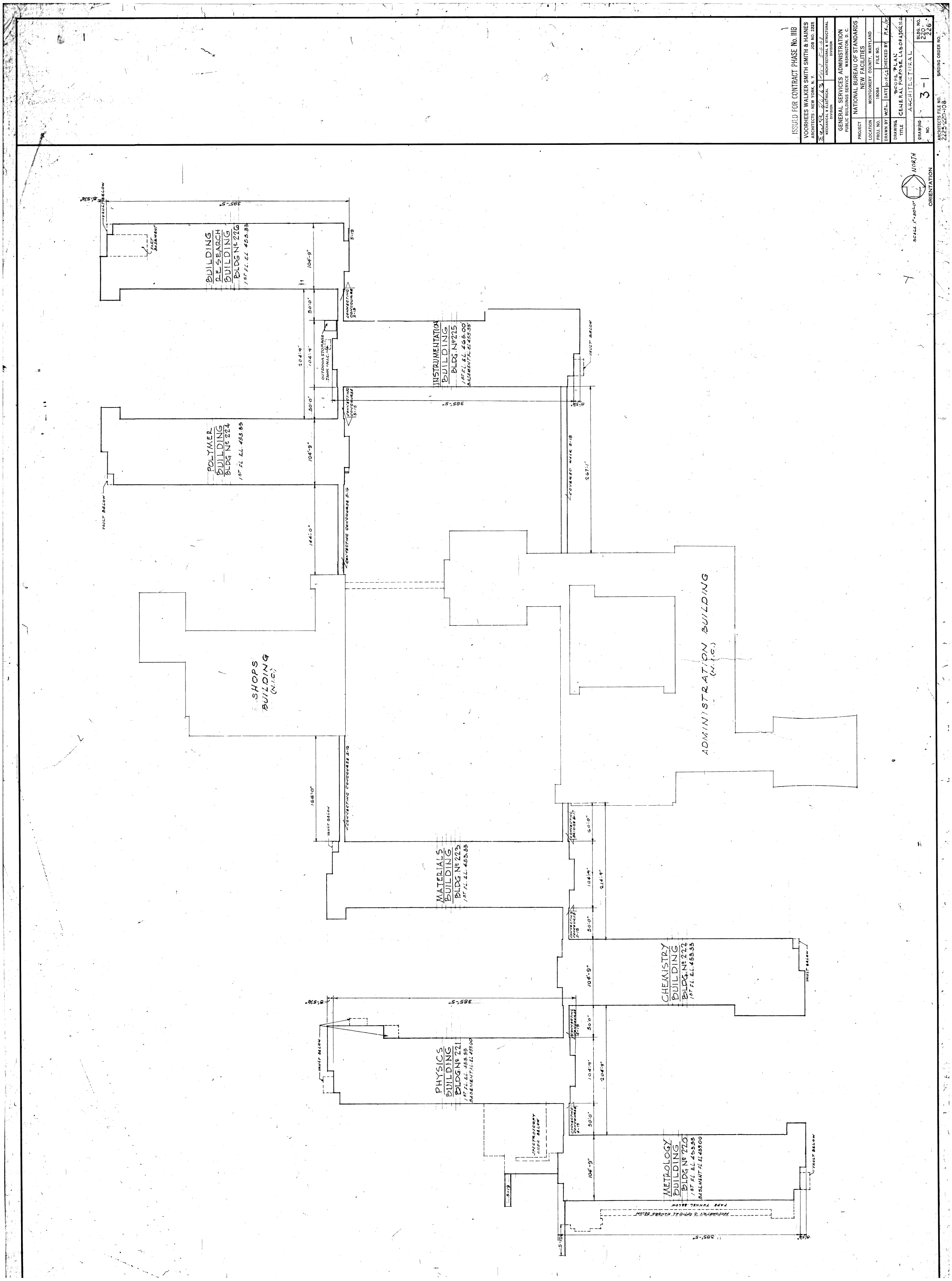

Figure 7.6 Scope Plan, General Purpose Laboratories (Source: Metropolitan Architects and Planners, Inc.).

spaces. The buildings are nearly identical in design, with minor differences in the placement of loading bays (either the north or south elevations) and the location of primary entrances (east or west elevations). Windows generally consist of single-light, fixed-sash, metal units with metal spandrels below the window openings (Figure 7.7 and Figure 7.8). Primary entrances are delineated by vestibules constructed of limestone and featuring double-leaf glass and metal doors with transoms. Each building has a three-story projecting stairwell. The GPLs are connected by concourses. External ornamentation is limited to the spandrels. The exterior designs of the buildings retain their original design integrity (Figure 7.9 and Figure 7.10). Additionally, Building 222 was modified in 2008 when the majority of laboratory spaces were converted to offices. The windows were replaced and the exterior walls were insulated at that time.

Building 226 is slightly different than the other buildings in the GPL complex. Generally, Building 226 retains the same materials and design as the other laboratory buildings; however, the south elevation is different than that of the other GPLs. According to original drawings, porcelain steel panels were installed at the second floor. A series of loading docks is present at the first floor of the south elevation. A one-story brick projection terminating in a flat roof extends from the elevation. Two metal doors are present on the projection's south elevation. This projection is original to the building and was constructed as a high bay. A covered concourse extends from the east end of the south elevation and connects to Building 225. This three-story concourse features fixed, single-light, metal-sash units similar to the windows found on Building 227. A brick-clad stairwell also is located on the building's east elevation (NIST Var).

Characteristics of the International Style are exhibited in the design of the GPLs and Building 101. The regular rhythm of voids and solids, and minimal architectural ornamentation are common features of the style. Curtain wall construction, which enabled the prominent use of glass through the application of large, single-light, metal-sash windows, was a hallmark of the style. First popularized during the late 1920s, the International Style grew in popularity following the end of World War II. More commonly used for commercial buildings, the style also was applied to domestic architecture.

Administrative/laboratory buildings house offices and and/or laboratories along double-loaded corridors. Offices are found along the exterior walls and two rows of back-to-back laboratory/administrative space run along the building interiors. Windows to the exterior are not present in the back-to-back spaces (Figure 7.11, Figure 7.12, Figure 7.13, and Figure 7.14). Some of the GPLs were constructed to house specialized equipment. For example, Building 222 was designed to house a Rowland Circle Spectrograph and both Buildings 222 and 223 included Mossbauer spectrographs (NIST var.; Schooley 2000:123; NBS 1966c). Public space is restricted to unadorned building entrance lobbies. Building 227, which was constructed in 1999, continues the exterior design precedent established in the earlier buildings (Figure 7.15).

Building 101 falls within the administrative/laboratory property type; however, as the primary administrative facility, the building includes numerous public spaces, including the major cafeteria for the campus, auditoriums, and the library (Figure 7.16, 7.17, and 7.18). Insulated porcelain steel spandrel panels are located above and below window openings (NIST var.). Beige face brick is employed. Administrative offices are located on the upper floors, and originally, laboratory space was included in the basement level. Through the varied use of stone and brick, the monumental entrance and lobby, and the change in rhythm between the administrative tower and the wings, the Administrative Building exhibits a greater degree of ornamentation than the GPLs (Figure 7.19).

A complete list of NIST administrative/laboratory resources is presented in Table 7.2.

7.3.2.1 Integrity

To retain the level of integrity necessary to convey their significance, administrative/laboratory buildings should retain most of their original design, materials, workmanship, and setting from their period of significance. The original design of the administrative/laboratory buildings called for the installation of movable interior partition

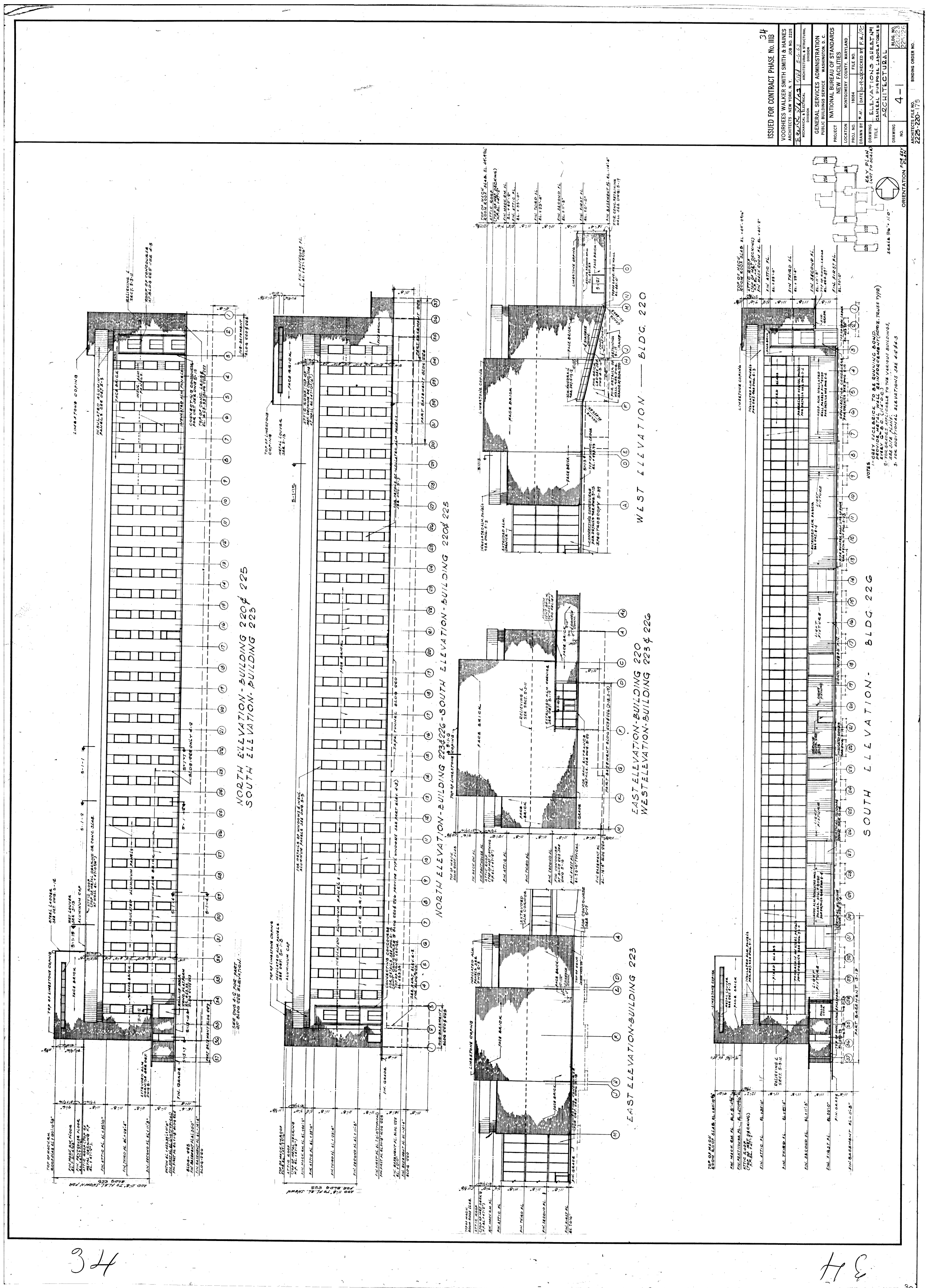

Figure 7.7 Elevations, General Purpose Laboratories (Source: Metropolitan Architects and Planners, Inc.).

Figure 7.8 Building 222, North and East Elevations (Source: RCG&A 2014).

Figure 7.9 Building 226, South Elevation (Source: RCG&A 2014).

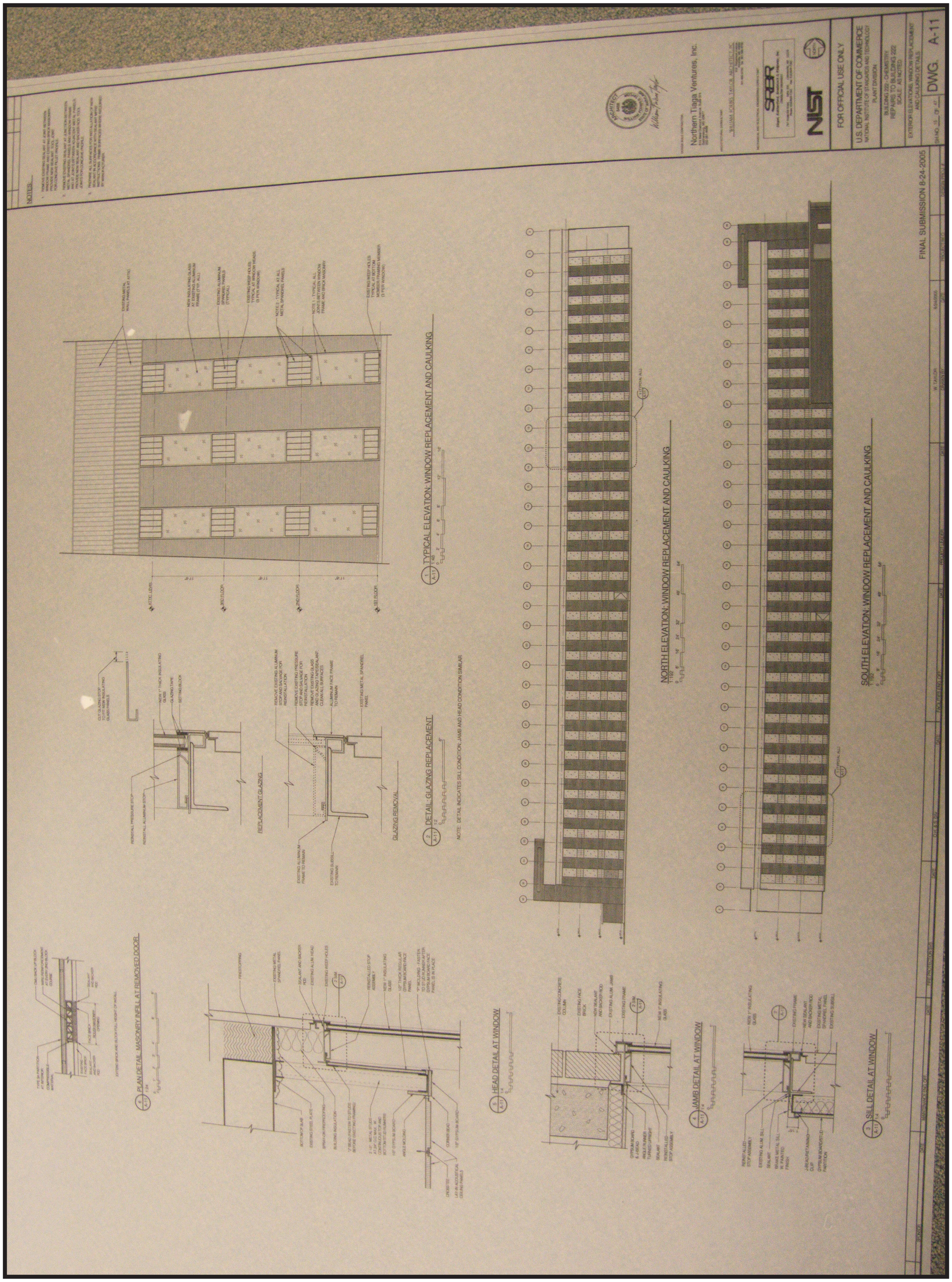

Figure 7.10 Building 226, Elevations and Window Detail (Source: NIST Office of Facilities and Property Management).

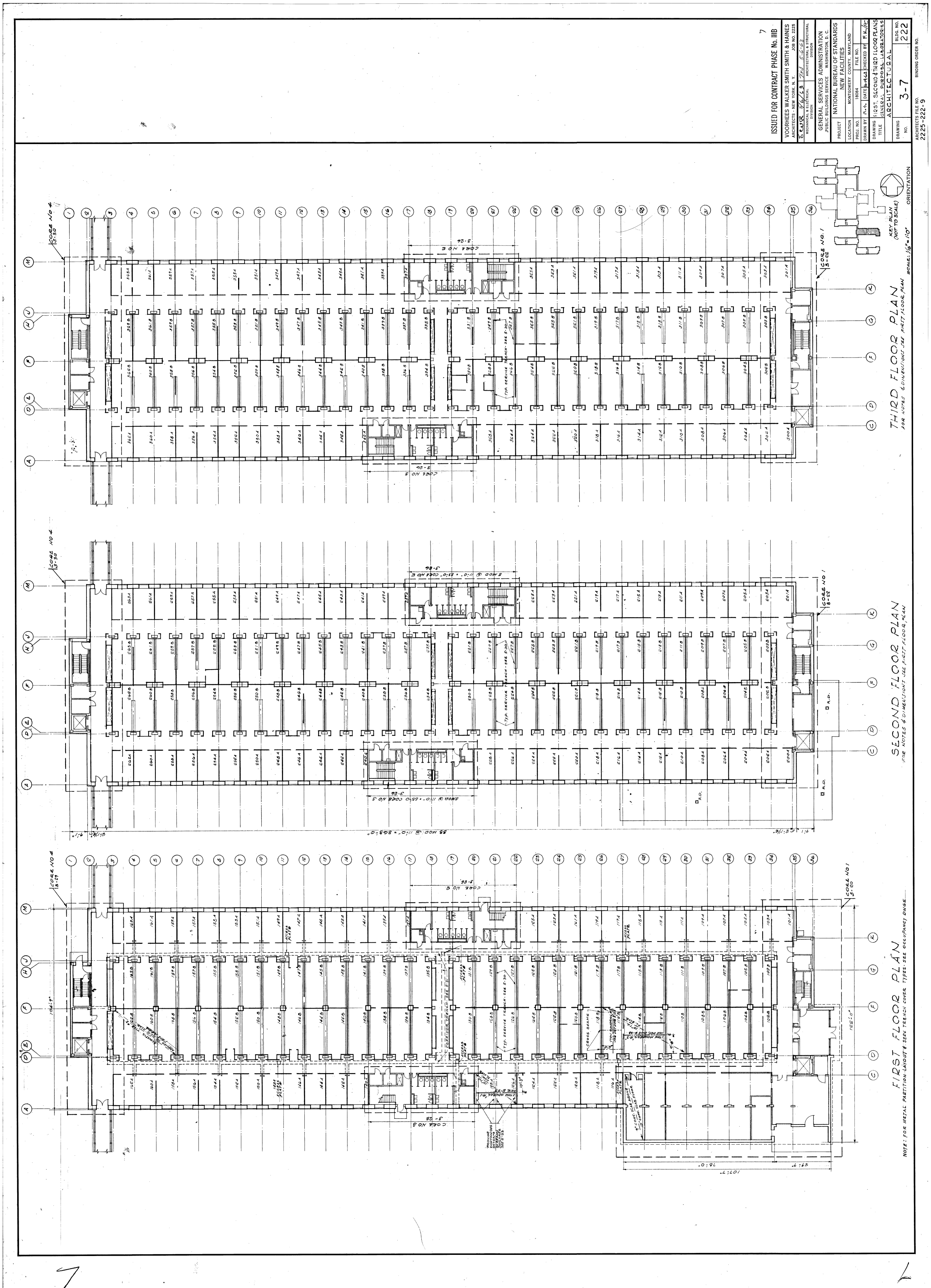

Figure 7.11 **First, Second, and Third Floor Plans, General Purpose Laboratories (Source: Metropolitan Architects and Planners, Inc.).**

Figure 7.12 First Floor Corridor, Building 223 (Source: RCG&A 2015).

Figure 7.13 Typical Office, Building 223 (Source: RCG&A 2015).

Figure 7.14 Typical Laboratory, Building 223 (Source: RCG&A 2015).

Figure 7.15 Building 227, North and West Elevations (Source: RCG&A 2014).

Figure 7.16 Administration Building, Lobby (Source: RCG&A 2015)

Figure 7.17 Administration Building, Cafeteria (Source: RCG&A 2015)

Figure 7.18 Administration Building, Library Stair (Source: RCG&A 2015)

Figure 7.19 Administration Building (Source: RCG&A 2014)

Table 7.2 Administrative/Laboratory Buildings

Building Number	Building Name	Construction Date
101	Administration Building	1962-1965
220	Metrology	1963-1966
221	Physics	1963-1966
222	Chemistry	1963-1966
223	Materials	1963-1966
224	Polymer	1963-1966
225	Technology	1963-1966
226	Building Research	1963-1966
227	Advanced Chemical Sciences Laboratory	1999

walls to facilitate adaptation and modification of work space to meet current research and testing needs. Indeed, the ability to modify laboratory and office space was one of the key requirements identified by NIST scientists and administrators for the design of the new laboratory facilities. The long, uninterrupted hallways were employed as a means of encouraging spontaneous discussions and collegial interactions among scientists. Changes to office and laboratory configuration do not affect resource integrity with the retention of the long corridors and original door openings.

Changes in material and function will not necessarily affect the building's integrity provided that sufficient fabric remains for the resource to retain its original design. Where renovations have modified or removed architectural elements, the buildings still can possess sufficient integrity if they retain the majority of their design features, including massing, spatial relationships, proportion, pattern of openings, and materials. Replacement materials that are similar to original materials do not affect integrity if the replacement materials convey the original design intent. Changes that may be required in order for the buildings to continue in active use may not affect resource integrity (ACHP 2002). This property type was integral to the NIST mission and the buildings were constructed during the Initial Period (1961 – 1969) of construction. They are emblematic of the postwar research campus. While the GPLs may not be individually eligible for inclusion in the NRHP, they may contribute to an NRHP historic district.

Building 101 retains its original design intent in terms of materials, configuration, and use. Character-defining features of the International Style are present on the building through the regular rhythm of solids to voids, the use of curtain-wall construction, the generous use of windows, the relative lack of ornamentation, and the presence of a monolithic block. The building may be individually eligible for inclusion in the NRHP as an example of the International Style.

7.3.3 Special Purpose Laboratories

Special Purpose Laboratories are those facilities that were constructed to enable highly-specialized testing and research that could not be accommodated in the GPLs. This type of testing includes fire research, robotics, sound, and neutron, among others. This property type exhibits the greatest variety in design aesthetic, scale, and footprint.

Architecturally, the Special Purpose Laboratories constructed during the 1960s are similar to the GPLs. Beige brick and preformed metal panels are common cladding materials (Figure 7.20 and Figure 7.21). Those Special Purpose Laboratories constructed during later construction campaigns reflect then-popular architectural trends. Related buildings constructed during the first period of construction are similar in design. This approach was adopted for groups of buildings (i.e. Buildings 215, 216, 217, 218, and 219) constructed during later periods of development.

In general, the configuration of the Special Purpose Laboratories reflect the interior demands of the testing program and occupy a variety of different footprints, most of them complex. Select buildings, such as Buildings 205 and 235, require exterior support systems and buildings. Flat roofs and single-light, fixed-sash metal windows are common. Depending on research requirements, the buildings may be monumental in scale and incorporate an administrative wing. Ornamentation is minimal and public space is limited to the building lobbies (Figure 7.22 and Figure 7.23). Ornamentation and public space are absent. Additions that are larger than the original building

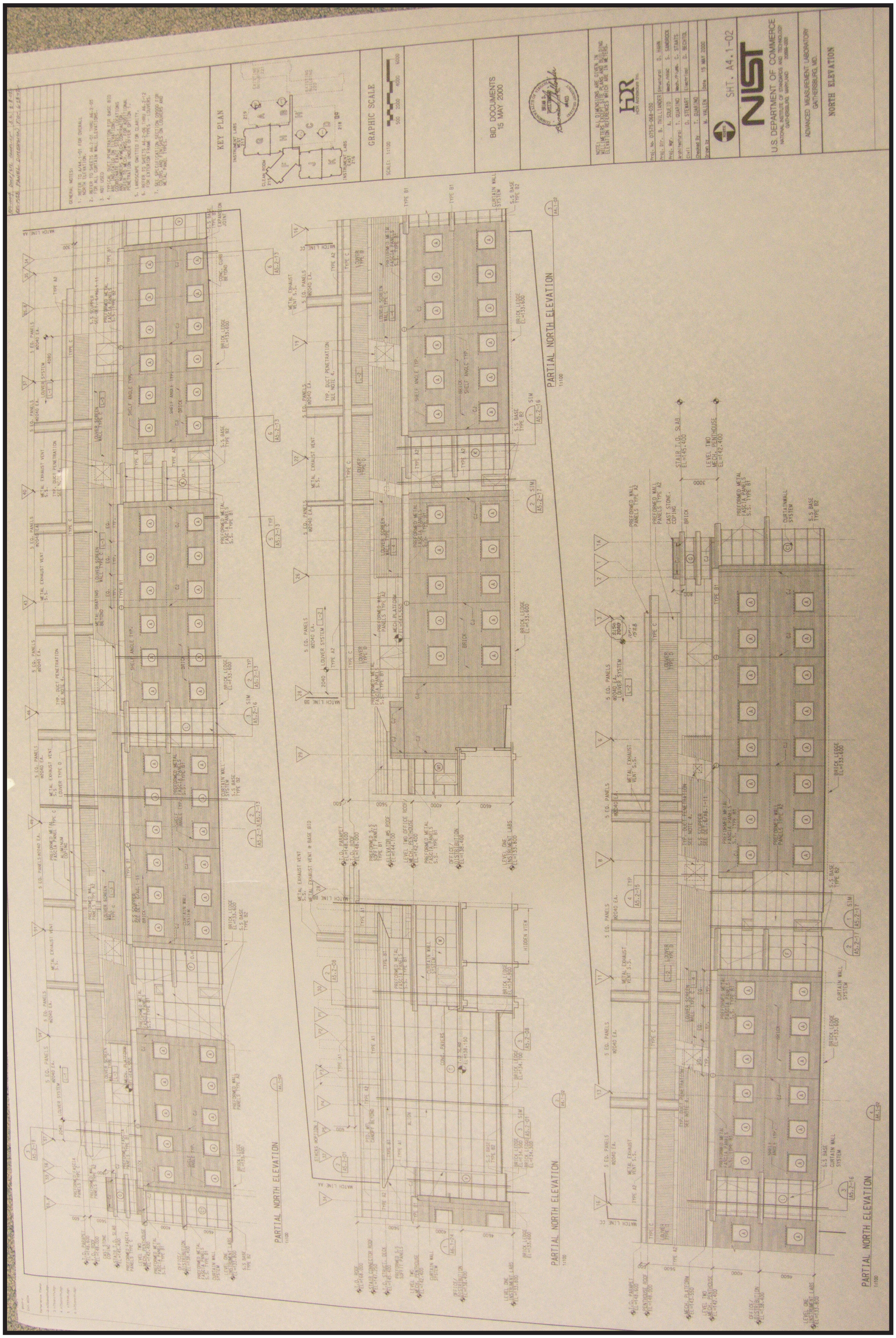

Figure 7.20 Elevations, AML (Source: NIST Office of Facilities and Property Management).

Figure 7.21 Building 216, South Elevation (Source: RCG&A 2014).

Figure 7.22 Interior Lobby, Building 215 (Source: RCG&A 2014).

Figure 7.23 Interior, Lobby Building 202 (Source: RCG&A 2015).

are not uncommon. In plan, multiple double-loaded corridors, in Buildings 216 and 217 of the Advanced Measurements Laboratory (AML), for example, provide access to laboratory and office spaces. As with the GPLs, natural light to the buildings in the AML complex is limited (Figure 7.24). The offices, which have windows, are located on the building perimeters, while the laboratory spaces have blind interiors.

With 24 buildings, including associated support buildings and structures, Special Purpose Laboratories represent the largest, mission-related property type present at NIST. Each are unique designs. For example, Building 202 housed the 12 million-pound force Universal Testing Machine, which was installed in 1971 (Schooley 2000:237-241) (Figure 7.25). Building 222 was designed to house a Rowland Circle Spectrograph and both Buildings 222 and 223 included Mossbauer spectrographs (NIST var.; Schooley 2000:123; NBS 1966c). The AML facility incorporates vigorous environmental controls. In addition, the facility includes a 8,000-square-feet Class 100/ISO 5 cleanroom in Building 215 (NIST 2013). Modifications to this property type include the construction of additions and alterations to interior space. Special Purpose Laboratories at NIST are presented in Table 7.3.

A masonry test wall is located northwest of Building 236 (Figure 7.26). The wall originally was located at the Washington campus and was moved to Gaithersburg in 1977. The wall was used to test a variety of masonry materials under different conditions. Generally, moved resources are not eligible for inclusion in the NRHP. Therefore, moved items are evaluated under Criteria Consideration B. In order to merit NRHP eligibility, the test wall would need to achieve its significance primarily for its architectural value or represent the surviving property most importantly associated with a historic person or event (National Park Service n.d.).

7.3.3.1. Integrity

To possess the integrity necessary to convey their significance, Special Purpose Laboratories should retain most of their original design, materials, workmanship, and setting from their period

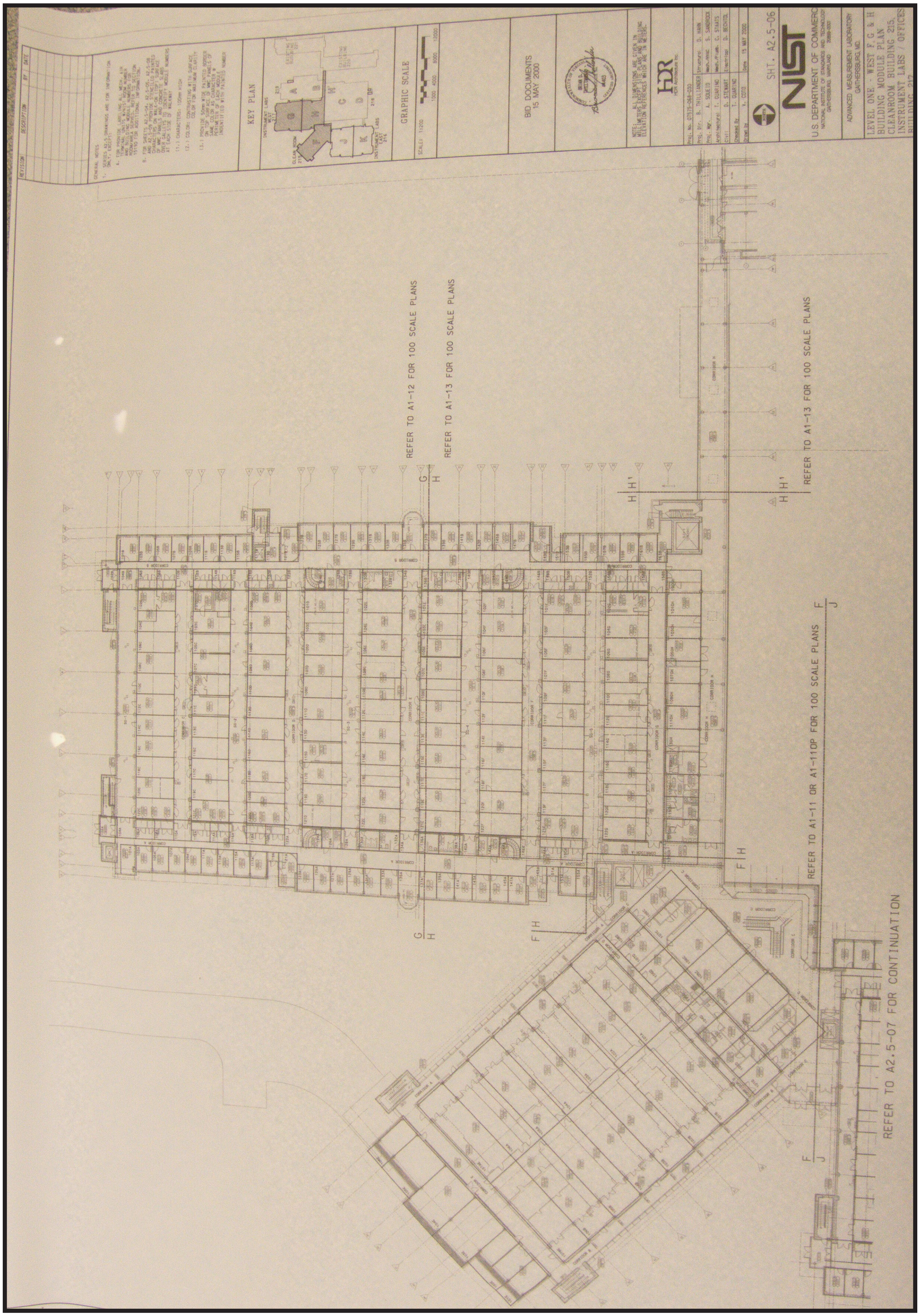

Figure 7.24 **Level One Floor Plans, Buildings 215 and 216 (Source: NIST Office of Facilities and Property Management)**

Figure 7.25 Highbay, Building 202 (Source: RCG&A 2015).

Table 7.3 Special Purpose Buildings

Building Number	Building Name	Construction Date
202	Engineering Mechanics	1961-1963
203	Standard Reference Materials Facility	2012
205	Large Fire Facility	1973-1975; 2014
205E	Emissions Control Electrical	ca. 2000
205M	Emissions Control Mechanical	ca. 2000
205E#2	Emissions Control Electrical	ca. 2014
205M2	Emissions Control Mechanical	ca. 2014
2	Hopper	ca. 2014
3	Hopper	ca. 2000
206	Concrete Materials	1966-1968
207	Robot Test Facility	2012
208	Net-Zero Energy Residental Test Facility	2012
215	Nanofabrication Facility	2002-2004
216	Center for Nanoscience & Technology (Instrument East)	2001-2002
217	AML Instrument West	2002-2004
218	AML Metrology East	2000-2004
219	AML Metrology West	2000-2004
230	Fluid Mechanics	1967-1969
231	Industrial	1966-1968
233	Sound	1965-1968
235	NCNR	1963-1967
236	Hazards	1966-1968
237	Non-magnetic Laboratory	1964-1968
238	Non-magnetic Laboratory	1964-1968
245	Radiation Physics	1962-1964

Figure 7.26 Test Wall, North Elevation (Source: RCG&A 2015).

of significance. Changes in material and function will not necessarily affect the building's integrity or its ability to convey its significance if sufficient fabric remains for the resource to retain its original design. Indeed, modifications and alterations are necessary for the buildings to continue to function in their original capacity. Where renovations have modified or removed architectural elements, the buildings still can possess sufficient integrity if they retain the majority of their design features, including massing, spatial relationships, proportion, pattern of openings, and materials. Replacement materials that are similar to original materials do not affect integrity if the replacement materials convey the original design intent. Changes that may be required in order for the buildings to continue in active use may not affect resource integrity (ACHP 2002). This property type was integral to the NIST mission and the buildings were constructed during all three periods of campus construction.

7.3.4 Utility and Support Facilities

Support facilities comprise several different types of buildings united by their common support function to the primary scientific research conducted at the campus. Some of the buildings were constructed as part of the original campus develop (i.e., Buildings 302 and 304); others were constructed later to address changing personnel needs (i.e., Buildings 103 and 320). A major difference between the laboratory buildings (including the GPLs and the Special Purpose Laboratories) is brick color. Research buildings are executed in beige brick; whereas, the support buildings generally are completed in red brick. Twenty-eight utility and support buildings are included in the NIST inventory.

7.3.4.1 Personnel Support (CCC and Security)

Four types of personnel support buildings are present on the NIST campus. These include the Visitor's Center and Gate House (Building 103), security gate houses (Buildings B, C, and, F), the ES Consolidated Facility (Building 318), and the CCC (320). Gates D and E no longer are active. In general, buildings having a security function are similar in design. With the exception of Building 320, which has an L-shaped footprint, the personnel support buildings occupy rectangular or square plans. All the security buildings are one story in height and terminate in flat roofs, with the exception of Gate B, which terminates in a pyramidal roof. The buildings rest on poured-concrete foundations. Openings are single-light, fixed-sash windows, and metal and glass doors. The three smaller gates (B, C, and F) are constructed of metal.

The main gate, Building 103 (Visitor's Center and associated gate house), are the most elaborate designs. Building 103 occupies an irregular footprint. The building rests on a concrete foundation. The exterior walls are faced with light-colored, all stretcher bond brick. The flat roof is ornamented in metal. The northeast corner of the building is chamfered. The lower wall of the northeast corner is faced with stone. The main entry in the north elevation contains double-leaf glass doors under a projecting metal hood. A bay containing fixed lights set in a metal frame is located west of the door. The northeast corner contains a band of fixed-light windows. The west, south, and east walls are faced in plain brick (Figure 7.27).

The associated gate house occupies a square footprint and rests on a concrete slab. The lower north wall is faced in stone, while the west, south, and east walls are faced in light-colored, stretcher bond brick. The upper wall of the north elevation is finished in metal. The flat roof has metal coping. Fixed-light windows are located on the east, north, and west elevations. Openings are located on the east and west elevations. A large metal canopy supported on metal columns extends over the driving lanes.

The other two buildings included in the personnel support property type are the ES Consolidated Facility and the CCC. The ES Consolidated Facility is a one-story building occuping an irregular L-shaped footprint. The exterior walls are faced in red, all stretcher bond brick. The roof is flat with metal coping. The main entry is located in the center of the north elevation. This area is clad in metal panels with large, fixed-glass windows and contains double-leaf glass doors set under a cantilevered hood. Openings also are present on the west elevation.

The CCC is faced with light-colored, all stretcher bond brick. The east and north elevations are ornamented with projecting bays faced with red brick with horizontal bands of light-colored bricks and capped with grey stone. The bays contain fixed-glass windows set in metal frames. The main entry is located in the northeast corner of the building. The entry contains double-leaf glass doors with fixed-light transom and sidelights. The entry is sheltered by a projecting roof that is supported on brick piers. The west elevation contains similar windows and multiple openings.

7.3.4.2 Campus Support

A number of buildings and structures were constructed to support the research activities conducted at NIST as well as resources needed to maintain the proper functioning of a large campus. This property type includes supply and plant (Building 301), shops (Building 304), and grounds maintenance (Building 309) buildings. The buildings range in size and scale. Common materials include red or light color brick and prefabricated metal panels. Windows, if present, can be single-light fixed units in metal sash. The buildings occupy a complex footprint. Overhead garage doors are not uncommon (Figure 7.28 and Figure 7.29).

7.3.4.3 Utility

Two primary types of utility buildings are present at NIST. These types include single-story buildings (Buildings 314 and 315), one of which is relatively small (i.e., Building 313), and those that are monumental in scale (i.e., Building 302 and 305) (Figure 7.30 and Figure 7.31). Generally, the buildings occupy rectangular footprints and terminate in flat roofs. Red brick is the principal cladding material. Doors are double-leaf metal. If present, windows generally consist of single-light, fixed-sash, metal units. The two buildings (Buildings 306 and 307) constructed for PEPCO are included in this property type.

Figure 7.27 Building 103, North Elevation (Source: RCG&A 2015).

Figure 7.28 Building 301, East Elevation (Source: RCG&A 2014).

Figure 7.29 Building 309, East Elevation (Source: RCG&A 2014).

Figure 7.30 Building 313, West and South Elevations (Source: RCG&A 2014).

Figure 7.31 Building 302, North Elevation (Source: RCG&A 2014).

7.3.4.4 Storage

Storage buildings for general storage purposes were constructed at the NIST campus. Examples of this property type include Buildings 307, 310, 311, and 319 (Figure 7.32). The permanent storage buildings occupy rectangular footprints and terminate in flat or gable roofs. Exterior walls are faced with light-colored or red brick or prefabricated metal panels. Garage doors and single-leaf metal doors are common.

Support buildings in the NIST inventory are presented in Table 7.4.

7.3.4.4.1 Integrity

Support buildings, in order to possess the integrity necessary to convey their significance, should retain most of their original design, materials, workmanship, and setting from their era of significance. Many of these resources may have been altered to accommodate changing technology or mission requirements. The buildings still can possess sufficient integrity if they retain the majority of their design features, including massing, spatial relationships, proportion, pattern of openings, and materials even when later additions or modifications have resulted in the removal or alteration of architectural elements. These buildings were constructed as secondary resources needed to support the agency's mission of standardization and scientific investigation. Support buildings have may an association with the identified themes of Science and Technology and Postwar Research Campus Design because they were integral to the agency's larger scientific role or because they are elements of the original campus design and first period of construction. Many of these resources likely may not individually be eligible for inclusion in the NRHP; however, they may contribute to an NRHP historic district.

7.3.5 Recreation Resources

Recreational facilities also are included in the NIST inventory. These resources include an outdoor volley ball court, two baseball fields, and a picnic area with playground. The two baseball fields are located east of East Drive. Each field includes a chain link fence behind the catcher's box. Chain link fences also shield the seating for

Figure 7.32 Building 311, North and East Elevations (Source: RCG&A 2014).

Table 7.4 Utility and Support Buildings

Building Number	Building Name	Construction Date
103	Visitor's Center and Gate House	2009
B	Gate House	ca. 2009
C	Gate House	ca. 2009
F	Gate House	ca. 2009
301	Supply and Plant	1962-1964; 2013
302	Steam and Chilled Water Generation Plant	1961-1964; ca. 1990s; ca. 2010
303	Service	1962-1964
304	Shops	1962-1964
305	Cooling Tower	1961-1964; 2011
306	Potomac Electric Power Company (PEPCO) Electrical Substation	1961-1964
306A	PEPCO	1961-1964
306B	PEPCO	1961-1964
307	Hazardous Chemical Waste Storage	1970-1971
309	Grounds Maintenance	1974-1978
310	Hazardous Materials Storage	1986-1987
311	Grounds Storage Shed	1990
312	Materials Processing Facililty	1996
313	Site Effluent Neutralization	1996
314	Backflow Preventer Building	1998
315	Backflow Preventer Building	1998
316	Electrical Service Building	1998
317	Cooling Tower	2010
1	Building associated with 317	2010
318	ES Consolidated Facility	2014
319	ES Storage Building	2014
320	CCC	2013
321	Liquid Helium Recovery Facililty	Under construction

the home and visiting players. The seating consists of one plastic bench for each team. Facilities for trash, recycling, and storage also are present (Figure 7.33). The fields were constructed during the late 1990s (Susan Cantilli, personal communication 5/6/2015).

The picnic area is sited east of East Drive and adjacent to the baseball fields. Mature trees define the eating area. Grills, stone trashcans, and wood and plastic picnic tables are present. The picnic area also includes a playground (Figure 7.34). Visual observation suggests the playground equipment and the picnic tables were installed during the late twentieth century or early twenty-first century. A volley ball court is located behind Building 301, on the west side of Service Road. The court was constructed ca. 2009 and features a net and sand pit (Susan Cantilli, personal communication 5/6/2015).

Recreational facilities in the NIST inventory are presented in Table 7.5.

7.3.5.1 Integrity

Recreational facilities, in order to possess the integrity necessary to convey their significance, should retain most of their original design, materials, workmanship, and setting from their era of significance. Many of these resources were constructed to improve morale, foster creativity, and encourage productivity and discovery. These resources are not integral to the Science and Technology or the Postwar Research Campus themes. Recreational facilities likely would not be individually eligible for listing in the NRHP. They may, however, contribute to an NRHP-eligible historic district.

7.4 Property Types Associated with Mid-Twentieth Century Domestic Architecture in Montgomery County

A single example of domestic architecture is included at the NIST campus. The building predates the agency's move to Gaithersburg. Archival research suggests the dwelling was constructed by 1953. It was used as an insulation and consumer products testing facility and most recently, it served as the campus daycare center. Currently, the building is vacant, awaiting demolition.

The Bowman House is an example of mid-century domestic architecture. The Washington, D.C. metropolitan region was slow to adopt changing architectural trends in domestic design. The Federal Housing Administration (FHA) developed guidelines for residential construction. In order for a property owner to obtain a government–secured mortgage, the dwelling had to meet the minimum FHA-established guidelines. In the D.C. region, the FHA strictly applied its guidelines when appraising properties for mortgages. As a consequence, two-story dwellings with low-pitched, gable-roofs often were approved (Lampl 2004:E56). High-style "Modern" style dwellings constructed by prominent architects such as Richard Neutra, Marcel Breuer, and Walter Gropius, among others, were not as popular in the Washington, D.C. region as they were in other parts of the country. Flat-roofed dwellings still remained rare in the Capital region (Lampl 2004:E56). By the early 1950s, the predominant house types in the region represented "soft modernism:" a modernized version of the Cape Cod or the ranch house (Lampl 2001:E56).

The Bowman House (Building 308) is a single-story, wood-frame dwelling terminating in a side-gable roof and resting on a poured-concrete foundation. The building is clad in vinyl siding and occupies an irregular footprint. Vinyl replacement windows are employed throughout. An addition constructed on the east end of the south elevation nearly doubles the size of the building.

The dwelling was adapted for NIST use after the property was acquired by the Federal government. The dwelling was used for insulation testing, consumer-product testing, and most recently a daycare (Figure 7.35). Alterations over time, including the construction of an addition on the south elevation, the replacement of all the windows, and the application of vinyl siding, have resulted in a loss of resource integrity; consequently, the dwelling no longer is able to convey its significance as an example of mid-twentieth-century domestic architecture in Montgomery County.

7.4.1 Integrity

In order to be eligible for inclusion in the NRHP, the dwelling would need to possess the

Figure 7.33   Baseball Field 2, Looking Southeast (Source: RCG&A 2014).

Figure 7.34   Picnic Area, Looking Northwest (Source: RCG&A 2015).

Figure 7.35 Building 308, North Elevation (Source: RCG&A 2014).

Table 7.5 Recreational Facilities

Building Name	Construction Date
Baseball Field 1	Late 1990s
Baseball Field 2	Late 1990s
Volley Ball Court	ca. 2009
Picnic Area	Late 20th centurty

integrity necessary to convey its significance. Retention of its original design, materials, workmanship, and setting from its era of significance would be necessary. If additions are present or modifications have resulted in the removal or modification of architectural features, the building still can possess sufficient integrity if it retains the majority of its design elements, including massing, spatial relationships, proportion, pattern of openings, and materials. The dwelling was acquired by the Federal government not long after it was constructed. The building then was used for testing purposes, and later as a childcare center. While the resource most likely would not be individually eligible for inclusion in the NRHP, it may contribute to an NRHP historic district.

7.5 Landscape Features

The NIST campus includes formal as well as natural landscaping. Large expanses of mowed lawn serve as a buffer between I-270 and the surrounding residential construction. Mowed lawn also surrounds the administrative/laboratories, Special Purpose Laboratories, and support buildings. A woodlot is found south of Building 202 and extends to Quince Orchard Road. A chain-link fence encompasses the campus.

The NIST landscaping makes extensive use of specimen trees and ornamental planting. State trees were planted on the grounds to acknowledge the receipt of sets of standards by respective states. A cutting from the Newton apple tree is an interesting landscape feature. The tree, which was planted in 1966, is located in the courtyard between Building 101 and Building 225, north of the library (Figure 7.36). Mature deciduous and coniferous trees generally are found due to the large deer population residing on the campus near building entrances; small shrubs are lacking due to the large deer population residing on the campus. Objects include the flagpole east of Building 101 and the entrance gates, located northeast of Building 101, which were moved from the Washington campus in 1976 (Figure 7.37 and Figure 7.38). The courtyard of Building 101 features flowering shrubs and trees, a water feature, benches, and sun dial. Windows enclose the courtyard, which is accessible from hallways from the main lobby (Figure 7.39). Generally, moved resources are not eligible for inclusion in the NRHP. Therefore, moved items are evaluated under Criteria Consideration B. In order to merit NRHP eligibility, the entrance gates would need to achieve their significance primarily for their architectural value or represent the surviving property most importantly associated with a historic person or event (National Park Service n.d.).

Paved roads function as the primary internal transportation network linking the buildings to one another. Sidewalks also are present. Parking, which is ample, consists of paved lots, generally sited on a north-south access. Three stormwater management ponds, two east of East Drive, and one west of Buildings 237 and 238 also are present (Figure 7.40). The two ponds adjacent to East Drive are large; mature coniferous trees and water grasses define the edges of the ponds. A review of historic aerial photography suggests the ponds were installed in ca. 1965 (Historic Aerials var.). Limited seating, i.e., picnic tables, is found at the northernmost pond. A small footbridge is located adjacent to the southern pond. A lack of access prohibited survey of the pond located west of Building 235. A woodlot is found south of South Drive and stretches between Center Drive and Quince Orchard Road (Figure 7.41). The landscape plan as a resource includes the original plan prepared by HLW International and incorporates the planting materials, woodlot, objects, Building 101 courtyard, sidewalks, and road network. Landscape resources are presented in Table 7.6.

Figure 7.36 Newton Apple Tree, Looking North (Source: RCG&A 2014).

Figure 7.37 Flag Pole. Looking Southeast (Source: RCG&A 2014).

Figure 7.38 Gate Post, Looking South (Source: RCG&A 2014).

Figure 7.39   Building 101 Courtyard (Source: RCG&A 2015).

Figure 7.40 Stormwater Management Pond 1, Looking North (Source: RCG&A 2014).

Figure 7.41 Woodlot, Looking Southwest (Source: RCG&A 2014).

Table 7.6 Landscape Features

Building Number	Construction Date
Campus Landscape Plan (including Newton apple tree)	1961-1969; 1966
Stormwater Mangement Pond 1	ca. 1965
Stormwater Mangement Pond 2	ca. 1965
Stormwater Mangement Pond 3	ca. 2006
Flag pole	1965
Entrance Gates	1976
Masonry Test Wall	1977
Test Wall	1977

7.6 Summary and Conclusion

Property types included in the NIST inventory consist of administrative/laboratory buildings, Special Purpose Laboratories, support facilities, recreational facilities, and domestic architecture. Most of the construction was completed during the 1960s, with relatively minor construction occurring during the 1970s through the 1990s. Major new construction projects were undertaken during the 2000s.

The Gaithersburg campus is an example of Postwar Research Campus design commonly constructed during the 1950s and 1960s. The large-scale buildings exhibit elements of the Modern Style in general and the International Style specifically. The International Style gained in popularity during the postwar years, and frequently was the style chosen by major companies to reflect a corporate image. Masonry construction is prevalent. Buildings generally occupy rectangular footprints, terminate in flat roofs, and employ vast quantities of windows. Windows generally consist of single-light, fixed-sash, metal units. Simple metal or metal and glass doors provide access to building interiors. Most buildings are three-stories in height. Single-story buildings are not uncommon. The Administration Building, at 11 stories, is the tallest building on the campus and serves as a focal point.

Double-loaded hallways with back-to-back laboratories characterize the GPL building interiors. Administrative space and offices often are intermixed with laboratories. The buildings were designed for maximum flexibility. Partition walls divide office and laboratory space, which enabled the efficient and the easy reconfiguration of workspace to meet current project needs. Public space is severely restricted, and, if present, lobbies are modest. Building 101, with its vast lobby, auditoriums, cafeteria, and inner courtyard, is the only building on the campus with significant amounts of dedicated public space.

Formal landscaping, incorporating specimen trees and flowering trees are planted throughout. Large expanses of mowed lawn surround the buildings. Sidewalks connecting all buildings and enclosed passages between the GPLs facilitate pedestrian access to the buildings.

The property types identified and summarized in the discussion above enable the evaluation of NIST built resources within their appropriate historic contexts as contributing or non-contributing resources to an NRHP-eligible historic district. The discussion provides a framework for additional resource-specific, in-depth research necessary to determine whether specific resources, besides Building 101, are individually eligible for NRHP designation. The results of contributing and non-contributing resource evaluations are presented in Chapter 8. The MIHP and DOE forms in Appendix A include detailed building descriptions as well as present the results of reurce evaluation.

7.6.1 Resource Integrity

To possess the integrity necessary to convey their significance, resources should retain most of their original design, materials, workmanship, and setting from their era of significance. Modifications to building materials and the construction of new additions will not necessarily affect resource integrity or its ability to convey its significance. Sufficient fabric should remain for the resource to retain its design. Additions and modifications that have removed or altered architectural elements will not necessarily affect resource integrity. If the building retains the majority of its design features, including massing, spatial relationships, proportion, pattern of openings, and materials, it can still retain integrity, despite the construction of the addition.

The original design of many of the administrative/laboratory buildings incorporated movable interior partition walls so that work space could be adapted and modified to suit research needs. Indeed, the moveable partition walls are character-defining features of the buildings. Consequently, changes to office and laboratory configuration may not affect resource integrity. A continuous program of upgrades and alternations are common for buildings used for scientific and technological purposes. Such modifications may be necessary in order for buildings to continue in active use. Such changes may not affect resource integrity (ACHP 2002). While some of these resources may not individually be eligible for inclusion in the NRHP, they likely could contribute to an NRHP historic district.

Recreational facilities were constructed as a means of improving employee morale. Such resources are not integral to the Science and Technology or Postwar Research Campus Design themes. For this reason, individual eligibility of recreational resources is unlikely nor is it likely that such resources would contribute to an NRHP-eligible historic district.

Chapter 8.0

Evaluation Results

This chapter presents a summary of the analysis of archival and architectural data applying the National Register Criteria for Evaluation (36 CFR 60 [a-d]. Buildings, objects, and landscape features contained on the NIST campus were assessed individually and collectively for significance and integrity within the important themes and time periods identified through archival research and explored earlier in this report. MIHP and DOE forms are presented in the appendix to this report.

8.1 Summary

Since its creation over a century ago, as the NBS in 1901, NIST has been at the cutting edge of scientific standardization and measurement. Work by NIST scientists has resulted in the standardization and measurement of nearly every facet of scientific inquiry. A small sampling of the testing and evaluation conducted by NIST scientists includes the development of standards for firefighting equipment; electricity and public utilities; and materials such as paints, cements, ceramics, rubber, paper, and leather products. The standards developed by NIST scientists have been widely adopted by private-sector industry. NIST also is an important research facility and scientists at the Gaithersburg campus conduct research and publish on a wide variety of topics. Selected areas of scientific investigation include fire research, environment and climate, physics, and law enforcement. NIST scientists continuously have made important contributions advancing scientific inquiry. Agency scientists have been recognized through numerous awards, including a number of Department of Commerce Gold Medals, an Emmy, and four Nobel Prizes.

NIST established an architectural identity for the agency when it constructed its research campus in Gaithersburg, Maryland. The agency selected the nationally preeminent architectural firm in the design of research and corporate campuses for work at Gaithersburg. The firm of HLW International is recognized as national experts in the design of postwar research campuses. The agency, in collaboration with the architects, participated in thoughtful and intensive architectural programming to design a campus that met the agency's needs and those of its scientists. The result was a research campus similar in design to campuses constructed by the public and private sectors during the 1950s and 1960s, but unique to the demands of the NIST mission. The existing campus was constructed during three major periods of development: Initial Construction (1961-1969), Second Period (1970-1999), and Third Period (2000-2015). Buildings completed during the Initial Construction were designed in the International Style. Character-defining features of the style include curtain-wall construction, ample use of glass, clean monolithic forms, and minimal ornamentation. Buildings constructed in support of the NIST mission and representative of buildings constructed for postwar research campuses include administrative/laboratory buildings, special purpose laboratories, and support buildings. Recreational resources and an example of postwar domestic architecture also are included in the NIST inventory.

8.2 Evaluation Results

A total of 74 buildings, structures, objects, and landscapes were documented under the current investigation. Analysis of archival and architectural data applying the National Register NRHP Criteria for Evaluation identified a cohesive collection of buildings, structures, and landscapes that represent a recognizable entity united by design and historical association with the first decade of NIST development (1961 – 1969).

At the time of its construction, the NIST Gaithersburg campus incorporated current innovations and approaches to the design of research campuses. Its suburban setting, formal landscape, greenspace, ample parking, large-scale, monumental buildings, and general and specialized laboratories are hallmarks of postwar research campus design. Importantly, the GPLs included modular administrative/laboratory space, which maximized flexibility and ensured that the buildings were easily adaptable to changing research needs. Movable or demountable walls were an easy, quick, and cost-effective way to modify laboratory space based on project need and requirements. Spatial flexibility was important to an agency devoted to scientific evaluation, testing, and experimentation. By the time HLW International designed the NIST campus, the firm had almost 30 years of experience designing research facilities. It had developed protocols and best practices for close client involvement. These practices included surveying scientists to ascertain needs, design review and development using scaled models, and building-specific programming for specialized laboratories.

The buildings constructed between 1961 and 1969 exhibit many of the hallmarks of postwar research campus design. These character-defining features include flexible workspace that could be configured in a variety of different ways to suit current research/laboratory needs regardless of the research discipline. The buildings were constructed incorporating administrative/laboratory modules. The buildings are linear in plan, housing modules across double-loaded hallways. The back-to-back laboratories were across from the exterior-facing administrative spaces. Long hallways would encourage spontaneous discussions among colleagues. In this manner, scientists could collaborate and discuss research problems in informal settings. The acreage afforded by the suburban site was acquired, in part, to facilitate expansion, as necessary. Greenspace with formal landscaping was held to be conducive to scientific inquiry and created a working environment reminiscent of an academic campus.

Following the construction of the original buildings in accordance with the plans prepared by HLW International, few large-scale buildings were constructed. The majority of construction projects completed during the Second Period of development expanded earlier buildings through major additions. Smaller-scale new buildings also were added during the period. Construction of the AML complex during the first decade of the twenty-first century initiated a major new building campaign in response to increased precision in measurement (i.e., measuring very cold and very hot temperatures).

Building 101 is the central focus of the campus and is a representative of the International Style applied to a principal building within a research complex. Similar to many private-sector research campuses of the period, the principal building was the primary focus for public space and architectural elaboration; Building 101 became an icon for the agency. Curtain-wall construction, generous use of windows, and minimal ornamentation, hallmarks of the style, are employed on the building. Public space is incorporated in the large lobby and cafeteria, spaces designed to encourage social interaction. Other public spaces include auditoriums, providing forums for professional presentations.

A comprehensive site plan was designed and implemented for the campus. A grid street system provides access to the research laboratories. Lawn, Mature specimen and deciduous trees, hardscapes, and stormwater management ponds were incorporated in the landscape.

The cohesive area capturing the design and operation of the campus during its initial period of development is defined by nine contributing resources encompassing the area defined on the east by East Drive, the south by the AML complex, the west by Research Drive to Building 304. At this point, the boundary turns west to follow Research Drive until the intersection with Center Drive. The boundary turns north to align with the sidewalks along the west elevations of Buildings 224 and 226 and continues north to a point 205 feet from the north elevation of Building 226. The boundary then turns east to the west edge of the parking lot located northeast of Building 227. The boundary then turns south and connects to the access road leading to East Drive., which is the starting point. The choice of 205 feet represents the distance between the existing GPLs.

8.2.1 Application of Criteria

Not all buildings within the cohesive collection of first period buildings have reached 50 years of age, as generally suggested to achieve the historical perspective necessary for the assessment of historic significance under the NRHP criteria. NIST has not developed specific internal guidance for the evaluation of properties from the recent past; the guidance applied to resources of similar types and age range by NASA in consultation with the National Register program provided insights helpful in this current analysis. In January 2012, National Register program administrators advised that 50 years is a guideline, rather than a requirement, for achieving historical perspective that may not be appropriate in the evaluation of all resources. For example, evaluation under the higher standards of the Criteria for Special Consideration was not necessary in cases such as the Goddard Space Flight Center campus, where significance could be demonstrated clearly applying the general NRHP Criteria for Evaluation (R. Christopher Goodwin & Associates, Inc. 2012:2-8). The Goddard Space Flight Center campus shares many design and functional similarities with the NIST campus.

While GSA served as construction managers for the initial construction campaign at NIST, the campus was never part of the formal GSA inventory. NIST principally was involved in site selection, selection of the architectural design firm, and in architectural programming. NIST also retained maintenance and management responsibilities of the campus. Due to GSA involvement during construction, a review of GSA historic contexts and internal guidance regarding the evaluation of resources constructed during the recent past also was undertaken.

The agency has a large collection of buildings constructed during the postwar years in its real property inventory. To assist in the evaluation of those resources, the agency has developed an historic context for Federal buildings designed during the Modern period. *Growth, Efficiency, and Modernism. GSA Buildings of the 1950s, 60s, and 70s* identifies the key design philosophies of Modern architecture, provides a summary history of the GSA, and presents policies and guidelines that governed Federal construction under GSA during the 1950s through the 1960s (GSA 2005). The study includes a methodology for the evaluation of GSA buildings constructed during the Modern era. Thirteen qualities for consideration in the evaluation of the architectural importance of resources from the recent past are presented. Among these are design considerations, i.e., the resource is a design of a master or is representative of a Modern style; whether the resource is "an outstanding example of a Federal program seeking quality design;" is a representative example of combining cost efficiency and function; is the site of an exceptionally important event in history; contributes to a historic district; and exceptionally retains the qualities of significance (GSA 2005:104-105).

The area at NIST is significant as an historic district under Criterion A for its association with events that have made important contributions to the broad patterns of history under the Science and Technology and Postwar Research Campus Design themes and under Criterion C as a recognizable entity that embodies the characteristic of Postwar Research Campus design. Buildings in the historic district were designed by an architecture and engineering firm with an established national practice specializing in research campuses. HLW International was the acknowledged expert in designing research laboratories and was a design innovator in the field. The NIST campus is representative of the firm's body of work.

The AML complex comprising Buildings 215, 216, 217, 218, and 219 are excluded from the proposed historic district. The interconnected buildings, while incorporating similar building materials as the GPLs, were designed as a complex unique from the general purpose labs architecturally, structurally, and in sophistication of the environmental controls systems. Two of the five buildings are completely underground. Additionally, the buildings were constructed within the past thirteen years. Insufficient time has elapsed to enable evaluation of the complex under National Register Criteria A and C. The complex does not appear to rise to the level of exceptional significance as defined under Criteria Consideration G.

Ten buildings are included in the NRHP-eligible historic district; one of them (Building

227), is non-contributing. The campus landscape plan, including the Newton Apple Tree, also is a contributing resource to the district. Contributing objects include the flag pole. In addition to contributing to the NRHP, Building 101 individually is eligible for listing in NRHP for the quality of its architectural design as campus administrative headquarters (Criterion C). All contributing built-resources in the proposed NIST historic district were completed between 1965 and 1966.

Resources excluded from the historic district generally comprise support and utility buildings, such as Buildings 301 and 302, which did not directly support the agency's scientific mission, recently constructed buildings, or buildings with major recent additions. The NRHP-eligible historic district is depicted in Figure 8.1. Campus-wide resource evaluations are presented in Table 8.1.

8.3 Summary and Conclusion

The resources contained with the NIST Gaithersburg campus were analyzed applying the NRHP Criteria for Evaluation (36 CFR 60.4[a-d]). Site investigation and resource evaluation indicated that resources at the Gaithersburg campus are significant within the themes of Science and Technology and Postwar Research Campus Design (Criterion A). The facility also represents a significant and distinguishable entity whose components may lack individual distinction (Criterion C). Additionally, Building 101 individually possesses the significance and integrity for NRHP consideration under Criterion C as a representative example of the International Style.

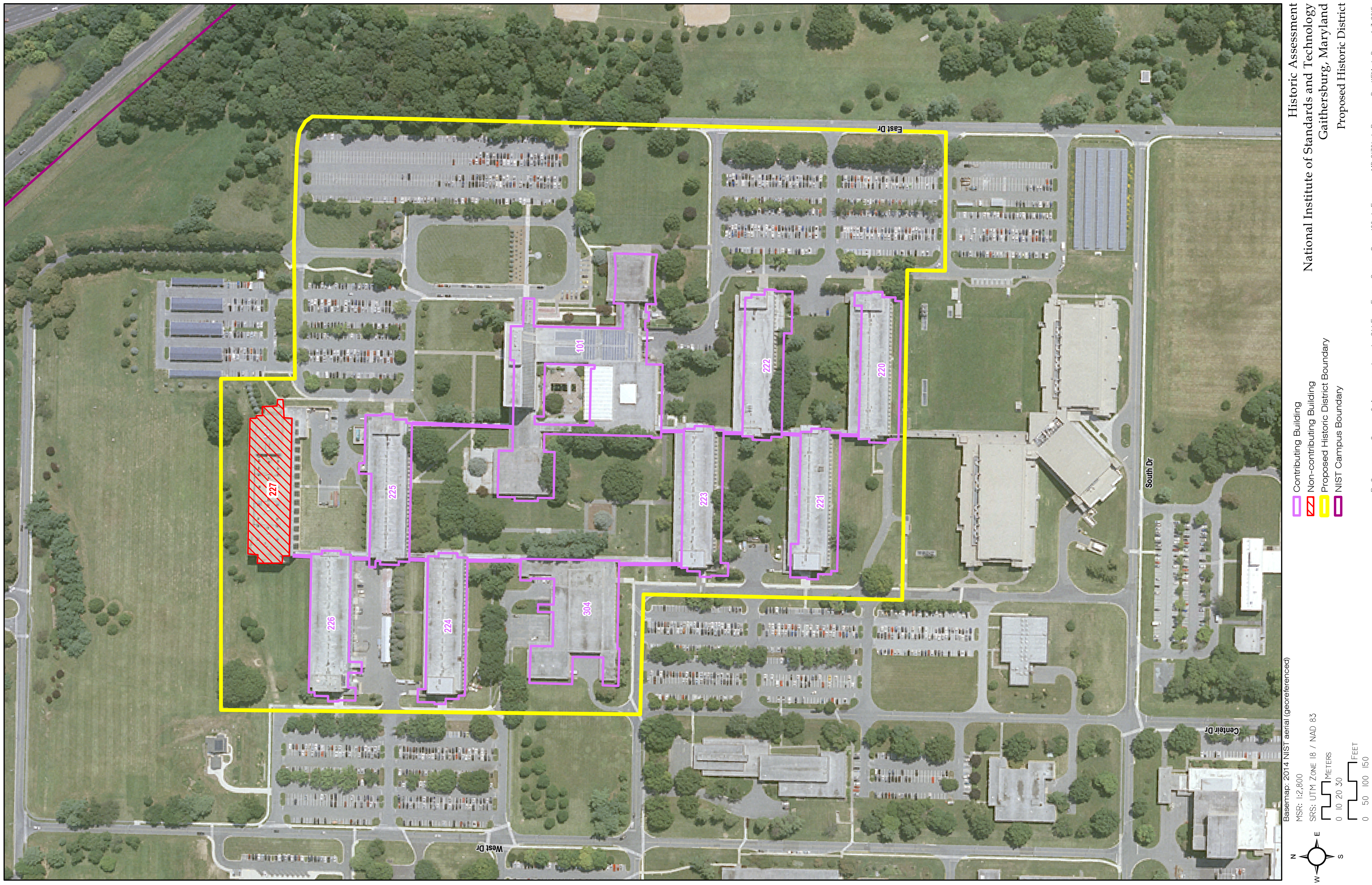

Figure 8.1 NIST Historic District Boundaries

Table 8.1 Resource Evaluations

Building Number	Building Name	Construction Date	Resource Evaluation
101	Administration Building	1962-1965	Contributing and individually eligible under A and C
103	Visitor's Center and Gate House	2009	Not eligible
B	Gate House	ca. 2009	Not eligible
C	Gate House	ca. 2009	Not eligible
F	Gate House	ca. 2009	Not eligible
202	Engineering Mechanics	1961-1963	Not eligible
203	Standard Reference Materials Facility	2012	Not eligible
205	Large Fire Facility	1973-1975; 2014	Not eligible
205E	Emissions Control Electrical	ca. 2000	Not eligible
205M	Emissions Control Mechanical	ca. 2000	Not eligible
205E#2	Emissions Control Electrical	ca. 2014	Not eligible
205M2	Emissions Control Mechanical	ca. 2014	Not eligible
2	Hopper	ca. 2014	Not eligible
3	Hopper	ca. 2000	Not eligible
206	Concrete Materials	1966-1968	Not eligible
207	Robot Test Facility	2012	Not eligible
208	Net-Zero Energy Residental Test Facility	2012	Non-contributing
215	Nanofabrication Facility	2002-2004	Not eligibe under Criteria or Criteria Consideration G
216	Center for Nanoscience and Technology (Instrument East)	2001-2002	Not eligible under Criteria or Criteria Consdieration G
217	AML Instrument West	2002-2004	Not eligible under Criteria or Criteria Consdieration G
218	AML Metrology East	2000-2004	Not eligible under Criteria or Criteria Consdieration G
219	AML Metrology West	2000-2004	Not eligible under Criteria or Criteria Consdieration G
220	Metrology	1963-1966	Contributing
221	Physics	1963-1966	Contributing
222	Chemistry	1963-1966	Contributing
223	Materials	1963-1966	Contributing
224	Polymer	1963-1966	Contributing
225	Technology	1963-1966	Contributing
226	Building Research	1963-1966	Contributing
227	Advanced Chemical Sciences Laboratory	1999	Non-contributing
230	Fluid Mechanics	1967-1969	Not eligible
231	Industrial	1966-1968	Not eligible
233	Sound	1965-1968	Not eligible
235	NCNR	1963-1967	Not eligible
236	Hazards	1966-1968	Not eligible
237	Non-magnetic Laboratory	1964-1968	Not eligible
238	Non-magnetic Laboratory	1964-1968	Not eligible
245	Radiation Physics	1962-1964	Not eligible
301	Supply and Plant	1962-1964; 2013	Not eligible
302	Steam and Chilled Water Generation Plant	1961-1964; ca. 1990s; ca. 2010	Not eligible

Building Number	Building Name	Construction Date	Resource Evaluation
303	Service	1962-1964	Not eligible
304	Shops	1962-1964	Contributing
305	Cooling Tower	1961-1964; 2011	Not eligible
306	Potomac Electric Power Company (PEPCO) Electrical Substation	ca. 1970	Not eligible
306A	PEPCO	1961-1964	Not eligible
306B	PEPCO	1961-1964	Not eligible
307	Hazardous Chemical Waste Storage	1970-1971	Not eligible
308	Bowman House	1952-1953	Not eligible
309	Grounds Maintenance	1974-1978	Not eligible
310	Hazardous Materials Storage	1986-1987	Not eligible
311	Grounds Storage Shed	1990	Not eligible
312	Materials Processing Facililty	1996	Not eligible
313	Site Effluent Neutralization	1996	Not eligible
314	Backflow Preventer Building	1998	Not eligible
315	Backflow Preventer Building	1998	Not eligible
316	Electrical Service Building	1998	Not eligible
317	Cooling Tower	2010	Not eligible
1	Building associated with 317	2010	Not eligible
318	ES Consolidated Facility	2014	Not eligible
319	ES Storage Building	2014	Not eligible
320	CCC	2013	Not eligible
321	Liquid Helium Recovery Facililty	Under construction	Not eligible
Baseball Field 1		Late 1990s	Not eligible
Baseball Field 2		Late 1990s	Not eligible
Volley Ball Court		ca. 2009	Not eligible
Picnic Area		Late 20th century	Not eligible
Campus Landscape Plan Including Newton Apple Tree)		1961-1969; 1966	Contributing
Stormwater Mangement Pond 1		ca. 1965	Not eligible
Stormwater Mangement Pond 2		ca. 1965	Not eligible
Stormwater Mangement Pond 3		ca. 2006	Not eligible
Flag pole		1965	Contributing
Entrance Gates		1976	Non-contributing
Masonry Test Wall		1977	Non-contributing

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APPENDIX I

MIHP AND DOE FORMS

M:20-47
National Institute of Standards and Technology (NIST)
Montgomery County, Maryland
Gaithersburg
1961-2015
Public (Restricted Access)

Capsule Summary

Since its creation in 1901 as the National Bureau of Standards (NBS), the National Institute of Standards and Technology (NIST) has been at the cutting edge of scientific standardization and measurement. Work by NIST scientists has resulted in the standardization and measurement of nearly every facet of scientific inquiry. NIST scientists continuously have made important contributions advancing scientific inquiry. Agency scientists have been recognized through numerous awards, including a number of Department of Commerce Gold Medals, an Emmy, and four Nobel Prizes.

NIST comprises multiple buildings located on a formally landscaped campus organized by a grid network of internal roads. Large-scale, multi-story, monumental buildings separated by parking areas and mowed lawn define the campus. The internal road network consists of roads running in north/south and east/west directions. The primary research areas are clustered around the Administrative Building (Building 101) and the General Purpose Laboratories (GPLs).

Building hierarchy is denoted through building materials. The Administration Building, GPLs, and Special Purpose Laboratories are executed in beige brick; support buildings are completed in red brick. The buildings are monumental in scale; occupy irregular, often complex footprints; and, terminate in flat roofs. Fixed-sash, single-light metal windows are common. With the exception of the Administration Building, public spaces and ornamentation, both interior and exterior, are absent.

Maryland Historical Trust
Maryland Inventory of Historic Properties Form

Inventory No. M:20-47

1. Name of Property (indicate preferred name)

historic	National Institute of Standards and Technology (NIST)
other	N/A

2. Location

street and number	100 Bureau Drive	__ not for publication
city, town	Gaithersburg	__ vicinity
county	Montgomery	

3. Owner of Property (give names and mailing addresses of all owners)

name	United States of America (Department of Commerce)				
street and number	100 Bureau Drive			telephone	
city, town	Gaithersburg	state	MD	zip code	20899

4. Location of Legal Description

courthouse, registry of deeds, etc. Montgomery County Courthouse liber 03859 folio 00765

city, town tax map FT31 tax parcel P440 tax ID number 00777838

5. Primary Location of Additional Data

- ____ Contributing Resource in National Register District
- ____ Contributing Resource in Local Historic District
- X Determined Eligible for the National Register/Maryland Register
- ____ Determined Ineligible for the National Register/Maryland Register
- ____ Recorded by HABS/HAER
- ____ Historic Structure Report or Research Report at MHT
- ____ Other: Corridor Cities Transitway, Identification & Evaluation of Historic Architectural Properties Technical Report

6. Classification

Category	Ownership	Current Function		Resource Count		
				Contributing	Noncontributing	
X district	___ public	___ agriculture	___ landscape	9	50	buildings
___ building(s)	___ private	___ commerce/trade	___ recreation/culture	1	7	sites
___ structure	___ both	___ defense	___ religion	0	4	structures
___ site		___ domestic	___ social	1	2	objects
___ object		___ education	___ transportation	11	63	Total
		___ funerary	___ work in progress			
		X government	___ unknown			
		___ health care	___ vacant/not in use			
		___ industry	___ other:			

Number of Contributing Resources previously listed in the Inventory

0

7. Description

Inventory No. M:20-47

Condition

X excellent ___ deteriorated
___ good ___ ruins
___ fair ___ altered

Prepare both a one paragraph summary and a comprehensive description of the resource and its various elements as it exists today.

Summary Description

The National Institute of Standards and Technology (NIST) is a Federal research campus located in Montgomery County, Maryland. The facility comprises 74 buildings, structures, objects, and sites on a landscaped campus. Resources include monumental, multi-story buildings housing laboratory and administrative spaces. Brick is the predominant construction material. Most laboratory buildings occupy complex footprints; however, rectangular footprints are not uncommon. Landscaping consists of mature coniferous and specimen trees. Large expanses of mowed lawn define the campus. Circulation networks consist of a grid-like street network and sidewalks.

Detailed Description

NIST is located in Gaithersburg, Maryland, a suburb of Washington, D.C. Major roads, consisting of I-270 to the east, Muddy Branch Road to the southeast, and Quince Orchard Road to the west, separate the campus from the surrounding commercial and residential development constructed during the late twentieth century. A single-family and townhouse neighborhood abuts the campus to the southwest. Commercial development consists of strip malls, big-box retailers, and office buildings. Residential neighborhoods are located adjacent to the campus.

NIST comprises multiple buildings located on a formally landscaped campus organized by a grid network of internal roads. Large-scale, multi-story, monumental buildings separated by parking and mowed lawn define the campus. The internal road network consists of roads running in north/south and east/west directions. The publically-restricted road network creates large superblocks occupied by research buildings. Parking is expansive. The primary research areas are clustered around the Administrative Building (Building 101) and the general purpose laboratories (GPL)s. Two smaller research areas south of the campus center are accessible from Center Drive.

Principal north/south roads include East, West, and Center drives. Center Drive provides access to the southern portion of the campus. North and South drives provide east/west access. Access to the support buildings is via Sound, Research, and Steam drives, and Service Drive, which runs in a north/south direction. No distinction in terms of design, landscaping, or road width is made between the service roads and the principal roads.

The main laboratory complex falls between North and South drives and East and West drives. Isolated laboratory complexes are located south of South Drive and are accessible from Center Drive. Service and support buildings generally are located along the west side of West Drive. The topography is relatively flat. Formal landscaping includes specimen trees and mature coniferous trees.

Building hierarchy is denoted through building materials. The Administration Building, GPLs, and Special Purpose Laboratories are executed in beige brick; support buildings are completed in red brick. The buildings are monumental in scale; occupy irregular, sometimes complex footprints; and terminate in flat roofs. Fixed-sash, single-light metal window are common. With the exception of the Administration Building, public space and ornamentation, both interior and exterior, are absent.

An extensive landscape plan prepared by HLW International was implemented for the NIST campus.[1] Large expanses of lawn buffer the campus from the main thoroughfares. A large wood preserve is located between Quince Orchard Road and Buildings 202 and 235. Three stormwater management ponds of various sizes are located along the eastern and southwestern edges of the campus. Specimen and ornamental trees are planted throughout the campus. The Newton apple

[1] The architectural firm that designed the Gaithersburg campus, Voohees Walker Smith Smith & Haines, underwent a number of name changes since it was established. A change in name also occurred during the design and construction of the NIST campus. For simplification and to avoid confusion, HLW International (the firm's current name) will be used.

tree, which is derived from cuttings of the Newton apple tree in England, is planted in the courtyard between Building 101 and Building 225. Building 101 features an inner courtyard with flowering shrubs and trees. A water feature, benches, and a sun dial also are located in the courtyard.

A review of architectural drawings and conversations with NIST staff suggest that the resources located at NIST have undergone a continuous program of modification and alteration. Changes to building interiors are particularly common as laboratory and testing spaces have been altered to make the spaces relevant in the face of ever-changing research needs. Other building modifications include the construction of additions. Again, such modifications are necessary in order for the buildings to meet contemporary research requirements. In some cases, the additions are larger than the original building.

The core campus reflects the unified campus design developed by HLW International. The firm designed many of the buildings and prepared the campus landscape plan. Other architectural and engineering firms with expertise in the design of specialized, scientific buildings also have contributed to the evolution of the campus.

A total of 74 buildings, structures, objects, sites, and landscapes were systematically surveyed in December 2014 and January and March 2015. The attached table identifies resources surveyed during this current investigation. The NIST campus is depicted on the accompanying maps.

Security protocols prohibited discussion and photography of certain buildings and building features. The following data were collected: building type, style, location, number of stories, plan shape and type, exterior wall materials, roof shape and materials, placement of building openings, and modifications over time. Summary resource descriptions, arranged by building type, are provided below. Summary resource descriptions, arranged by property type, are presented below. Property types are based on function at the time of building construction and not on current building use.

Administration/Laboratories

Building 101

The Administration Building, constructed to house the agency's executive offices, also contained computer, applied mathematics, and statistical engineering laboratories. The building occupies a complex footprint comprised of connecting masses (office tower, library, auditorium, and lobbies) of differing sizes and heights. The building was completed in 1965. A landscaped inner courtyard is a character-defining feature of the building.

The eleven-story administrative block occupies a rectangular footprint in the northeast portion of the complex. The metal-frame building is clad in beige-brick executed in stretcher bond. The mass terminates in a flat roof that features a penthouse. The roof over the cafeteria is scalloped. Fixed, single-light, metal-sash windows with metal spandrels above and below the window openings define the north and south elevations. The east and west elevations are blind. The primary entrance is found on the east elevation. A flat-roof canopy supported by stone posts projects into a driveway that leads to the building. A slightly projecting vestibule with double-leaf metal and glass doors provides access to the building's interior. A single-story, glass-enclosed corridor extends from the north elevation and leads to the library.

The three-story library occupies a square footprint, rests on a poured-concrete foundation, and terminates in a flat roof. Cladding materials are stone laid in a decorative pattern. The primary elevation faces north. A multi-bay integral porch runs the length of the north elevation. Large plate-glass windows with metal mullions characterize the elevation. The east elevation is blind; a multi-bay glass and stone projection is found on the west elevation. Single-light, fixed-sash ribbon windows are located at the basement level. The upper floors employ single-light, fixed-sash windows. The bays are divided horizontally by metal spandrels and vertically by metal mullions. A patio with stone pavers is found on the north elevation. The minimally landscaped patio features the Newton apple tree and benches. A single-story brick and glass passage extends from the southeast corner of the library to connect Building 101 to Building 223.

A two-story, brick mass is located south of the library. Fixed, single-light windows define the west end of the south elevation. A loading dock is present on the elevation's east end.

A glass-enclosed passage, extending from the southeast corner of the tower block, leads to another glass enclosed-passage that connects to the auditorium, which consists of a single-story, limestone and marble mass resting on a poured-concrete foundation. The auditorium wing terminates in a flat roof.

The inner courtyard features stone pavers, flowering shrubs and trees, benches, a water feature, and a sundial. Large, plate-glass windows enclose the courtyard. A covered walkway extending from the southeast elevation of Building 225 connects to the north elevation of Building 101. The walkway has a poured-concrete foundation and a geometric roof supported by rectangular posts.

Interior public spaces are monumental in scale. The principal lobby is executed in marble. Ample seating is afforded in the main lobby and the adjacent smaller lobby. Both lobbies feature display and exhibit booths. The cafeteria, which looks out onto the inner courtyard, also is monumental in scale.

General Purpose Laboratories

Buildings 220, 221, 222, 223, 224, 225, 226, and 227 were constructed as GPLs. With the exception of Building 227, which was constructed in 1999, all the GPLs were completed in 1966. They are nearly identical in design, exhibiting a great degree of uniformity in materials and execution. Original drawings reference grey face brick suggesting building color might have changed between the time the drawings were prepared and the time the buildings were constructed. Buildings 220, 221, and 225 were constructed with basements to house specialized research spaces. Because of their similarity, a general description of the buildings is provided below. Descriptions of individual GPLs summarize key differences.

The GPL is a three-story building that occupies a rectangular footprint and terminates in a flat roof. The building rests on a poured-concrete foundation. Exterior cladding is beige brick executed in stretcher bond. The building is comprised of three masses: an office/laboratory block, a stairwell block, and a covered concourse connection to the adjacent building. The multi-bay office/laboratory block rises three stories with attic. The attic level is clad in metal panels. Windows are single-light, fixed-sash, metal units. Metal spandrels are located above the window openings. The stairwell intersects the office/laboratory block and projects above the roof of the office/laboratory block. The primary entrance, which is located within a projecting vestibule, is housed in the stairwell block. The entrance features double-leaf metal and glass doors. The doors are framed by paired, single-light, fixed-sash windows in metal frames. One single-light transom is found above each window bay and the doors. A projecting bay for facilitating the movement of large objects is located in the stair tower and is accessed from the secondary elevation. Each laboratory building has a covered concourse that connects to an adjacent building. The concourse terminates in a flat roof. Cladding materials are red brick completed in 5:1 common bond. Large, fixed-sash, single-light windows with metal sash divide the concourse into multiple bays. Metal spandrels are located below each window unit. Double-leaf metal and glass doors generally are centered in the elevation. Landscaping around the buildings is sparse. Mature coniferous trees and deciduous saplings are present.

Building 220 (Metrology Building)

Building 220 faces east. It is similar in design as described above in the general description.

Building 221

Building 221 faces west. It is similar in design as described above in the general description. The east elevation is blind. One covered concourse is found at the east end of each of the south and north elevations of the building. The concourse is comprised of fixed, single-light, metal-sash windows. The concourse connects Building 221 to Building 220 to the south and Building 222 to the north.

Building 222 (Chemistry Building)

Building 222 faces east. It is similar in design as described above in the general description; however, in 2008, the building was modified when the majority of lab spaces were converted to offices. The windows were replaced and the exterior walls were insulated at that time (Susan Cantilli personal communication 5/6/2015).

Building 223 (Materials Building)

Building 223 faces west. It is similar in design as described above in the general description. The east elevation is blind. A covered concourse is located at the east end of both the north and the south elevations. The concourse on the south elevation is comprised one three-story concourse featuring fixed, single-light, metal-sash windows. This concourse connects Building 223 to Building 222. The concourse on the north elevation is elevated and rises one story in height. The windows are similar to those found on the south concourse. A single-story covered concourse also is located at the west end of the north elevation. The concourse features fixed, single-light, metal sash windows above metal spandrels.

Building 224 (Polymer Building)

Building 224 faces west. It is similar in design as described above in the general description.

Building 225 (Technology Building)

Building 225 faces east. A covered walkway extends from the southeast corner of the building and connects to the north elevation of Building 101. Two projections are present on the north elevation. A single-story metal addition terminating in a flat roof and resting on a poured concrete foundation is located adjacent to the loading dock. An opening is present on the east elevation of the addition. A smaller, single-story brick addition terminating in a flat roof is located adjacent to the metal addition. The projection also rests on a poured-concrete foundation.

Building 226 (Building Research)

Generally, Building 226 retains the same materials and design as the other laboratory buildings; however, the south elevation is different than those of the other GPLs. According to original drawing, porcelain steel panels were installed at the second floor. A series of loading docks is present at the first floor of the south elevation. A one-story brick projection terminating in a flat roof extends from the elevation. Two metal doors are present on the projection's south elevation. The projection is original to the building and was constructed as a high bay. A covered concourse extends from the east end of the south elevation and connects to Building 225. This three-story concourse features fixed, single-light, metal-sash units similar to the windows found on Building 227. A brick-clad stairwell also is located on the building's east elevation (National Institute of Standards and Technology [NIST] Var.).

Building 227 (Advanced Chemical Sciences Laboratory)

Building 227 maintains the general massing and proportions as the GPLs constructed during the initial construction period at the Gaithersburg campus. Materials are similar to those used on the original GPLs. The building, which faces east, occupies a rectangular footprint and terminates in a flat roof. Metal paneling conceals equipment. Projecting stairwells are located at the east and west elevations. The primary entrance is located on the east elevation in a projecting stair tower. The three-bay east elevation of the stair tower is defined by fixed-sash, single-light, metal-frame windows flanking a brick mass. The entrance is centered on the elevation and consists of double-leaf metal and glass doors. A single-story brick wall extends in a southerly direction from the entrance block. Large single-light, fixed-sash-metal windows with transoms are present on the first floor. The multi-bay north and south elevations also feature single-light, fixed-sash metal windows. A single-story brick projection on the south elevation houses a recessed loading dock. The brick mass on the west elevation houses the stairwell and projects from the plane of the principal block.

Special Projects Laboratories

Building 202 Engineering Mechanics

Building 202 is the Engineering Mechanics Laboratory designed by Voorhees Walker Smith Smith & Haines, the predecessor firm to HLW International and completed in 1963. The building is executed in two primary masses, a 5:1 common-bond, red-brick, two-story mass and a larger multi-story mass housing a high bay completed in beige brick. The building occupies a complex footprint and terminates in a flat roof. Roofing materials are not visible. The two-story portion of the building represents the building's administrative functions. The multi-bay, two-story mass includes the building's primary entrance, which is located on the east elevation. Fixed-single-light, metal-sash windows with spandrels below the second floor windows define the elevation. A flat roof-canopy supported by stone piers shelters the main entrance, which contains double-leaf glass doors in metal frames. Transoms and sidelights define the doors. A single-story ell extends from the north elevation. The east elevation of the ell contains four bays and an overhead garage door. The west elevation features a covered loading dock and openings. The multi-bay south elevation also features single-light, fixed-sash, metal windows as well as a single-story brick projection. Openings are found on the east and north elevations of the high bay.

Building 203 (Standard Reference Materials Facility)

Building 203 was completed in 2012. The single-story building abuts Building 202 to the north. The building occupies a rectangular footprint, rests on a poured-concrete foundation, and terminates in a flat roof. The building is clad in beige brick. A multi-bay covered loading dock defines the north elevation. Single-light, fixed-sash windows are found in the east and south elevations.

Building 205 (Fire Research Laboratory) and Support Facilities

Building 205, completed in 1975, was constructed as the Fire Research Laboratory designed by Gipe, Fry and Welch Associated Engineers and Architects. The south half of the current building is the original section. The original one-story building is constructed of poured concrete and faced with stretcher bond, beige brick. The multi-level building terminates in a flat roof with metal coping; roofing materials are not visible. Openings include double-leaf glass and metal doors, metal doors, and loading dock doors. The south elevation contains the main entry comprising double-leaf glass and metal doors with transom and sidelights in the southeast corner of the building. The doorway is sheltered by a projecting canopy. Three bays of narrow vertical windows separated by spandrels occupy the east elevation. The south elevation wall currently is blind; the opening that originally contained fixed windows has been infilled. In 2014, a major, two-story addition doubling the original building was completed along the north elevation. This new addition is faced in concrete and metal panels. A band of fixed windows is located along the southeast corner of the addition.

The fire research building is supported by two, two-story metal exhaust systems. The exhaust system located northwest of Building 205 was constructed by 2002. The metal structure rests on a concrete slab and has two circular metal air filters, a large rectangular metal hopper, and a stack. Two, one-story support buildings (Buildings 205E and 205M) are located near the base of the metal structure. Each building occupies a concrete slab and has a flat roof with concrete coping. The exterior walls are faced with stretcher bond, beige brick. Each building has one set of double-leaf metal doors. The other elevations are blind.

A second exhaust system, constructed as part of the 2014 addition, is located north of the addition. The metal structure rests on a concrete slab and has two circular metal air filters, a rectangular metal structure, and a stack. Two, one-story support buildings (Buildings 205E2 and 205M2) are located near the base of the metal structure. Each building occupies a concrete slab and has a flat roof with concrete coping. The buildings are constructed of concrete block. Each building contains single-leaf or double-leaf metal doors. The other elevations are blind.

Building 206 (Concrete Materials)

Building 206 was built as the Concrete Materials Building to house the equipment for batching, blending, and storing of aggregates used in the structural concrete programs, to produce standard samples of aggregates and sands, and in standard soil samples for the interstate highway program (NBS 1966a:22). The building was completed in 1968. Generally, the single-story building occupies an L-shaped footprint and rests on a poured-concrete foundation. Cladding materials consist of stretcher bond, beige brick on the south, east, and west elevations. The north elevation abuts a hill and is not visible. The multi-level building terminates in a flat roof with metal coping; roofing materials are not visible. No main entry is visible. Other openings comprise single-leaf and double-leaf metal doors and overhead garage doors. The southwest corner contains one pair of metal doors and three overhead metal garage doors. Four openings are located in the east elevation.

Building 207 (Robot Test Facility)

Building 207 was constructed in 2012. The building occupies a rectangular footprint with a one-and-half-story central high bay flanked by one-story bays on the east and west elevations. The building rests on a concrete-slab foundation. The exterior walls are constructed of metal panels. The lower walls are clad in red, horizontal ribbed paneling. The upper walls of the central bay are dark gray, vertical panels. The side bay walls are clad in light gray, vertical metal panels. The flat roof has metal coping. The main entry in the north elevation contains a single glass door off-set in a large fixed window with a transom. Large fixed-light glass walls are located in the bays on the south elevation. Glass openings set in light-colored square metal panel surrounds occupy the north and south elevations of the center bay. Bands of fixed-glass windows are located in the east and west elevations.

Building 208 Net-Zero Energy Residential Test Facility

Building 208 is the Net-Zero Energy Residential Test Facility constructed in 2012. The building is a five-bay, two-story house linked by a breezeway to a one-story garage. The house rests on a concrete slab. The exterior walls are clad in vinyl siding. The house has a side gable roof clad with composition shingles with three-bay shed dormers on the north and south elevations. The main entry is centered in the south elevation. The door has glass sidelights. The windows are six-over-six-light units set in metal frames. An integral porch supported by columns spans the south elevation.

Buildings 215, 216, 217, 218, and 219 were competed between 2002 and 2004 to support measurement research in a variety of different fields. Two of the buildings (Buildings 218 and 219) are below grade; above-grade entrance blocks provide exterior access to the below-grade buildings. The buildings in the complex employ similar materials and have a common design vocabulary. HDR Architecture, Inc. designed the buildings.

Building 215 (Nanofabrication Facility)

Building 215 was completed in 2004. Generally, the building occupies a rectangular footprint. The building plane is complex, with a variety of projecting and recessed masses. The building terminates in a flat roof; roofing materials are not visible. Primary access to the building is from the southeast elevation and is recessed from the principal mass. Double-leaf glass doors provide access to the building’s interior. Cladding materials are beige brick completed in stretcher bond and preformed metal panels. Projecting bays of various sizes are a character-defining feature of the building. Fixed, single-light metal windows are common. A wall of windows at the floor defines the southeast elevation and the second floor of the northeast elevation. A loading dock with flat roof is present on the northwest elevation.

Building 216 (Center for Nanoscale Science and Technology (Instrument East))
Completed in 2002, Building 216 was the first building in the AML complex to be constructed. The two-story building is executed in beige brick completed in stretcher bond and preformed metal panels. Metal coping defines the roof; roofing materials on the flat roof are not visible. Windows are single-light, fixed-sash, metal units. A double-leaf metal and glass door provides access to the building from the west elevation. Recessed and projecting bays divide the south and north elevations. Metal panels characterize the east and west elevations.

Building 217 (AML Instrument)
Completed in 2004, Building 217 occupies a generally rectangular footprint and terminates in flat roof. The multi-story building features a number of projecting and recessed bays. Cladding materials are stretcher bond beige brick and preformed metal panels. Fixed-light, metal-sash windows are employed throughout. The primary entrance is on the west elevation. Entrances are double-leaf metal and glass doors and single-leaf metal doors. The north and south elevations are divided into three projecting bays which are in turn are divided into eight bays featuring single-light, fixed sash windows. Each projecting bay also contains a projecting wall of fixed-sash windows. The building attaches to Building 215 at its southeast corner.

A single-story brick and glass corridor extends from the east end of the north elevation and connects to the south elevation of Building 220.

Building 218 (AML Metrology)
Completed in 2004, nearly all of Building 218 was constructed underground. Two above-ground projections provide access to the building's interior. The west entrance building terminates in a flat roof that slopes to the west elevation and is sheathed in metal panels. The foundation is not visible. The entrance is a metal-frame building clad in prefabricated metal panels. Access to the interior is by double-leaf metal and glass doors. A flat-roof canopy shelters the entrance. Windows are fixed, single-light, metal-sash units. The north, south, and west elevations are blind.

An east entrance also provides access to the below-ground portion of the building. This building is nearly identical to that employed for Building 219. The entry consists of a two-story building clad in brick and terminating in a flat roof. Access to the building is from the east elevation, which features double-leaf metal and glass doors and fixed, single-light windows in metal frames. The west elevation features a lower mass. Fixed, single-light ribbon windows are present on the north, south, and west elevations of the main block and the secondary mass.

Building 219 (AML Metrology)
Building 219 was completed in 2004. With the exception of the entry, the entire building is underground. The entry consists of a one and a-half-story building clad in brick and terminating in a flat roof. Access to the building is from the west elevation, which features double-leaf metal and glass doors and fixed, single-light windows in metal frames. The east elevation features a partially below-grade mass. Fixed, single-light ribbon windows are present on the north, south, and east elevations of the main block and the secondary mass. This building is very similar to the east entrance to Building 218.

Building 230 (Fluid Mechanics)

Building 230 is a two-story building clad in beige brick executed in stretcher bond. The building rests on a poured-concrete foundation and occupies a generally square footprint. The building terminates in a flat roof. Windows are fixed-single-light units with metal sash. Metal spandrels are found above and below the openings. The primary entrance is found at the north end of the east elevation and features a flat-roof metal canopy that shelters double-leaf metal and glass doors. The remainder of the elevation is blind. The north elevation is eight bays. A brick and metal mass extends from the west elevation. The projection's west elevation is clad in metal panels. The south elevation is completed in brick and metal panels; loading bays are found on the elevation. The building was constructed to calibrate large air and water meters, fluid meters, hydraulics, and aerodynamics.

Building 231 (Industrial)

Completed in 1968, Building 231 is a single-story beige brick building executed in stretcher bond. Building 231 was constructed to study papermaking and textiles. The footprint consists of two rectangular masses: one that is brick and the other that is clad in metal panels. Windows are paired single-light, fixed-sash units with metal spandrels above and below the openings. The primary elevation faces east and contains one set of recessed, double-leaf metal and glass doors with sidelights and transoms at the south end of the elevation. A two-story metal mass connects the principal block to a single-story brick projection with single-light, fixed-sash, metal ribbon windows are at the eave. Openings are found on the north elevation of the projecting mass. A single-story projection extends from the west elevation of the principal block. The north elevation of the projection is blind; the west elevation features metal ribbon windows at the eave. The west elevation connects to a metal-clad mass with a single-story brick projection. This brick projection is executed similarly to the one described above. The windows on the south elevation consist of paired units.

Building 233 (Sound)

Building 233 was completed in 1968 as the sound laboratory for acoustical research. The building was designed by Voorhees Walker Smith Smith & Haines. The building was built of heavier than normal masonry construction to reduce interference from sound and vibration from external sources. The one-story building rests on a concrete foundation and essentially has a rectangular footprint. Test chambers project from the north end and from the south end. The exterior masonry wall is faced in beige, stretcher bond brick. The roof is basically flat with a set-back monitor clad in gray insulated aluminum siding. The south elevation contains 19 bays of paired fixed-light windows. A central entry contains a pair of glass doors set in a concrete surround. The north elevation also contains multiple bays of paired fixed-light windows. The projections contain the anechoic and the reverberation chambers. These test chambers are built of concrete and faced with brick. The exterior walls of the chambers are blind. Each test chamber was built with an inner shell set on vibration isolators surrounded by a second shell of concrete (NBS 1966a:22).

Building 235 (NCNR)

Building 235, completed in 1965, was designed by Burns and Roe, Inc., Architect-Engineers from New York City. The original building occupied a T-shaped footprint. The building has a concrete frame. The east elevation has one and two-story sections that contain the offices and laboratories. The east wall has 14 bays of fixed-light windows set in metal frames separated by concrete framing. The main entry is centered in the east elevation and contains glass doors set in metal frames and surrounded by fixed lights. The doorway is sheltered by a slightly projecting concrete canopy. The upper wall of the south end of the building is faced in beige brick. The glass windows extend along a portion of the west elevation of the south end of the building. A three-story, poured-concrete wing devoid of openings projects from the west elevation.

The building has received multiple additions. In 1986, planning began for the construction of an addition to house expanded offices and laboratories. Completed in 1989-1990, construction comprised a one-story, six-bay office addition on the north end of the east elevation and a two-story addition constructed on the north wall of the rear wing. The additions were constructed of insulated vertical metal panels with a band of fixed-light windows. Glass doors were installed near the center of the addition. In 2009, the building was extended again through additions on the north and west elevations. These multi-story additions were constructed of dark metal panels with fixed-light windows (NIST drawings files, Rush and Cappalletti 2011).

Building 236 (Hazards)

Building 236 was built as the Hazards Laboratory, later known as the Special Projects Building, completed in 1968. The building was constructed to house laboratories for work with the potential for hazardous accidents (NBS 1966a:22). Generally, the single-story building occupies an L-shaped footprint and rests on a poured-concrete foundation. Cladding materials consist of beige, stretcher bond brick on the south elevation and east elevations; poured-concrete walls are evident on the west and north elevations. The building terminates in a flat roof with a metal eave along the south elevation; roofing materials are not visible. Access to the building is from the south elevation, which features a recessed double-leaf glass door with glass sidelights. The south elevation contains six bays of paired narrow, metal-frame windows set in concrete frames near the southwest corner of the building. The north elevation features a collapsible wall facing a 40-foot high earth berm (NBS 1966a:22). The wall has 11-bays of poured-concrete framing containing plastic panels set in metal frames. A poured-concrete tower is located on the west elevation. The tower is blind on the south and west elevations; it is attached to the principal block on its east elevation. The north elevation of the tower contains plastic panels set in metal frames. Two, poured-concrete sections, both partially below grade, extend from the northeast corner of the north elevation. The east elevation features two sets of double-leaf metal doors.

Buildings 237 and 238 (Non-Magnetic Laboratories)

Building 237 and 238 were completed in 1968 as non-magnetic office and laboratory facilities designed by Voorhees Walker Smith Smith & Haines. The two buildings are linked by a long covered concrete walkway.

Building 237 is a one-story, concrete-block building constructed on a concrete-slab foundation. The building adopts an L-shaped footprint. The exterior walls are clad in beige, stretcher-bond brick. The flat roof has a metal eave. A pair of glass doors set in a metal frame is located in the south elevation. The window bays contain fixed glass-lights with dark panels above and below.

Building 238 is constructed with no metal components. The three-story building is wood-frame construction set on a concrete slab. The exterior walls are clad in vinyl siding. The roof is flat with vinyl coping. The windows are paired, two-light, wood-frame units with fixed lights. Wood doors are located in the north elevation. An external wood stair provides access to the upper floors.

Building 245 (Radiation Physics)

Building 245 was completed in 1964 for radiation physics research. The building occupies a complex footprint and rests on a poured-concrete foundation. Six masses comprise the building. Exterior cladding materials consist of beige brick executed in common bond, insulated metal panels, and poured concrete. The building changes in height from three stories to one depending on location and siting. Portions of the building are below grade.

The three-story principal mass fronts South Drive. The multi-bay north elevation features fixed, single-light, metal-sash windows with metal spandrels above and below the window openings. The off-center entrance is sheltered by a flat-roof canopy supported by brick piers. Doors are double-leaf metal and glass; transoms and plate-glass windows also define the entrance. The mass terminates in a flat roof. A metal-clad penthouse sits atop the roof. The east and west elevations are blind.

A single-story, beige-brick clad ell extends from the south elevation. The ell employs windows on its east and west elevations similar to those found on the principal block. A loading dock also is present on the ell's east elevation. The ell connects to a multi-story mass off its south elevation. Openings on the north and south elevations of the single-story eastern mass feature windows similar to those on the building's principal block. The east elevation features a one story-brick projection. One opening is found on the north and south elevations of the projection. A single-story brick ell extends from the west end of the south elevation of the east mass. A multi-story concrete mass extends from the brick ell.

A flat-roofed covered concourse with decorative glass block projects from the west elevation of the principal mass and connects to a one story, brick building terminating in a flat roof.

A detached, single-story metal building terminating in a flat roof is located south of Building 245. This building connects to Building 245 below grade. A brick tower is located south of the metal building.

Support Buildings

Support buildings comprise four primary building types: Personnel Support, Campus Support (i.e., shops, grounds maintenance, plant and supply, etc.,), Utility, and Storage. The buildings generally occupy rectangular footprints and are clad in red brick, metal, or a combination of brick and metal. Windows are single-light, metal sash; overhead garage doors are common. Building descriptions are grouped based on property type.

<u>Personnel Support Buildings</u>

Four types of personnel support buildings are present on the NIST campus. These include the Visitor's Center and gate house (Building 103), Security gate houses (B, C, and, F), the ES Consolidated Facility (Building 318), and the CCC (Building 320).

Building 103 (Visitor's Center and Gate H ouse)

Building 103, constructed in 2009, is the main visitor center. The one-story building occupies an irregular footprint. The building rests on a concrete foundation. The exterior walls are faced with beige, stretcher bond brick. The flat roof is ornamented in metal. The northeast corner of the building is chamfered. The lower wall of the northeast corner is faced with stone. The main entry in the north elevation contains double-leaf glass doors under a projecting metal canopy. A bay containing fixed lights set in a metal frame is located west of the door. The northeast corner contains a band of fixed-light windows. A brick pillar extends above the roof line and displays a digital clock and the letters "NIST" in metal. The west, south, and east walls are faced in beige, stretcher bond brick.

Building 104 (Gate House)

The gate house, constructed in 2009, has a square footprint and rests on a concrete slab. The lower north wall is faced in stone, while the west, south, and east walls are faced in beige, stretcher bond brick. The upper wall of the north elevation is finished in metal. The flat roof has metal coping. Fixed-light windows are located on the east, north, and west elevations. Doors are located on the east and west elevations. A large metal canopy supported on metal columns extends over the driving lanes.

Security Gates (Gate B, C, and F)

All the security buildings are one story in height and terminate in flat roofs, with the exception of Gate B, which terminates in a pyramidal roof. The buildings rest on poured-concrete foundations. Openings are single-light, fixed-sash windows, and metal and glass doors. The gates are constructed of metal. Gate F accommodates both entry and exit. Unlike Gates B and C, Gate F contains two gatehouses rather than one and a large canopy extends over the roadway.

Building 318 (ES Consolidated Facility)

Building 318 was completed in 2014 as the ES Consolidated Facility Building. The one-story building occupies an irregular L-shaped footprint. The exterior walls are faced in red, stretcher-bond brick. The roof is flat with metal coping. The main entry is located in the center of the north elevation. This area is clad in metal panels with large fixed-glass windows and contains paired glass doors set under a cantilevered canopy. The fire station is located in the southwest corner of the building, which contains four overhead garage doors. The south elevation is clad in metal panels and contains fixed windows and openings that access an outdoor patio.

Building 320 (CCC)

Building 320 was completed as the CCC in 2013. The building was designed by the Baltimore, Maryland-based firm of Colimore Thoemke Architects. The building rests on a concrete foundation and has an L-shaped footprint. Its exterior masonry walls are faced with beige and red, stretcher-bond brick. The east and north elevations are ornamented with projecting bays faced with red brick with horizontal bands of beige bricks and capped with grey stone. The bays contain fixed-glass windows set in metal frames. The main entry located in the northeast corner of the building is clad in red brick. The entry contains double-leaf glass doors with fixed-light transom and sidelights. The entry is sheltered by a projecting canopy supported on brick piers. The west elevation contains similar windows and multiple openings that access a playground.

<u>Campus Support</u>

Building 301 (Supply and Plant)

Building 301 is a single-story building occupying a complex footprint. The principal block is rectangular; an ell connects to the principal block at its northwest corner. The building rests on a poured-concrete foundation and terminates in a flat roof. Roofing materials are not visible. Exterior materials are 5:1 common-bond red brick. The multi-bay primary elevation faces east. Windows generally consist of single-light, fixed-sash, metal units, with spandrels above and below the openings. Double-leaf metal and glass doors provide access to the building. Sidelights and transoms frame the doors. Limestone piers support the flat-roofed metal canopy at the entrance. The north elevation of the principal block is defined by a long row of windows, similar to those found on the east elevation. The west elevation is comprised of a multi-bay loading dock.

The multi-bay east elevation of the ell extends from the northwest corner of the north elevation. A row of windows similar to those found on the east elevation are present on the east end of the north elevation; a multi-bay loading dock is found at the west end. One opening is found on the west elevation.

Additions were constructed in 2013. An addition was appended to the south elevation of the principal block. Metal-panel and brick east elevation is blind. A loading dock is present on the west elevation, which is defined by metal paneling. The metal and brick south elevation is blind. A single-story meta-frame addition with a flat roof was constructed on the addition's south elevation. Openings are present on the south and east elevations. The west elevation features a two-bay open garage.

Building 303 (Service)

Building 303 is a single-story 5:1 common-bond brick and metal building that occupies a complex footprint consisting of a metal wing with flanking brick blocks. The building terminates in a flat roof; roofing materials are not visible.

The building rests on a poured-concrete foundation. Openings generally consist of single-leaf metal doors, overhead garage doors, and one-over-one-light, double-hung, metal-sash windows. A flat-roof metal canopy defines the principal (south) elevation. Openings are present on the south, east, and west elevations.

Building 304 (Shops)

Building 304 is a single-story building that terminates in a flat roof. The building, completed in 1964, occupies an irregular footprint. A second story is found at the eastern end of the building. The building is clad in red brick executed in 5:1 common bond. Windows are single-light, fixed units in metal sash. Spandrels are found above and below the openings. The primary entrance is found on the south elevation and is sheltered by a flat-roof canopy supported by limestone pillars. The double-leaf metal and glass doors are framed by sidelights and transoms. Two, single-story brick masses project from the west elevation. Generally, these masses are blind. The north elevation contains fixed, single-light windows in metal sash and a loading bay. A covered concourse at the east end of the south elevation connects Building 304 to Building 223. A similar concourse at the east end of the north elevation connects to Building 224.

Building 309 – Grounds Maintenance Building

Building 309, constructed in 1976, is a single-story, 5:1-bond, red-brick and metal building occupying a rectangular footprint executed in two masses: a brick office and a brick-and-metal garage. The building terminates in a flat roof, the materials of which are not visible. The building rests on a poured-concrete foundation. Openings consist of single-light-fixed-sash metal windows, overhead garage doors, and single-leaf metal doors. The primary entrance is located on the east elevation. The recessed opening features a single-leaf metal and glass doors with flanking sidelights.

Building 312 (Materials Processing Facility)

Building 312 was completed in 1996 as the Materials Processing Facility. The one-story building occupies a square footprint. The exterior walls are faced in stretcher-bond, beige brick. The flat roof has metal coping and metal roof projections from the western side of the roof. Openings contain single and double-leaf metal doors and overhead garage doors in the south and east elevations. Window openings are located in the northeast corner of the east elevation and the west elevations. The openings contain multiple light plastic panels in metal frames.

<u>Utility</u>

Heating and Chiller Plant

The heating and chiller plant consists of five buildings and structures constructed between 1964 and 2010. The resources range in size and materials. The major components of the complex include Building 302, the steam boiler and chilled water generating plant, and Building 305 the chiller plant cooling tower.

Building 302 (Steam and Chilled Water Generation Plant)

Building 302 was completed as the steam boiler and chilled-water generating plant in 1964. The original building was designed by Voorhees Walker Smith Smith & Haines. The plant occupies an L-shaped footprint comprised of two, two-story brick sections that are linked by a one-story section at the northeast corner of the complex. The building rests on a concrete foundation. The two-story sections of the building exhibit brick walls faced in 5:1 common bond. All sections of the building have flat roofs. The south section of the building exhibits pronounced bay delineations, louvered openings along the foundation, and horizontal bands of ornamental geometric terra cotta panels on the east and west elevations. The west section of the building has plain brick walls. The south and west ends of the building have openings. The northeast corner of the complex contains offices with fixed-sash windows set in vertical metal spandrels. The main entry consists of double-leaf glass doors set in a metal frame on the north elevation. Additions have occurred to the section of the building along Steam Drive. The east and west ends of the building were extended during the 1990s. The west end was extended again since 2010.

Building 305 (Cooling Tower)

Building 305 is the chiller plant cooling tower completed in 1964. The rectangular metal structure rests on a reinforced-concrete basement. The exterior walls are partially enclosed by metal sheathing. The roof is flat. The building was rebuilt on the existing foundations in 1993 and expanded in 1995. The building was again rebuilt and expanded to the south ca. 2011. Upgrades to the chiller plant cooling tower occurred in 2011 (Susan Cantilli personal communication 5/6/2015).

Building 316 (Electrical Service Building)

Building 316 is a one-story electrical service building located near the northeast corner of Building 305 completed in 1998. The building occupies a rectangular footprint, rests on a concrete slab, and terminates in a flat roof with a metal eave. The exterior walls are faced in red, stretcher-bond brick. The east elevation contains a large overhead garage door.

Building 317 (Cooling Tower)

Building 317 was constructed in 2010. The metal structure occupies a rectangular footprint and rests on a reinforced-concrete basement. The exterior walls are partially enclosed by metal sheathing. The roof is flat.

Building 1 (Building number assigned by RCG&A)

A one-story support building is located south of the new chiller cooling tower (Building 317). The one-story building occupies a rectangular footprint and terminates in a flat roof with metal coping. The exterior walls are faced in red, 5:1 common-bond brick. The south elevation contains a set of double-leaf metal doors. The north, east, and south elevations are blind.

Building 306 PEPCO

This complex contains three buildings constructed for Potomac Electric Power Company (PEPCO). Although three buildings are present, the complex shares one building number. The buildings sit within an enclosure with limited access. The complex features a single-story building occupying a rectangular footprint. The building terminates in a front-gable roof and faces north. The building rests on a poured-concrete foundation. Cladding and roofing materials are prefabricated metal panels. Openings consist of single-leaf and double-leaf metal doors. The east elevation is blind; no access was available to the south and west elevations.

A single-story 5:1 common-bond brick building occupying a rectangular footprint and resting on a poured-concrete foundation also is present in the complex. The building comprises two brick masses with a metal framing system connecting both masses to one another. Openings on the eastern block consist of an overhead garage door, single-leaf metal doors, and louvered openings. The two-bay building faces north. The east elevation is four bays. The south elevation is similar to the north elevation. The connecting west block also is one story in height. The multi-bay west elevation is open and houses transformer equipment. The north, east, and south elevations are blind.

Buildings 313, 314, and 315 are similar in design. The primary difference is size; Buildings 314 and 315 are larger than Building 313.

Building 313 (Site Effluent Neutralization)

Building 313, constructed in 1996 as a site effluent neutralizer building, occupies a rectangular footprint and terminates in a flat roof with a metal eave. A metal projection extends from the roof. The exterior walls are clad in red, stretcher-bond brick. The west elevation contains a set of double-leaf metal doors. The north, east, and south elevations are blind.

Buildings 314 and 315 (Backflow Preventer Building)

Completed in 1998, both buildings are executed in stretcher-bond red brick and terminate in flat roofs with metal eaves. On Building 314, double-leaf metal doors are present on the north and south elevations. East and west elevations are blind. On Building 315, the openings are present on the east and west elevations, whereas, the north and south elevations are blind.

Storage

Building 307 (Hazardous Waste Chemical Storage)

Building 307, constructed in 1970-1971, occupies a rectangular footprint and terminates in a flat roof with a metal eave. The exterior walls are clad in beige, stretcher-bond brick. The west elevation is divided into three bays featuring one single-leaf metal door in each bay. The north, east, and south elevations are blind.

Building 310 (Hazardous Waste Chemical Storage)(With 307)

Building 310 is a storage building constructed in 1986-1987 and faces south. The north elevation is constructed into a poured-concrete retaining wall. The single-story building occupies a rectangular footprint and terminates in a flat roof with metal coping. The exterior walls are faced with beige, stretcher-bond brick. The three-bay south elevation features three large openings. The center opening contains chain link doors, while the flanking openings also are enclosed with chain link. A small window opening is found near the eave on the west elevation.

Building 311 (Grounds Storage Shed)

Building 311 is single-story, metal-frame building occupying a rectangular footprint. Prefabricated metal panels are used for the cladding and roofing materials. The four-bay principal (south) elevation features three overhead garage doors and one single-leaf metal door. An opening also is present on the north elevation. The east and west elevations are blind.

Building 319 (ES Storage Building)

Building 319, constructed in 2014, occupies a rectangular footprint and terminates in a flat roof with metal coping. The exterior walls are clad in red, stretcher-bond brick. The west elevation contains a metal door and an overhead door. The north, east, and south elevations are blind.

Building 321 (Liquid Helium Recovery Facility)

Building 321 is a one-story metal-frame building clad in prefabricated metal panels. The building, which occupies a rectangular footprint, rests on a poured-concrete foundation and terminates in a side-gable roof. The roof is partially clad in metal panels. A pedestrian door opening is located at the northeast corner of the north elevation; no door is present. An opening also is located on the west elevation.

Residential Resources

Building 308, known as the Bowman House, was constructed in 1952-1953 and transferred to NIST through a land purchase in 1969. The one-story, wood-frame house is clad in vinyl siding. The side-gable roof is sheathed in composition shingles. The main entry located in the north elevation is slightly recessed and contains a plywood door. The windows are all modern replacement units comprising fixed picture windows flanked by four-over-four-light, double-hung sash units; and, six-over-six-light units. The windows have modern louvered shutters. A massive square brick chimney projects from the south side of the roof. A screen porch is located on the southwest corner of the building. A major rectangular addition was constructed along the south elevation of the house. The addition is clad in vinyl siding with a composition-shingled gable roof. All doors and windows are modern units. NIST acquired the house with the property in 1969. Between 1969 and 1983, the Building Research Division used the house to study insulation in older homes. In 1976, the house served as the human factors laboratory to "provide a realistic and comfortable setting in which to study people using ordinary consumer products in a natural way" (NBS 1976:22). In 1983, the house was adapted into a daycare center. The addition was added in 1988 (Schooley 2000:180-181, 876).

Landscape

A comprehensive landscape and site plan was prepared for the campus. Vehicular and pedestrian circulation networks, parking lots, and building setbacks were developed holistically. The natural environment, such as the existing woodlot located south of Building 202, was integrated into the design of the campus. In addition, an extensive plant schedule was prepared. The landscape also includes the Newton apple tree, which was planted in 1966. The tree is located between Building 101 and Building 225.

Flagpole

A flagpole erected in 1965 is located east of Building 101. The metal pole is set into a circular granite base incised with the following words from George Washington "Let us raise a standard to which the wise and honest can repair" (Passaglia 1999:488).

Masonry Test Wall

A masonry test wall is located northwest of Building 236. The wall originally was built in 1948 at the NBS campus in Washington, D.C., to study weathering agents on structural materials. The wall is faced in 2,059 stone samples on the front face and 293 samples of the rear and ends. Stones from 48 states number 2,032, while 320 stones are from foreign countries. The wall was moved to its current location in 1977 (Passaglia 1999:491).

Entrance Gate

Two stone entrance gate posts with gate were relocated to the Gaithersburg campus from the Washington, D.C. campus in 1976. The posts are executed in random ashlar. Visual observation suggests the posts rest on granite bases and have sandstone caps. Each post has a bronze plaque reading "National Bureau of Standards". A metal gate is attached to each post. The gate and posts are located on North Drive, north to the entrance to Building 101.

Landscape Features

Three stormwater management ponds, two east of East Drive, and one west of Buildings 237 and 238 also are present The two ponds adjacent to East Drive are large; mature coniferous trees and grasses define the edges of the ponds. Limited seating, i.e., picnic tables, are found at the northernmost pond. A small footbridge is located adjacent to the southern pond. A review of historic aerial photography suggests the ponds were installed in ca. 1965 (Historic Aerials var.). A lack of access prohibited survey of the pond located west of Building 235. The pond located near Building 235 was constructed in 1995 in preparation for the construction of the AML complex (Susan Cantilli personal communication 5/6/2015).

Recreational Facilities

Baseball Fields

The two baseball fields are located east of East Drive. Each field includes a chain link fence behind the catcher's box. Chain link fences also shield the seating for the home and visiting players. The seating consists of one plastic bench for each team. Facilities for trash, recycling, and storage also are present. The fields were constructed during the late 1990s (Susan Cantilli personal communication 5/6/2015).

Picnic Area

The picnic area is sited east of East Drive and adjacent to the baseball fields. Mature trees define the eating area. Grills, stone trashcans, and wood and plastic picnic tables are present. The picnic area also includes a playground. Visual observation suggests the playground equipment and the picnic tables were installed during the late twentieth century or early twenty-first century.

Volley Ball Court

A volley ball court is located behind Building 301, on the west side of Service Road. The court features a net and sand pit. The volley ball court was installed ca. 2009 (Susan Cantilli personal communication 5/6/2015).

8. Significance

Inventory No. M:20-47

Period	Areas of Significance	Check and justify below		
__ 1600-1699	__ agriculture	__ economics	__ health/medicine	__ performing arts
__ 1700-1799	__ archeology	__ education	__ industry	__ philosophy
__ 1800-1899	__ architecture	__ engineering	__ invention	__ politics/government
X 1900-1999	__ art	__ entertainment/ recreation	__ landscape architecture	__ religion
__ 2000-	__ commerce		__ law	X science
	__ communications	__ ethnic heritage	__ literature	__ social history
	__ community planning	__ exploration/ settlement	__ maritime history	__ transportation
	__ conservation		__ military	__ other: _____

Specific dates 1961-1969 **Architect/Builder** Voorhees Walker Smith Smith & Haines (HLW International)

Construction dates 1961-1969, 1970-1999, 2000-2015

Evaluation for:

__X____ National Register _________Maryland Register _________not evaluated

Prepare a one-paragraph summary statement of significance addressing applicable criteria, followed by a narrative discussion of the history of the resource and its context. (For compliance projects, complete evaluation on a DOE Form – see manual.)

Summary

NIST is the only Federal agency charged with establishing national measurement standards and keeping them uniform, compatible, and reliable. Basic measurements include mass, length, time, temperature, electric current, resistance, and chemical composition. The 12 bureaus, including NIST, that fall under the Department of Commerce, collectively assist that Federal department with fulfilling its mission of encouraging and prompting the economic growth of the United States. NIST's location within the Department of Commerce helps ensure that new products and services are developed and improved for use in commercial applications. Further, NIST assists the department by facilitating development of new technologies and innovations that can be adopted by the private sector (U.S. Department of Commerce 2014).

This MIHP form presents an historic context on the establishment of NIST and the agency's move from its Washington, D.C. headquarters to its current location in Gaithersburg, Maryland. The themes of science and technology and postwar research campus design also are explored. The documentation concludes with an assessment of the Gaithersburg campus as an historic property applying the National Register Criteria for Evaluation (36 CFR 60.4[a-d]).

Establishment of the National Bureau of Standards and Administrative Overview

The U.S. Congress chartered the National Bureau of Standards (NBS) in March 1901 (Public Law 177-56th Congress, 2d Session quoted in Cochrane 1966:541). The NBS took over the duties of the Office of Standard Weights and Measures founded in 1836 as part of the Coast and Geodetic Survey. The original purpose of the Office of Standard Weights and Measures was to provide the states with standardized weights and measures to support the collection of taxes by ensuring uniform shipment of goods across state lines and internationally. The work of the office was focused on the measurements of length, volume, and weight (Cochrane 1966:20-21, 29).

By the late nineteenth century, the Federal and state governments had no legislated standards for weights and measurements. Wide variations existed from state to state for the most basic of measurements. In addition, new standards were required for electrical measurements; for building materials, such as the tensile strength for concrete and the composition of steel; and, for consumer products to avoid chaos in the market place (Cochrane 1966:37, 38).

In 1900, Secretary of the Treasury Lyman J. Gage proposed the formation of a national standards laboratory in the United States. He selected Samuel W. Stratton to draft a bill establishing such an agency and to become its first director (Cochrane 1966:39-40). The NBS originally was placed in the Department of the Treasury. In 1903, the NBS was assigned to the Department of Commerce and Labor. After the two departments were split in 1913, the NBS remained in the Department of Commerce. In 1903, the NBS moved from downtown Washington to a new laboratory located on the west side of the intersection of Connecticut Avenue and Van Ness Street in northwest Washington, D.C. The NBS remained in this location until the agency moved to Gaithersburg in 1966.

Between 1920 and 1940, the NBS continued to grow and mature as an organization. Projects undertaken during this time reflected political priorities. During the 1920s, NBS staff worked more closely with projects designed to benefit industry under the leadership of Secretary of Commerce Herbert Hoover. During the 1930s, the Great Depression directly impacted the agency. The agency's basic scientific programs returned to prominence.

The beginning of World War II ushered in a period of explosive growth for NBS. From a staff numbering below 1,000 in 1939, the personnel level rose to 1,204 and was supported by a budget of $3.37 million by December 1941. By 1945, the staff had increased to 2,206 and the budget had risen to $9.7 million (Passaglia 1999:16; Cochrane 1966: 558, 563).

NBS scientists were involved in many significant projects, such as the radio proximity fuse, which contained a tiny radio that transmitted waves towards a target and controlled detonation to inflict maximum damage. This development increased the effectiveness of antiaircraft shells, rockets, and bombs (Briggs and Colton 1951:770). NBS scientists also developed a fully automated guided missile, known as the "Bat," that was used in the last months of the war against Japanese land and sea targets (Sangster 1975:D-23; National Institute of Standards and Technology [NIST] 2000:n.p.). Radio research focused on improving radio direction finders, studying radio propagation phenomena, and supporting aerial navigation, radio-telephony, radio-telegraphy, and radar. NBS investigations also were conducted to develop methods to conserve petroleum, to manufacture optical glass, and to investigate a broad range of substitute materials, such as synthetic rubber, quartz crystals, and plastics (Sangster 1975:D-23).

The experiences of World War II resulted in a dramatically changed scientific landscape. Technological advances made during the war posed the potential for immense changes in all areas of life. The development of the atomic bomb ushered in the atomic age, followed, in 1957, by the beginning of space age with the launch of Sputnik by the U.S.S.R. The role of NBS in this new world of science and technology was a topic of discussion during the late 1940s.

In 1950, the Secretary of Commerce proposed new enabling legislation to codify activities assigned to the NBS by "supplementary legislation, executive orders and customary procedure" (Passaglia 1999:149-150). During the late 1950s and throughout the 1960s, NBS administrators made concerted efforts to maintain consistent standards, while keeping the agency's scientific research programs relevant to meeting national needs. By the late 1970s and early 1980s, the NBS administrators led the agency to "undertake programs to foster the delivery of technology to the industrial, intergovernmental and international sectors" (Schooley 2000:452).

In 1988, the Omnibus Trade and Competitiveness Act (Public Law 100-418) redefined the roles and mission assigned to the NBS. The NBS was renamed the National Institute of Standards and Technology (NIST) to reflect its new responsibility: to play a major role in revitalizing U.S. trade in the face of Japanese and German technological superiority. The drafters of Public Law 100-148 both acknowledged the traditional NIST research areas and defined its important future role.

In 2010, the NIST's research programs again were realigned from a laboratory-based to a mission-based structure fostering interdisciplinary research groups collaborating on projects. The new organization replaced a single deputy director with three associate directors and reduced the number of laboratories to six. The laboratories comprised Material Measurement Laboratory, Physical Measurement Laboratory, Engineering Laboratory, Information Technology Laboratory, Center for Nanoscale Science and Technology, and NIST Center for Neutron Research (NIST 2010). By 2014, the Communications Technology Laboratory in Boulder became the seventh operating unit (NIST 2014c).

Historic Context: NIST's Move to Gaithersburg

By the 1950s, the NBS had outgrown its Washington, D.C. facilities. The D.C. campus comprised over 90 buildings on a 68-acre campus. Many of the buildings were ill suited to conducting the research needed to fulfill the agency's mission. In addition, the expanding residential areas of Washington, D.C., had encroached on the NBS campus, resulting in interference with some areas of research work. The agency was in desperate need of room and modern facilities.

A campaign to relocate the NBS began during the mid-1950s when James Worthy, Assistant Secretary of Commerce for Administration, approached NBS regarding relocation as part of an effort to disperse Federal agencies outside the District of Columbia, which, during the height of the Cold War, was considered a high potential target area. NBS director A.V. Astin accepted the offer, and thus began the multi-year NBS relocation process. Director Austin coordinated with the GSA to prepare a construction budget, which was submitted to Congress for approval, and ultimately, the appropriation of funds. While the GSA acted in a construction management capacity, the agency did not assume operational and management responsibility for the buildings once they were completed. Rather, the new campus and buildings became part of the NBS real property inventory.

Many factors were considered in site selection. Agency requirements for acreage and distance from the nation's capital established basic criteria for potential locations. The new site needed to encompass a large area, ideally 500 or more acres, and to be located approximately 15 to 20 miles outside the District of Columbia, but not in the Baltimore-Washington corridor. Future expansion also was a key consideration in site selection. The site of the new home for the NBS needed to be large enough to accommodate the construction of additional buildings.

Isolation from population centers and the associated mechanical, electrical, and atmospheric disturbances that could interfere with the agency's precise scientific measurement and research programs was paramount. In addition, the site needed to be accessible to NBS scientists; access to downtown Washington, D.C., and proximity of the site to where NBS scientists lived were imperative (Voorhees Walker Smith Smith & Haines 1961b:1). Like with other research facilities constructed during the period, project planners sought a site that was located outside the city center in a suburban location that would be convenient for NBS employees. In addition, NBS maintained strong working relationships with research institutions and other government agencies. The ability to continue those relationships from the new location was important to administrators and scientists.

In May 1956, Director Astin was shown a site that appeared to meet the agency's requirements. The Gaithersburg, Maryland, location comprised 575 acres in rural Montgomery County and was accessible by rail and road. Final site selection set in motion land acquisition and the preparation of plans and cost estimates.

In selecting a firm to design the new campus, the Federal government sought an established company experienced in the design of research facilities meeting exacting requirements. Specifically, NBS officials wanted a team with: "the experience, competence, and the size necessary to accomplish the planning for a large research facility like the National Bureau of Standards" (National Bureau of Standards [NBS] 1966a:3). The selected firm, Voorhees Walker Smith Smith & Haines, had extensive technical expertise in designing laboratory space. Indeed, the decision to select the design team was well-considered. Since World War II, the firm had designed and constructed approximately 10 million square feet of laboratory space for such clients as DuPont, Ford, General Electric, and IBM, in addition to the Bell Telephone Laboratories

(NBS 1966a:3). The firm concurrently designed research laboratories for NASA's Goddard Space Flight Center in nearby Greenbelt, Maryland.

In December 1956, GSA contracted with the New York City-based architectural firm to initiate preliminary studies for the new NBS facility. Their assignment was "to determine the number, size and type of structures required, to develop a fundamental site development plan as a basis for final designs, and to prepare cost estimates. Basic requirements for the exploratory study were to consolidate NBS' various operating divisions into the smallest practicable number of buildings; to provide mechanical and electrical facilities that would serve the laboratories…; to plan the buildings for a limited increase in the future work load and site addition of further research facilities as required" (Voorhees Walker Smith Smith & Haines 1961a:1). HLW International was awarded the architectural design contract in 1959 (U.S. Department of Commerce 1961; NBS 1966a:6).

Design of the new campus was conducted simultaneously with the land acquisition process. The first land acquisition was completed during 1958. Additional parcels were acquired between 1959 and 1962. In all, 565.3 acres were acquired from nine owners. The smallest parcel was 1.7 acres, while the largest parcel was 260.2 acres. The remaining 14.6 acres were purchased from four owners between 1967 and 1986 (NIST n.d.).

When the Gaithersburg campus was planned, three institutes were scheduled to move to the new facility: the Institute for Basic Standards, the Institute for Materials, and the Institute for Applied Technology. Public and private-sector employees participated in discussions regarding the new campus (NBS 1966a:1). The new campus would house the world's largest physical science laboratories "designed to meet the varied environmental and space requirements of many kinds of specialized equipment and delicate, highly precise measuring instruments" (NBS 1966a:3).

<u>Designing the Gaithersburg Campus</u>

Upon selection of the design team, the first major decision confronting the designers was the issue of the type of research facility envisioned: a single-structure plan versus a multiple-building campus. The GSA preferred a single building option as a measure to contain construction costs. NBS administrators and scientists preferred a campus setting with multiple buildings and landscaped grounds, reminiscent of the D.C. campus. The architects prepared a variety of options, submitting one multiple-building plan and three single building plans. Ultimately, the architects recommended the multiple-building plan because it offered maximum flexibility and minimal restriction in planning the varied research programs conducted at NBS (Voorhees Walker Smith Smith & Haines 1961b:1-2; NIST 1958:3:21-1-2). Additionally, the nature of some testing required isolation from other laboratories to eliminate environmental interference. The architects determined that the one-building scenario for accommodating all of the employees slated to move to Gaithersburg and that could also meet the necessary required vibration and noise tolerances was not practical. Two types of laboratories would be needed: one type of laboratory for general purposes and another type that would be isolated from other buildings for highly technical testing to minimize environmental interference.

Once the decision on the type of facility was resolved, design of the new facility began in earnest. An intense collaborative relationship developed between NBS scientists, administrators, and the architectural design team. As part of this collaboration, a multi-pronged approach to the design process was developed. This process included site visits to other research laboratories for comparative research into similar facilities, the creation of a planning committee, and the construction of scale models.

Part of the collaborative design philosophy included input from scientists at other research institutions. To accomplish that goal, NBS administrators and scientists and representatives from the architecture firm visited many of the nation's noted research laboratories to solicit advice and opinions from associates at similar laboratories. Facilities visited included DuPont, Bell Telephone Laboratories, Argonne National Laboratories, Midwest Research Institute, Lincoln Laboratories, Westinghouse Corporation, General Electric Research Laboratory, General Electric Measurements Lab, IBM, General Motors, National Carbon Company, and Franklin Institute (Passaglia 1999:481; Laboratory Planning Committee 1957:4). Two of the research campuses, Bell Telephone Laboratories and Argonne National Laboratories, were designed by HLW International. The purpose of these visits was to gather data on the functionality and organization of the physical plant that could be incorporated into the design of the new NBS headquarters (NIST 1958:3.21-4).

The Laboratory Planning Committee, comprising a cross-section of scientists, was created to seek input from NBS colleagues, to liaise between the administration and the architects, to identify key laboratory requirements, and to offer feedback on the design of the campus in general, and laboratories specifically.

The Committee played a key and influential role in both the design of the campus and the inclusion of select features in the research buildings. The Committee advised on building programs and office/laboratory space parameters. Through the Committee, NBS scientists identified the following minimum uses to be housed on the campus: auditorium, shops, storerooms, library, and cafeteria (Laboratory Planning Committee 1957:5). Committee members provided suggestions for the location of campus services and building program. A review of the drawings prepared by the project architects indicates that some of the Committee's recommendations were integrated into the design. For example, the Committee recommended easy access to the library; siting it on the roof of the major administrative building, as depicted in preliminary designs, was discouraged (Laboratory Planning Committee 1957:5).

NBS scientists who were not members of the planning committee also influenced laboratory design. Examples of NBS scientists expressing design preferences include discussions on the inclusion of windows in laboratory buildings and the minimum size requirements for individual laboratory spaces. The merits of natural versus artificial lighting were debated intensely between scientists and the architects. While employees expressed little disagreement on the inclusion of windows in the office spaces, they expressed strong opinions on whether windows should be included in the laboratories. Each NBS division was asked to provide an opinion on whether windows should be included in the laboratories in an attempt to develop consensus. Many sections preferred windowless labs, particularly those sections engaged in projects requiring periods of darkness (Associate Director for Administration 1956:1). In other divisions, the decision to exclude windows generated widespread displeasure, with some scientists threatening to quit if windows were excluded from work spaces (Associate Director for Administration 1956:2). Ultimately, those who advocated for the exclusion of windows prevailed. The GPLs were designed without windows in the laboratory spaces.

Prospective design flexibility, both in the future development of the campus and in the interior configuration of individual buildings, was a programming priority. Workspace flexibility was paramount, generating significant discussion among the Committee, the administration, and the architects, and intense focus and study by the design team. The Committee strongly supported the concept of the "modular" laboratory. Scientists working at the Bell and Westinghouse laboratories cautioned their NBS colleagues that while modular design offered maximum flexibility in the configuration of research spaces, such design also resulted in "rigidity because of inevitable overstandardization" (Laboratory Planning Committee 1957:11). Based on advice from Bell and Westinghouse scientists, the NBS Laboratory Planning Committee strongly recommended that the NBS avoid rules on the location of plumbing and electrical equipment to allow maximum flexibility in the reconfiguration of laboratory space (Laboratory Planning Committee 1957:11). Restrictions on the type and location of services could impact the size of laboratory modules and reduce flexibility.

The need for two types of laboratories, general laboratories and facilities for highly-technical research, was recognized early in the design process. The highly-specialized nature of some of the research programs required the construction of purpose-built buildings isolated from the general laboratories. However, the overwhelming majority of scientific investigation would occur in the GPLs, which were intended to "be suitable for most of the work performed within NBS laboratories" (NBS 1966a:5). The GPLs were easily adaptable. A chemistry lab easily could be converted for use as an electronics laboratory (NBS 1966a:7).

Buildings for highly-specialized research also were designed. Some of the work completed by the NBS required very specialized facilities that could not be accommodated in the GPLs. (Voorhees Walker Smith Smith & Haines 1961b:3). Special purpose laboratories were those that required laboratory space larger than the standard module; precise temperature control; special ventilation; or, excessive floor loading (Voorhees Walker Smith Smith & Haines 1961b:3). Due to the nature of the testing and experimentation that was to be conducted in the buildings, these laboratories could not be designed with adaptability and flexibility in mind (NBS 1966a:7).

Applying the knowledge gained through collaboration with the NBS, the architects developed a design concept. A scale model of the multi-building Gaithersburg campus was unveiled at the Project Design Review Meeting on 1 June 1960. The model was viewed by representatives of GSA, NBS, U.S. Department of Commerce, and the Bureau of the Budget. Photographs of the model appeared in local newspapers shortly thereafter (Passaglia 1999:483; *The NBS Standard*, June 1960). Once the basic design of the campus and individual buildings had been completed, the NBS issued a document akin to design guidelines, which outlined basic building provisions (NBS 1961). The document codified construction materials for the GPLs and established the dimensions of the demountable steel partitions used for the configuration of the interior modules. Flooring materials were specified and air conditioning, exhaust systems, and mechanical and electrical service were identified (NBS 1961).

<u>Construction of the Campus</u>

The final design of the Gaithersburg campus incorporated prevailing architectural design theories and tenets for successful research campuses. These tenets included: suburban siting; general research labs and highly specialized laboratories; flexibility in design to facilitate reorganization of spaces; and, adequate acreage to accommodate future expansion. Productive collaboration among colleagues was among the goals in the construction of postwar research campuses. Creating an environment conducive to collaborative interaction among scientists was also was a key consideration in the design of the NBS facilities.

The site plan for the Gaithersburg campus grouped the administrative, service, and special laboratory buildings into three general areas. The GPLs and the principal administration building were grouped together. Service and support functions generally were located west of the GPLs and the specialized, special purpose buildings generally were located south of South Drive. The architects planned to incorporate extensive landscaping (Voorhees Walker Smith Smith & Haines 1961b:6). They intended that most of the roads would be tree lined (Voorhees Walker Smith Smith & Haines 1961b:6).

The central focus and dominant building of the complex was the Administration Building (Building 101), which was linked by concourses to low scale buildings, including seven GPLs and the Instrument Shops Building (Building 304). The Administration Building housed all common facilities and public spaces, such as a variety of dining facilities; a library; and meeting rooms of various sizes, including an 800-seat auditorium, a 300-seat auditorium, three 100-seat, one 50-seat, one 25-seat, and two 12-seat lecture rooms (NBS 1966a:5). The executive offices for the agency director also were housed in the building.

The GPLs were identical in exterior design with minor differences. Three of the seven buildings were constructed with basements. All seven buildings rise three stories above the ground level. The GPLs were designed to house approximately 1,500 scientists, engineers, and support staffs. The seven GPLs represented a consolidation of research activities (NBS 1966a:7). The siting of the GPLs allowed for the construction of up to seven additional buildings, while retaining the original hierarchical plan of connected buildings.

The plant support area was located west of the Administration Building and the GPLs and contained the boiler and refrigeration plant, the Potomac Electrical Power Company substation, the supply and plant warehouse, and the motor pool. The other buildings in this area were specialized laboratories, such as the Engineering Mechanics Laboratory and the Radiation Physics Laboratory. A group of laboratories constructed for the Building Research Division were located at the south end of the property. These laboratories contained fire research and concrete material testing. These facilities were isolated from the main administration and laboratory complex due to the type of work conducted, the size of the equipment, and specialized research requirements. Exterior materials were used to delineate function in the design. Primary research buildings typically were faced in light beige brick, while support buildings were faced in red brick (Voorhees Walker Smith Smith & Haines 1961b:6; NBS 1966a:6; Susan Cantilli personal communication 12/3/2014).

New research projects assigned to NBS required adjustments to the overall campus design. For instance, the Engineering Mechanics Laboratory (Building 202) was not included in the initial plans for the research campus. The Engineering Mechanics Laboratory was designed to house several compression and tension testing machines, including a 12 million-pound universal testing machine and a 1 million-pound deadweight force-calibrating machine. The urgency for research requiring these new machines was due to the new emphasis on space sciences in response to the U.S.S.R. launch of its sputnik satellite in 1958. NASA enlisted NBS assistance to calibrate a load cell capable of measuring up to 1.5 million lbs to support the man-in-space project. NBS did not possess the machinery to accomplish the task. Buildings at the D.C. campus could not accommodate the massive testing equipment and no additional acreage was available at the facility to construct a purposely designed building. Consequently, a new building at the Gaithersburg campus was designed and constructed to house this important new program (NBS 1966a:18-22; Passaglia 1999:482).

Two additional buildings also were planned to accommodate special research requirements. These were a specialized physics building (Building 245) and the neutron studies building (Building 235). The physics building was specifically designed to house high-energy particle accelerators, specifically the linear accelerator (LINAC) (no longer extant), two Van de Graaff accelerators, and X-ray machines for use in "developing radiation standards and measurement methods and by obtaining basic data on the interaction of radiation with matter" (NBS 1966a:14). The neutron studies building was used to test the effects of neutron beams on materials of all kinds, including the structure of solids and liquids, aspects of crystal structure, and generating radioisotopes (NBS 1966a:11). Funding to construct the neutron studies building was a separate Congressional appropriation (U.S. Department of Commerce 1961).

Architectural Vocabulary Employed in the Construction of the NIST Campus

The Modern architectural style was adopted extensively by the Federal government during the mid-twentieth century for the construction of new buildings. The Modern style blurred or redefined public and private space. Public spaces, such as grand lobbies and entrances often were eliminated in favor of sweeping plazas, and functionalism became the prevailing consideration (General Services Administration [GSA] 2005:30). Extensive use of new materials and technologies was key. Steel, reinforced concrete, plastic, and glass were used in innovative ways (GSA 2005:30). Style was expressed through the use of innovative materials and the exposure of structural systems that previously were hidden beneath a decorated skin. Government agencies, with their desire to minimize taxpayer expense, readily embraced the Modern style because it was cost effective to construct (GSA 2005:31).

While Modern buildings had cheaper initial construction costs than buildings constructed in earlier styles, their expected service life was considerably shorter. Gordon Bunshaft of Skidmore, Owings & Merrill, a leading practitioner of the Modern movement, stated:

> It seems to me that the greatest change that is occurring in this country is that buildings are no longer being built to last five hundred years…. Today the economics of our civilization and the increasing requirements of comfort demanded by the people are making buildings obsolete in twenty to twenty-five years…As far as the technical aspects of development, there is no question that we must develop a method of building these buildings precisely, lightly, and quickly, and this, of course, leads to prefabrication (GSA 2005:31).

The GSA developed design standards for the construction of Federal buildings. The Public Buildings Service, charged with overseeing design and construction management activities for Federal agencies, issued guidelines in 1959. Private-sector architects and engineers could be retained to design Federal projects. However, such firms were required to complete projects within fixed government estimates. These estimated costs included site acquisition; design, construction, and interior design and furnishings for the buildings; as well as the administrative and supervisory costs incurred by the government (GSA 2005:62). A policy on material, systems, and equipment selection was developed. The GSA prescribed buildings that were "functionally efficient and economical in construction, operation, and maintenance" (GSA 2005:62).

In 1962, the GSA again issued guidelines for the construction of Federal buildings under its management. The new guidelines encouraged maximization of net useable space, flexibility in space assignment, and economy. The guidance also encouraged designs that would promote employee morale and that were conducive to the protection of life and property (GSA 2005:62). The GSA continued to modify its guidelines and issue revisions throughout the 1960s and early 1970s. The 1962 GSA guidelines were issued after the design and construction of the NBS campus was underway. In an effort to be prudent with taxpayer funds, the GSA emphasized economy and expediency in Federal construction projects. NBS management, in contrast, were concerned that too great an emphasis was placed on minimizing costs at the potential expense of long term functionality. The timing of the issuance of the first formal GSA guidelines in 1959, some of which codified requirements that NBS officials found objectionable, suggests the guidelines may have been in development during the design phase of the NBS project and did not apply to the Gaithersburg project.

When designing the NBS campus, the architects selected the International Style, a substyle of the Modern aesthetic movement and which was then-popular for the construction of commercial buildings. Coined in 1932 in *The International Style* by Henry-Russell Hitchcock and Philip Johnson, which was published in conjunction with the "Modern Architecture: International Exhibition" at the Metropolitan Museum of Art, the style did not gain in popularity in the United States until after World War II. The work of European architects, including Le Corbusier, Walter Gropius, and Mies van der Rohe introduced the style to an American audience. Hitchcock and Johnson identified three characteristics of the style: "architecture as volume, regularity, and voiding the application of ornament" (McAlester 2013:617).

A major feature of the style was the use of curtain-wall construction. The postwar increase in the availability of steel resulted in the construction of light-weight buildings that were taller than their predecessors and that could incorporate an abundance of windows. Cladding materials were smooth and unadorned. Additional character-defining features include clean geometrical forms, flat roofs, a lack of ornamentation, asymmetrical facades, and cantilevered projections (Pennsylvania Historical & Museum Commission n.d.).

While its use was not uncommon in residential applications, the style more commonly was applied to commercial office buildings. Indeed, it became popular in the design of skyscraper office towers and corporate and research campuses, as well as low-scale commercial buildings. In some cases, such as the General Motors Technical Center in Warren, Michigan, and the Seagram's Building in New York City, the style became an expression of corporate image.

Campus Landscape Design

A contemplative environment was seen to support productive scientific research and investigation. Postwar research campuses frequently were located in suburban environments and an abundance of well-designed and manicured greenspace was common. Formal landscape designs were used to enhance research "campuses" by defining vehicular and pedestrian circulation patterns, reinforcing connectivity between buildings, creating informal gathering points for professional interaction, and establishing an idyllic environment with minimal urban distractions that was conducive to focused scientific investigation.

The GPLs and the Administration Building are clustered at the eastern edge of the campus. Covered concourses connect the laboratory buildings to one another. The buildings are aligned along an east/west access with mowed lawn between the buildings. Parking lots, which are arranged along a north/south access, are relegated to the periphery of the GPL complex. In general, parking lots were sited to allow for future building expansion (Voorhees Walker Smith Smith & Haines 1961b:6).

The support buildings and some of the special purpose laboratories generally are located west of Research Drive. Buildings requiring isolation are sited south of South Drive. The buildings at the southern end of the campus are isolated from the main concentration of buildings clustered north of South Drive as well as isolated from each other. Large expanses of mowed lawn define the southern end of the campus. Roads generally are aligned along a north/south access. The road network provides efficient vehicular circulation; sidewalks accommodate pedestrian circulation.

Landscaping to support the campus site plan at Gaithersburg was extensive. By 1966, 3,000 trees and shrubs had been planted (NBS 1966a:6). Two existing wood lots were integrated into the design. One was converted into a glade with grass and light shade; the other wood lot was an "open flowering woods with winding paths and azaleas" (NBS 1966a:6). The interior courtyard of Building 101 was landscaped extensively and included benches, specimen trees, and a water feature.

A well-developed landscape plan was not a unique feature to NIST. Many Federal agencies constructing buildings during the postwar years took landscape design into consideration in comprehensive site development. Indeed, "the landscapes of Federal buildings and complexes were also prominent components of many Modern buildings. Landscaped plazas and courtyards were often executed as part of original building plans" (GSA 2005:9).

Architect and Engineering Firms Working at NIST

Architectural and engineering firms experienced in designing extremely specialized buildings generally were selected to design the research campuses. The design teams working at NIST had particular expertise in the design of laboratories, research facilities, and research campuses. For example, HLW International, the principal architects for the campus, were nationally known for their specialization in research campuses, whereas Burns and Roe Associates, the firm responsible for the initial design of Building 235, had particular experience in designing energy facilities for public and private-sector clients.

Construction at the Gaithersburg campus was initiated after Congress appropriated $23.5 million in 1961 (U.S. Department of Commerce 1961). The new NBS campus was a major undertaking and construction activities were divided among numerous builders. Funds to build the HLW International-designed campus in its entirety were not appropriated in a single funding package. Consequently, buildings included in the original campus design were completed in phases as funds were appropriated and construction contracts were awarded. Annual funding and the agency's prioritization of building need dictated construction order. HLW International designed all the buildings completed under the initial construction period (1961-1969).

Development of the campus can be divided into three broad periods: Initial Construction (1961-1969), Second Period (1970-1999), and Third Period (2000-2015). The first period of construction (Initial Construction) is further divided into five phases coinciding with Congressional funding and the awarding of construction contracts. Twenty-six buildings were constructed during this period. Twelve buildings were constructed during the Second Period of construction. Two buildings, Building 102 (the original gatehouse) and Building 310 (a townhouse), were demolished. The current gatehouse replaced the original when the existing building was constructed in 2009. The date of demolition for Building 310 is unknown. Sixteen buildings were constructed during the Third Period of construction. One building, Building 308, predates the campus. Building 308 is a dwelling constructed during the early 1950s. Select projects are discussed in additional detail below.

Initial Construction Period (1961-1969)

Phase I of the Initial Construction Period comprised initial site work and construction of the Engineering Mechanics Laboratory (Building 202) and the power plant (Buildings 302 and 305). The contractor for Phase I was Paul Tishman Co., Inc., from New York, New York (Voorhees Walker Smith Smith & Haines 1961c:2). Official groundbreaking ceremonies were held at the actual site of the engineering mechanics laboratory on June 14, 1961.

Phase II construction comprised the Radiation Physics Laboratory (Building 245), Administration Building (Building 101), Supply and Plant Building (Building 301), Automotive Service Building (Building 303), and the Instrument Building (Building 304). The contractor for Phase II was Blake Construction Company, Inc., from Washington, D.C. A neutron testing facility (Building 235) was constructed during Phase III. The construction contractor for the building was Blount Brothers Corporation (NBS 1966a:6).

Phase IV construction comprised the seven general purpose laboratories: Metrology (Building 220), Physics (Building 221), Chemistry (Building 222), Materials (Building 223), Polymers (Building 224), Technology (Building 225), and Building Research (Building 226). Phase V comprised the special purpose laboratories for Sound (Building 233), Hazards (Building 236), Industrial (Building 231), and Concrete Materials (Building 206). The contractor for both construction Phases IV and V was J.W. Bateson Co., Inc., from Dallas, Texas (NBS 1966a:6; Voorhees Walker Smith Smith & Haines Contract Kits 1961c; NIST 1997). The archival record is unclear regarding the end date of Phase V. Some sources include the construction of Buildings 230, 237, and 238 under Phase V, while others do not (Passaglia 1999:487).

HLW International was the architecture firm responsible for the overall design of the campus and the original buildings. Architects at the firm were noted specialists and national leaders in the design of postwar research campuses. The firm developed innovations in the design of research laboratories. Those innovations were applied to the NBS buildings.

In addition to HLW International, a second New York City-based firm also designed buildings constructed during the Initial Construction period. Burns and Roe Associates designed the original portion of Building 235, which was completed in 1965. Burns and Roe Associates was established in 1932 (Bloomberg Business n.d.a). As an engineering firm, Burns and Roe Group, Inc., as the company later was known, provided desalination, air quality and pollution control, and advanced nuclear technology services, among others, to private and public sector clients (Bloomberg Business n.d.a). POWER Engineers acquired Burns and Roe in 2014 (Rubin 2014).

NBS staff moved to the campus as the buildings were completed. Power plant personnel were the first staff to move to the campus in March 1962. In October 1963, the Office of Weights and Measures and the Engineering Mechanic Section staff occupied Building 202. The Administration Building was occupied in July 1965; NBS Director Astin moved into the completed headquarters building in September 1965. The GPLs were occupied during 1966. The formal dedication ceremonies were held in November of that year (Passaglia 1999:488-489).

Second Period (1970-1999)

The Second Period of development at the Gaithersburg campus was modest. Buildings constructed were associated with expanded missions or new assignments. Building 307 (completed in 1971), Building 205 (completed in 1975), Building 309 (completed in 1976), Building 311 (completed in 1990), and Building 312 (completed in 1996) were constructed during the time period. Additional chemistry facilities were added to the campus with the construction of Building 227 in 1999. However, the majority of major construction projects comprised improvements or additions to existing buildings. Buildings 205 and 235 were expanded during this period.

Building 205 was constructed to support new testing demands for the existing fire research program. The architectural form of Fry and Welch designed the building, which was completed in 1975. The firm was established in 1954 by Louis Fry, Sr. and John Welch (Tuskegee University 2010:3). Early during its history, the practice specialized in campus construction and was responsible for the design of buildings at Prairie View A & M University, Texas; Tuskegee University, Alabama; Lincoln University, Pennsylvania; Howard University, Washington, D.C., and Morgan State University, Maryland, among others (Fry and Welch Associates, P.C. n.d.). The firm also undertook government projects as well as commercial commissions (Fry and Welch Associates, P.C. n.d.). Company co-founder, John Welch, later became the Dean of the Tuskegee Architecture Program (Tuskegee University 2010:4). The firm is one of the oldest African-American architectural practices in the country. Building 205 was expanded in 2014.

Building 235 also was expanded in 1988 to accommodate the growing program in cold neutron research (Rush and Cappelletti 2011:27). The 1988 addition was designed by NUS Corporation. Originally Nuclear Utility Services, Inc. NUS Corporation was an engineering consulting firm specializing in nuclear engineering, water management, and environmental safety (Nelkin 1974:31). Today, the company, Halliburton Nus Corporation, is a subsidiary of Halliburton Company (Bloomberg Business n.d.b).

A major expansion to Building 301 was completed in 1996. The addition to the building was designed by the Cleveland, Ohio-based Austin Company. The Austin Company was an early pioneer in the design of corporate campuses. The firm, under the leadership of company founder, Samuel Austin, designed the industrial research campus for the National

Electric Lamp Association (NELA), a predecessor to General Electric in 1911 (The Austin Company n.d.:2). The company undertook the design of lamp manufacturing plants and other projects in the Midwest, as well as the east and west coasts (The Austin Company n.d.:2). During World War I, the Austin Company completed projects for the defense industry, designing the Curtiss Aeroplane and Motor Company's manufacturing facility (The Austin Company n.d.:3). The company again turned to designing airplane manufacturing facilities during World War II. Today, the firm provides design services for projects ranging from office and commercial development to health care and hospitals, to facilities for information processing and communications technology.

During the late 1980s, NIST administrators regularly requested Congressional appropriations for upgrades to the facility. To prioritize these requests, Congress directed NIST prepare a ten-year plan for anticipated capital improvement projects. This request was formalized under Public Law 102-245 enacted in 1992, which mandated that the NIST director submit a report on projected renovations and upgrades for the upcoming decade to the appropriate Congressional committees. The report was to prioritize facility needs, estimate costs, and include plans for meeting identified needs (United States Code 1992).

Third Period (2000-2015)

The agency's mission and priorities continued to evolve during the first decade of the twenty-first century. Additional buildings were constructed to meet changing needs. New additions were constructed to expand selected buildings during the time period.

A major construction program was initiated to erect a five-building complex to support the Advanced Measurements Laboratory (AML). This program included Buildings 215, 216, 217, 218. and 219, which were designed in 2000 by HDR Architecture, Inc. The firm was established in Omaha, Nebraska, in 1917 and expanded through the mid-twentieth century. HDR Architecture, Inc. originally specialized in municipal engineering services. Early commissions included designing water and sewer systems in the Midwest (HDR Inc. n.d.). By the 1960s, the firm expanded into the healthcare industry, designing serval medical facilities throughout the country. Engineering expertise was provided through HDR Engineering and HDR Architecture provided design services. The firm's range expanded during the late twentieth and early twenty-first centuries to include environmental, transportation, water, and science and technology services (HDR, Inc. n.d.). Buildings in the NIST complex designed by HDR Architecture feature state-of-the-art laboratories, NanoFab laboratory space, and a cleanroom (NIST 2013). The buildings offer rigorous air quality, temperature, vibration, and humidity control (NIST 2013). The complex was constructed to support measurement research in a variety of different areas, including measuring electrical current, "distances in increments tinier than the radius of an atom," and molecules (NIST 2013).

STV Architects, Inc. of Douglassville, Pennsylvania, designed the chiller addition to Building 302 in 2009. STV, Inc. is an engineering firm with a national practice with experience in multiple fields, including aviation, military, capital improvement programs, tunnels, and data centers, among others. The firm is a conglomeration of several engineering firms, the earliest of which, Elwyn E. Seeyle, was established in 1912. Major projects include renovations to Grand Central Terminal, design of the corporate headquarters for Shire Pharmaceuticals, rail transportation projects for municipalities across the country, the Nets Arena, the USAMRIID Containment Laboratory at Fort Detrick, Maryland, and RCA manufacturing facilities (STV, Inc. n.d.).

Smaller projects completed during the period include construction of Buildings 320 and 207. Designed by Colimore Thoemke, construction of the CCC (Building 320) was completed in 2010. Building 207 (Robot Test Facility) was designed by Colimore Architects and completed in 2012. Established in 1973 by John A. Colimore, Jr., Colimore Architects specializes in commercial, industrial, educational, and institutional projects for public and private sector clients (Colimore Architects, Inc. n.d.).

Theme: Science and Technology

The NBS underwent a series of administrative reorganizations following the move from Washington, D.C. to its new Gaithersburg, Maryland, campus. The agency's mission also changed as a result of Congressional action. New missions often required the creation of new programs and the realignment of existing research programs to meet new national priorities. Major references consulted to compile this summary include *Responding to National Needs* by James F. Schooley (2000); the publication *NIST at 100* (2000); and the NIST website. Contributions of key scientists are identified.

Standards and Measurements

Advancing the science of metrology, the study of weights and measures, is central to the NIST mission. From its founding, NIST has established national measurement standards and safeguarded uniform, compatible, and reliable measurements. Basic measurements include mass, length, time, temperature, electric current, resistance, and chemical composition. Maintaining national measurement standards is not a static mission. Over time, requirements for measurements have become exacting and far exceed the level of precision previously accepted. For example, the original platinum-iridium bar that defined the meter was replaced by a more precise measurement based on the wavelength of krypton-86 in 1960. Large force measurements are required to support rockets for the space program or to measure large beams used in skyscrapers, while measurements of atoms are required for nanotechnology. Greater precision in measurement has led to the development of a variety of new and more rigorous measuring devices. Measurements are a requisite to new technologies, and scientific research is required to advance the precision of the science of measuring.

In 1968, NIST scientists Walter Hamer, Richard Davis, and Vincent Bower examined the basic measurement for the electric charge by testing five different solutions. The results of the testing led to improved measurement of the faraday, the basic unit of electric charge (Schooley 2000:83). In 1985, Clark Hamilton, Richard Kautz, and Frances Lloyd with the Electromagnetic Technology Division at Boulder succeeded in developing the world's first practical superconducting voltage standard for 1 volt. The team connected 1500 Josephson junctions in a series array. The new array remained stable despite temperature fluctuations. This achievement led to a variety of new and more precise voltage measurements. In 1986, a 10-volt standard was released using 20,000 Josephson junctions. (Schooley 2000:669; NIST 2014b; NIST 2000:n.p.). In 1989, Edwin R. Williams, P. Thomas Olsen, Marvin Cage, Ronald Dzuiba, John Shields, and Barry Taylor were awarded a Department of Commerce Gold Medal for their research on "the time-dependence of the NBS ohm and the …volt representation, as well as the low-field proton gyromagnetic ratio." Their work was credited with contributing valuable information supporting the 1990 international adjustment of electrical units (Schooley 2000:525).

During the early 1970s, two groups of NIST scientists worked independently to advance precise measurement for the speed of light. Two teams, Roger Barger, Bruce Danielson, Gordon Day, Kenneth Evenson, John Hall, F. Russell Petersen, and Joseph S. Wells at Boulder and Gabriel Luther and Zoltan Bay at Gaithersburg, researched how to provide a more precise measurement for the speed of light. In Gaithersburg, Bay and Luther in the Quantum Metrology Section of the Optical Physics Division measured light based on the 633 nm line of a helium-neon laser using microwaves. The Boulder group used a methane-stabilized laser of known frequency and wavelength to measure the speed of light. The new measurement of the speed of light at 299,792,456.2 +/- 1.1 meters per second was 100 times more accurate than previous measurements. Both values were published in 1972 within months of each other (Schooley 2000:363-364, 369-370; NIST 2014b).

Between 1969 and 1971, NIST physicist Russell Young built the topografiner, a new type of microscope that scanned and mapped surfaces at a level approaching individual atoms. The topografiner demonstrated the operating principle used in the later scanning tunneling microscope. The IBM inventors of the scanning tunneling microscope based in Zurich were awarded the Nobel Prize in Physics in 1986. The Nobel committee noted the important contribution of Young to the work: "The first to succeed in doing this [building an instrument that operated on the principle of maintaining a small constant distance between the sample surface and a sharp mechanical stylus] was the American physicist Russell Young at the National Bureau of Standards in the USA. He used the phenomenon known as field emission…However, Young realized, that it should be possible to achieve better resolution by using the so-called tunnel effect" (Schooley 2000:423-434; Martin and Frederick-Frost 2014).

In 1979, NIST scientists issued a new measurement system with the first photomask linewidth standard. The tiny ruler was developed to measure integrated circuits for the semiconductor industry. NIST continued to refine accurate methods of measurements for smaller and smaller dimensions approaching one-tenth of a micrometer or less. Methods to measure the spacing between crystalline silicon atoms was under investigation in 2000 (NIST 2000:n.p.).

In 1984, NIST scientist John Cahn was among the team of scientists that announced the discovery of a new material, quasicrystals, comprised of metallic particles. Guest researcher Dan Shechtman of the Israel Institute of Technology grew the crystals in Building 231 at the Gaithersburg campus. In 2011 Dan Shechtman won the 2011 Nobel Prize in Chemistry for this discovery. John Cahn won the National Medal of Science for his lifetime contributions to the fields of materials science, solid-state physics, chemistry, and mathematics (NIST 2000:n.p.; Martin and Frederick-Frost 2014).

The production and distribution of standards and measurements for the general public, government, and industry have been ongoing NIST programs since the founding of the agency. Standards and measurements are distributed through calibration services for measuring equipment and devices and through publications, including Standard Reference Data, reports, journal articles, and conference materials. A popular standard reference data was the more than 1,000-page *Handbook of Mathematical Functions*, which was first published in 1964. The handbook was reprinted in 1965 and most recently in 1999. The handbook has been converted to a digital format (NIST 2000:n.p.).

One important means of distributing standards to the public is through the NIST Standard Reference Materials (SRMs) program. Under the SRM program, compounds, pure materials, chemicals, and other substances are certified for their physical properties and provided as standards to industry. This program originated in 1905 with the development of standard samples for the composition of steel, concrete, glass, and ceramics. The program has expanded exponentially over NIST's history. NIST has prepared over 4,900 SRMs. The current inventory contains approximately 1,300 SRMs and contains a wide variety of samples beyond the original physical master samples (Watters and Parrish 2006:1-7). A sample of SRMs that have been developed since 1966 includes SRMs to measure cholesterol and aerosols.

In addition, the NIST Office of Law Enforcement Standards produced several SRMs to support law enforcement agencies. In 1993, the Justice Department requested that NIST produce a SRM for DNA profiling. The study took two years and resulted in a SRM to test "every step of the restriction fragment length polymorphism analysis method" for forensic DNA analysis (NIST 2014b). In 1998, NIST started to develop a SRM for bullet casings, which was issued in 2006. Other SRMs developed to support law enforcement include materials for measuring blood-alcohol levels, for verifying drug detection in hair and urine, and for identifying residues in smokeless gunpowder and residues of ignitable liquids in arson (Watters and Parrish 2006:1-7).

The ongoing development of measurements and standards is central to NIST's current programs and is conducted at the Material Measurement Laboratory (MML) and the Physical Measurement Laboratory (PML); both laboratories have divisions in Gaithersburg and Boulder. The MML serves as the national reference laboratory in chemical, biological and material science. The divisions within the MML are Applied Chemicals and Materials, Biomolecular Measurement, Biosystems and Biomaterials, Chemical Services, Materials Measurement Science, and Materials Science and Engineering. The research conducted in this laboratory includes applied research on the composition, structure, and properties of environmental, industrial, and biological materials and processes, as well as development and distribution of tools and reference data. Areas of research include advanced materials; fossil and alternative fuels; measurement of environmental pollutants; food safety and nutrition; health care; infrastructure; manufacturing; and safety and forensics (NIST 2015a).

The PML "develops the national standards of length, mass, force and shock, acceleration, time and frequency, electricity, temperature, humidity, pressure and vacuum, liquid and gas flow, and electromagnetic, optical, microwave, acoustic, ultrasonic, and ionizing radiation." Divisions in the PML comprise Electromagnetics, Quantum Electronics and Photonics, Quantum Measurement, Quantum Physics, Radiation Physics, Semiconductor and Dimensional Metrology, Sensor Science, Time and Frequency, and the Office of Weights and Measures (NIST 2015b).

Two other shared-use facilities for measurement located at NIST Gaithersburg are the Center for Nanoscale Science and Technology and the NCNR, both established in 2007 (Martin and Silcox 2010:iii). The Center for Nanoscale Science and Technology supports the "U.S. nanotechnology enterprise from discovery to production" in diverse fields, including "electronics, computation, information storage, medical diagnostics and therapeutics, and national security and defense" (NIST 2014d). The NCNR, which encompasses previous NIST divisions associated with neutron research, offers a broad range of instruments and capabilities for the study of both hot and cold neutrons (NIST 2015c).

<u>Testing and Evaluation</u>

NIST scientists conduct research in several programs that support the Federal government and industry in testing and evaluation. Many of these programs are assigned to the current NIST Engineering Laboratory. As constituted in 2015, the Engineering Laboratory comprises six divisions: Materials and Structural Systems, Energy and Environment, Fire Research, Intelligent Systems, and Systems Integration and the offices of Applied Economics, the Smart Grid Program, the National Earthquake Hazards Reduction Program, and the National Windstorm Impact Reduction Program (NIST 2014e).

The following sample of NIST's testing and evaluation programs illustrates the agency's accomplishments since moving to the Gaithersburg campus. The discussion is not comprehensive, but selected from the research areas of fire, building materials, structure and building failures, energy, environment, and law enforcement.

Flammability and fire research is one important research area in the Engineering Laboratory. Fire research is a program historically associated with agency. NIST undertook fire research almost from its establishment. A major impetus for research into the flammable properties of clothing was the passage of the Flammable Fabrics Act of 1953, which was enacted following a series of children's deaths linked to highly flammable clothing, such as brushed rayon sweaters and cowboy outfits. Following passage of this legislation, NIST developed a standard flammability test. Any fabric that burned faster than the standard could not be sold and marketed between the states (Schooley 2000:497-499).

In 1967, Congress expanded the provisions of the Flammable Fabrics Act to include paper, plastic, and foam used in clothing and interior furnishings. The legislation instructed the Secretary of Commerce to conduct research into the flammability of products, fabrics, and materials; conduct feasibility studies to reduce the flammability of these items; and develop flammability test methods. The Secretary of the Department of Commerce assigned these tasks to NIST. Tasks included research to determine the products of fabric combustion, calorimetry of fabric combustion, laboratory burning of fabrics, analysis of burn cases, study of flame retardants, controlled burning of full-scale household furnishing, and study of heat transfer from burning fabrics. Studies conducted at NIST investigated the flammability of carpets, mattresses, children's sleepwear, and blankets.

In 1972, the legal responsibility for continuing the mandates under the Flammable Fabrics Act was transferred to the Consumer Product Safety Commission. The commission continued to fund fire research at NIST. For example, NIST was requested to devise a test to minimize the probability of ignition in fabrics. Emil Braun, John Krasny, Richard Peacock, and Ann Stratton completed the project by 1975. Braun's group later evaluated the effectiveness of protective clothing worn by firefighters and industrial workers exposed to high temperatures. Vytenis Babrauskas and William Twilley developed a cone calorimeter to measure the changing mass of a specimen during fire tests. The cone calorimeter won an award in 1988 from *Research and Development Magazine* (Schooley 2000:497-500).

The Fire Research and Safety Act of 1968, followed by the Federal Fire Prevention and Control Act of 1974 resulted in the establishment of the Center for Fire Research. John Lyons was appointed the first Chief of the Division. The Secretary of Commerce was assigned the tasks of creating "a national fire research and safety program, including the gathering of comprehensive fire data; a comprehensive fire research program; fire-safety education and training program; demonstrations of new approaches and improvements in fire prevention and control; and, reduction of death, personal injury, and property damage" (Schooley 2000:225-226). Since its establishment, the Center for Fire Research has operated a robust research program into all aspects of fire, including fire retardants, smoke, soot formation, toxicology, materials combustion, and combustion of furnishings and room interiors. Scientists have been called into examine causes and effects of fire disasters (Schooley 2000:499-510). In 1997, NIST scientist Gregory Linteris traveled on the space shuttle to conduct a NIST-designed, low-gravity combustion experiment (Schooley 2000:519). The focus of the current research program is fire detection, fire-fighting technologies, fire materials research, fire measurements, and fire computer modeling (NIST 2014f).

Fire performance standards for smoke detectors were one valuable product resulting from the agency's fire research. Work in this area was begun in 1974 by Richard Bright. NIST also developed recommendations on the number, type, and locations for the installation of home smoke detectors. These recommendations were incorporated into building and fire codes and were credited with a 50 per cent reduction of death by fires in 1997. In 1980, Irwin Benjamin conducted a similar study of the design of smoke detectors used in large buildings (NIST 2000:n.p.; Schooley 2000:507).

In 1972, the Center for Building Technology was established at NIST at the direction of the Secretary of Commerce. The new center contained three divisions: Building Environment; Structures, Materials and Life Safety; and, Technical Evaluation and Applications. The new center had a staff of 250 and engaged in a wide range of projects. Some projects included the development of computer models to predict the dynamic thermal performance of houses in winter and summer weather cycles, investigations into failed heat pumps, development of a device to measure the dew point in sealed glass envelopes to evaluate the moisture content in double-pane glass, measurement of the thermal resistance of building insulation, development of a systematic method to predict the service lives of buildings materials, and development of standard test methods for solar energy collectors and thermal storage systems. Work also progressed towards developing a performance-based building code to specify desired attributes of building materials, components, or systems to satisfy the intended user (Schooley 2000:392-395). Building research continues at NIST in the research areas of construction integration and automation, cybernetic building systems, net-zero and high-performance buildings, and sustainable infrastructure materials (NIST 2015d).

Special studies were conducted into the causes of building and structure failure. In 1967, NIST scientists evaluated the collapse of the Silver Bridge in Point Pleasant, West Virginia. Their investigation revealed that the cause of the collapse was a microscopic pit in the surface of a single I-bar that connected the deck to the suspension chain. In 1982, investigations were undertaken to identify the cause of the collapse of suspended walkways in a hotel in Kansas City, Missouri. NIST scientists traced the failure to the box beam-hangar rod connections (NIST 2014b). NIST scientists have continued investigations of building failures to the present. One of the most high-profile cases was NIST's participation in the investigation into World Trade Center buildings 1, 2, and 7 conducted between 2001 and 2008. The purpose of the investigations was to "investigate the building construction, the materials used, and the technical conditions that contributed" to the collapse of the buildings following the initial impacts of the aircraft into Buildings 1 and 2 (NIST 2011). NIST scientists also routinely are called upon to evaluate damage to buildings and structures caused by hurricanes, tornadoes, and other natural disasters (NIST 2015d).

NIST scientists also researched and published design and evaluation criteria for energy conservation for the construction industry. Application of the criteria by the construction industry is voluntary. The design and evaluation criteria were designed to reduce energy consumption by over 50 per cent in new buildings. In a separate study, NIST scientists developed testing and rating procedures to evaluate energy consumption in household appliances (NIST 2000:n.p.). In 1976, NIST signed a Memorandum of Understanding with the Electric Power Research Institute to support the institute in the areas of equipment, power generation, measurement of electrical and electromagnetic quantities, evaluation of devices and control systems, and energy conservation (Schooley 2000:462). Ongoing NIST projects related to energy include the research areas of alternative energy; electric power metrology; energy conservation, energy conversion, storage, and transport; fossil fuels; and, sustainability (NIST 2015e).

NIST environmental research programs were developed to measure pollutants in air, water, and soil; and toxicity in organisms. New equipment was devised to measure pollutants, such as a portable meter to measure microscopic air particles. Standards were developed for fuel economy and automobile emissions. A computer model was developed to allocate salmon catches to support salmon fishery regulations. NIST, in cooperation with the U.S. Environmental Protection Agency (EPA), established a biomonitoring specimen bank that contains thousands of biological specimens preserved in liquid nitrogen to assist in the comparative study of chemical and pollutant exposure. As a result of the specimen bank, NIST scientists developed procedures and protocols for proper handling of environmental samples that have been adopted by environmental laboratories worldwide. One special project undertaken by NIST was the review of the organic chemical analysis in the 1982 EPA study of Love Canal. Another study was to characterize the damage to the earth's ozone layer caused by chloroflourocarbons from aerosol propellants and refrigerants (NIST 2000:n.p.). NIST current areas of research in the environmental field include climate science measurements, environmental technologies, marine health, and pollution/indoor air quality (NIST 2014g).

Testing and evaluation activities are conducted by NIST's Law Enforcement Standards Laboratory (LESL) established in 1971 to support law enforcement programs. NIST staff assigned to LESL identified problems with equipment and armament of police departments. LESL staff began studies that resulted in standards programs for vehicles, communications equipment, security systems, concealed-object detectors, protective equipment and clothing, emergency equipment, police weaponry, and building systems for law enforcement. Research projects carried out by NIST staff included improvements to body armor, helmets, and face shields; studies of the composition and color of paint for cars; gunpowder analysis; handcuffs; burglar alarms; and, window locks. LESL was not assigned its own laboratory but "purchased" research and development from existing NIST groups or outside contractors (Schooley 2000:266-267, 353-354, 355-357). Research to support law enforcement activities is an ongoing program in the MML. Current research areas include ballistics, biometrics, communications, forensics, and weapons and protective systems (NIST 2014h).

Technology

NIST has invested time and money to support improved technology in manufacturing and computers, both hardware and software. NIST built its first computer, known as SEAC, in 1950. Since that time, the agency has continued research into computer development. In 1965, a new Center for Computer Sciences and Technology was formed at NIST (NBS 1966b:2). Under the Brooks Act of 1972, NIST was charged with providing technical support to standardize the government use of computers and to increase the cost effectiveness of government expenditures for equipment. Currently, computer research is under the NIST Information Technology Laboratory. This laboratory has six divisions: Applied and Computational Mathematics, Advanced Network Technologies, Computer Security, Information Access, Software and Systems, and Statistical Engineering (NIST 2015f).

Software improvements included the development in 1966 of the Omnitab software, an early spread sheet. Omnitab was written to automate handling of data input and output, and the production of graphs. In 1977, NIST issued the first publicly available data encryption standard (DES). By 1997, approximately 50 per cent of U.S. cryptographic products implemented DES (NIST 2000:n.p.). In 2001, NIST released the Advanced Encryption Standard (NIST 2014b).

NIST scientists routinely developed computer applications for statistical analysis. In 1969, the Selective Service System requested assistance to make the 1970 military draft a truly random selection. Joan Rosenblatt and colleagues developed a methodology that used a selection of random calendars and priority permutations to accomplish the task. Her success on this and other projects earned Rosenblatt the Federal Woman's Award in 1971 (NIST 2014b).

Since the early 1970s, NIST scientists have been involved in automated manufacturing research through the design of computer-controlled manufacturing machines, or robots. Ernest Ambler, while Director of the Institute of Basic Standards, promoted the idea of automating the gear calibration process by combining the metrology division with the atomic physics program that linked three-dimensional coordinate measuring machines, mini-computers, laser interferometers, and robotics from the Institute for Computer Sciences and Technology. The result was the establishment of the Automated Manufacturing Research Facility in 1980 that operated until 1995. As part of the program Jim Albus, a leading robotics researcher, developed NIST's real-time control system, a system that "creates an efficient organization for knowledge-based intelligent control of complex systems" (NIST 2000:n.p.). In 1991, NIST unveiled a floor-cleaning robot that used the real-time control system. The system also was used in shipbuilding, hospitals, and in land mine clearance (Schooley 2000:618-621, 625; NIST 2000:n.p.; Zenzen 2001:1-8). A robotics program continues at NIST in 2015 under the NIST Engineering Laboratory. Research areas in this program comprise bomb-disposal robots, mobility, manipulation, and urban search and rescue robots (NIST 2015g).

Select NIST Scientists

Thousands of scientists have worked at NIST since the move to the Gaithersburg campus. Some scientists have made their careers at NIST; others have launched their careers at NIST, then transferred to work in academia or at industrial laboratories. NIST scientists have won recognition for their work from professional organizations in their respective fields, as well as from the Department of Commerce and NIST. The Department of Commerce Award program was begun in 1949 to recognize distinguished and exceptional performance. Three to four NIST scientists and one group routinely have won Department of Commerce Gold Medals in the years between 1966 and 2009.

Among the most prestigious award in science is the Nobel Prize. NIST scientists historically have made scientific advances and had executed experiments that have supported scientists in academia and other institutions in discoveries that have won Nobel prizes. These contributions are discussed in the overall historic context and above. Between 1997 and 2012, four NIST scientists were awarded Nobel prizes for their work conducted at NIST:

- In 1997, William Phillips of NIST shared the 1997 Nobel Prize in Physics for successfully developing the technique of laser cooling and trapping of atoms. This technique has the potential to build a new kind of atomic clock that will be more accurate than what currently is used. This work was undertaken from 1985-1988 on the Gaithersburg campus. (Martin and Frederick-Frost 2014; NIST 2014b).

- In 2001, Eric Cornell of NIST/JILA and his colleagues shared the Nobel Prize in Physics for creating the first Bose-Einstein Condensate, "a new state of matter that emerges at just a few billionths of a degree above absolute zero." Scientists have incorporated this finding into their routine work to support research in quantum mechanics. This work partly took place on the Boulder campus from 1990-1995. (NIST 2000:n.d.; Martin and Frederick-Frost 2014; NIST 2014b).

- In 2005, John Hall of NIST/JILA shared the Nobel Prize in Physics for his "contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique." Frequency combs have the potential to increase the precision of a broad array of measurements in the future. This work partly took place on the Boulder campus around 1984 (Martin and Frederick-Frost 2014; NIST 2014b).

- In 2012, David J. Wineland of NIST shared the Nobel Prize in Physics for "ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems." The research helped lay the groundwork towards building a computer using quantum physics and for a potential new time standard. This work took place between 1995-2005 on the Boulder campus (Martin and Frederick-Frost 2014; NIST 2014b).

NIST scientists have made important contributions to a broad variety of scientific and technological fields. Their cutting-edge work in measurement science and in the development and use of standards has led to great advances in science and technology that underpin the advances in U.S. industry and contributed to consumer safety. NIST scientists strive to continue to be a world leader in creating critical measurement solutions and promoting equitable standards.

Theme: Postwar Research Campus Design

Construction of the Gaithersburg campus of NIST followed a postwar trend in office development. A number of factors influenced the decisions of corporate leaders to relocate their headquarters or research divisions to suburban, if not rural, locations. The factors contributing to those trends and provides a framework for understanding the philosophies influencing the design of the NIST campus are explored below. Maximum flexibility in the configuration of research space and an aesthetically pleasing environment were hallmarks of the development pattern.

Early Precedents in Research and Corporate Campus Design

Two closely related property types developed during the years following the end of World War II: the corporate campus and the research campus. These property types emerged during the second quarter of the twentieth century as corporations began moving their research divisions out of central cities. Corporate headquarters soon joined the migration from urban areas. Corporations left the cities with their noise, congestion, buildings with small footprints, and challenges to expansion. Suburban settings were seen as affording greater amenities than their urban counterparts.

Corporate campuses differed from the research campuses in the amount of administrative space. The research campus, in contrast, provided facilities for corporate scientists to conduct experiments in rigidly controlled environments. Research and development branches emerged as distinctive entities from administrative and manufacturing arms of business and advanced technologies necessitated controlled environments. One building integrating management, research, and manufacturing functions, the common pattern during the nineteenth century, no longer was practical. By the early twentieth century, businesses increasingly began to separate the three functions into separate facilities.

Municipalities encouraged industry in the migration. Zoning ordinances that regulated land use were introduced during the first two decades of the twentieth century. As industry was reaching the pragmatic conclusion that research could not adequately be undertaken adjacent to heavy manufacturing due to noise, health, and safety reasons, local governments enacted legislation mandating the separation of manufacturing, commercial, and residential uses for some of the same reasons. In some cases, corporations seeking to keep its research functions in the center city were prohibited by zoning. Land use ordinances helped give rise to the construction of corporate and research campuses in suburban settings. These factors contributed to the development of the two types of campuses, which exhibited a common design aesthetic but differed in function.

The suburbs afforded space for the development of multi-building corporate and research campuses. In this new paradigm low-scale, sprawling buildings could be separated from one another by winding paths, lawn, and trees (Mozingo 2011:50). Zoning, however, was not the only impetus for corporations to move their administrative or research operations to the suburbs. Corporate management and academics felt that pastoral environments with designed landscapes emphasizing access to nature would improve scientific discovery and facilitate productivity.

The corporate and research campus was purpose-built and combined large, landscaped acreage with generally, low-rise buildings (Mozingo 2011:105). The design and quality of facilities of these pastoral campuses were used by business, industry, academia, and government to compete for a limited pool of scientists. Bucolic, tranquil landscapes were seen as key to attracting select qualified personnel. Aside from an idyllic environment, these new corporate campuses offered expansive parking and on-site cafeterias (Mozingo 2011:110). Other amenities included health facilities, gift shops, and walking trails (Dunham-Jones and Williamson 2011).

The research facilities developed for Bell Telephone Laboratories established an early precedent in the separation of research functions from manufacturing. The new facility, completed in 1939, introduced innovative ways of approaching the design of research facilities. Bell Telephone Laboratories set the standard for the design of postwar research campuses. The successful design of the facility established the reputation of its architectural designers, who eventually became leaders in the niche field of research campus design. NBS administrators and scientists selected demonstrated experts in the design of state-of-the-art institutions for the development of the Gaithersburg campus.

Research Campuses

Bell Telephone Laboratories was located on Manhattan's lower west side prior to the move to Murray Hill, New Jersey, in 1939. The company required additional space to conduct highly-sensitive research in strictly-controlled environments. Expansion within Manhattan was not feasible because urban noise, electrical intrusion, and traffic vibrations would interfere with the accuracy of experimental measurements (Mozingo 2011:54). The company's research needs led to the construction of the first corporate research campus. The design of the project was initiated in 1930 by the architectural firm, Voorhees, Gmelin and Walker; however, the Great Depression delayed realization of the plan until 1939. By that time, the architects of record were the reorganized firm of Voorhees, Walker, Foley, and Smith (now HLW International)

(Mozingo 2011:57). Historians have noted that "Bell Labs invented the fundamentals of the corporate campus." The integrated plan featured:

- green space, centrally located at the site;
- flexible laboratory space incorporating specialized utilities;
- ample parking and truck access;
- underground utilities;
- fenced property;
- three-story height limits; and
- generous landscape setbacks (Mozingo 2011:63).

Two key innovations of the Bell campus were generous site plans and the use of moveable walls in the laboratory spaces (Rankin 2013:54). As the largest of research facilities constructed during the period, the Bell facility became the prototype for future research laboratory construction. By the conclusion of World War II, the advantages of flexible space and site isolation had led to their adoption as accepted design practice. Architectural magazines, trade journals for the research-management field, and specialized laboratory-design handbooks extolled the benefits of the features first introduced at Bell Telephone Laboratories (Rankin 2013:54).

The vanguard architectural firm, HLW International, continued to integrate the innovations first introduced in the design of the Bell Telephone Laboratories in their commissions for the design of research campuses through the 1960s (Rankin 2013:54). The innovations first applied in the Bell campus were developed in direct response to the client's need for an economic solution and maximum flexibility (Haines 1951:337).

The resulting prototype for laboratory buildings integrated flexible laboratory space with common support space, such as cafeterias and libraries. Large-scale testing and research facilities, such as wind tunnels and nuclear reactors, were housed in separate, dedicated buildings (Rankin 2013:55). Laboratory buildings comprised flexible spaces, or modules, arranged in double-loaded corridor plans that could be modified, i.e., expanded or contracted, to suit research needs. The use of such flexible plans became universally accepted practice during the postwar period.

Notwithstanding the modular design standard for general research laboratories, research campuses were unique and sophisticated complexes requiring a broad-range of building types and specialized equipment. In addition, designs often included provisions for specialized service requirements and required sophisticated engineering to address such factors as fluctuating building loads. Safety features were major components of the design and might include safety showers, additional exits, and special grounding devices (McCulley 1968:10).

Modern laboratories necessitated increasingly sophisticated technical facilities and complex mechanical equipment. The sensitivity of testing equipment demanded buildings systems that controlled humidity, temperature, and air quality (McCulley 1968:65). Finishes that could be easily cleaned, yet were resilient to damage from testing or chemicals, were installed (McCulley 1968:66).

<u>Corporate Campuses</u>

By the 1940s, an architectural image emerged for corporate headquarters: sweeping entry drives, gently rolling grassy topography, and ample parking lots (Mozingo 2011:105). Changes in corporate architecture and setting were adopted for economic, as well as for aesthetic reasons. The exodus for the suburbs continued through the 1950s. As *Business Week* noted in an article published during the early 1950s, firms were leaving New York for exurban locales because of increasing rent and a lack of office space in urban centers. The magazine article went on to state that it was increasingly difficult to attract "first class personnel to work in some of the more unsightly, congested New York areas" and "management thinks workers will be happier looking at trees instead of grimy buildings and listening to birds instead of honking taxis" (Mozingo 2011:105).

During the postwar period, many major corporations adopted the corporate campus as the architectural expression for new headquarters. Companies with household names including GE, GM, and IBM had adopted the model (Rankin 2013:52). Universities and government agencies quickly followed the precedent established by large corporations (Rankin 2013:52).

The rise in popularity of the corporate campus facilitated the postwar move of businesses from the traditional urban core to the suburbs. Businesses moved their research and development departments to suburban campuses; corporate headquarters soon followed suit (Mozingo 2011:98). One result of the move of corporations to the suburbs was the relocation of white collar jobs from the urban core to the outskirts of the city limits. Increased automobile ownership and the construction of the interstate highway system facilitated the rapid movement of employees from the central cities to jobs in the new suburbs (Dunham-Jones and Williamson 2011:n.p.). Sophisticated corporations chose well-known "celebrity" architects to design new corporate campuses. Principal buildings symbolized corporate status and prestige.

General Foods was the first Fortune 500 company to leave Manhattan for the suburbs. The company chose Voorhees, Walker, Foley, and Smith (HLW International) and Olmsted Brothers, landscape architects to design its new facility (Mozingo 2011:98; 107). The design and construction of the General Foods corporate headquarters in White Plaines, New York, in 1954, introduced design elements that were later seen in the NBS campus: "architectural restraint, central courtyard, and self-contained site planning" (Mozingo 2011:110). With its rural siting, the General Foods campus became an architectural focal point, visible to commuters traveling along the expressway (Mozingo 2011:111).

Innovations in Research and Corporate Campus Design

During the construction of postwar corporate and research campuses, architects and designers, in collaboration with administrators and scientists, undertook extensive architectural programming studies. Comparable research laboratories were explored and full-scale models of proposed designs were constructed and refined (Rankin 2013:56). Collaboration among the architects and the scientists on the design for research laboratories was not uncommon. The Bell Telephone Laboratories researchers played a prominent role in the design of the Murray Hill facility (Knowles and Leslie 2013:255). They provided insights and critiques regarding the pragmatic and functional proposed designs based on their experience and from observations after touring other research facilities (Knowles and Leslie 2013:255). The design developed for Bell Telephone Laboratories was presented in a full-scale, fully-functional model composed of five modules (Knowles and Leslie 2013:266). While critics faulted the Laboratory's austere and "bland" exterior, the facility received high praise for the then-novel use of movable panels (Knowles and Leslie 2013:256). As a Bell Telephone Laboratories executive later observed "It has been so successful a model that scarcely any large industrial laboratory has subsequently been built without taking ideas from it and some laboratories are fairly close copies of it" (Knowles and Leslie 2013:256). The long halls, at once derided by scientists, were also praised because they facilitated collaboration. Researchers, forced to walk long distances, would meet their colleagues in the halls and walk past laboratories and offices, and thereby would learn about projects in other departments (Knowles and Leslie 2013:259). This objective of using physical design to foster collaboration also was employed later for the new NBS campus.

In depth analysis conducted by the Nuffield Foundation, a British charitable organization, during the mid- and late 1950s presented findings on the designs of the most efficient laboratories. The organization's analysis concluded that "requirements for space and services were found to vary only between scientists and assistants, not between disciplines" (Rankin 2013:57). In other words, the spatial needs for a chemist, biologist, or physicist were the same; however, the spatial requirements between the scientists and their assistants were different, with assistants requiring more space due to the nature of work they performed, i.e., less reading and writing than their scientist peers (Rankin 2013:57). The study also recommended that research campuses should include "amenities that would be used for only one percent of a researcher's tasks" (Rankin 2013:57). Designers and scientists agreed that high morale fostered scientific creativity; a properly designed work environment, one that encouraged collaboration, contributed to scientific productivity (Rankin 2013:58).

By 1951, Ralph Walker, principal in the New York City-based firm Voorhees, Walker, Foley & Smith, developed a methodology for designing corporate laboratories. Two steps he thought important included early discussions with key personnel regarding the location of mechanical and electrical services and the size of the module. Questionnaires also were a useful tool for soliciting feedback on design solutions and space allocation (McCulley 1968:11). In addition, Walker advocated the preparation of a full-scale model to help employees visualize the size and scale of the module, as well as to allow plumbing, electrical, and other contractors an opportunity to view the project before submitting an estimate (Walker 1951:149). The firm pioneered this approach with the design of Bell Telephone Laboratories and applied it later in the development of the NBS.

Key to the design of an effective laboratory was the incorporation of the "module." Walker's use of "module" was not to denote standardization; rather, he defined the module as "a unit of work space determined by human needs. It is dimensional only through its use factors. … The character of the research carried on, the need for safety considerations in the width of aisles, for example, each determines the final result" (Walker 1951:149). He further stated, "In the development of a module's dimensions there is no general standard and each research group should indicate for itself the size and character of its working conditions" (Walker 1951:149). The module was an effective use of research and office space because "the chief advantage of the module system is the known repetitive position of services and therefore the lack of interference between one laboratory at work and another in preparation for a new project requiring special and additional services" (Walker 1951:150). Concepts that were considered novel during the 1950s (i.e., movable partitions) became accepted practice. By the mid-1960s, they had become industry standard, with the expectation that one fifth of the partitions in any laboratory would move once a year (McCulley 1968:15).

The necessity for windows also was discussed in a 1951 article by Walker. He noted that windows may have become superfluous during the age of modern air conditioning and fluorescent lighting; however, in spaces deeper than 15', their inclusion may be desirable as "a wholly psychological device permitting the mind to relax" (Walker 1951:150). The necessity for windows was the subject of heated debate during the design of the NBS campus. Walker acknowledged that workers may state that they did not want windows; however, in practice, this was not the case, especially as research facilities moved to rural settings in part, to provide esthetically pleasing environments (Walker 1951:150).

<u>Profile of a Leading Architectural Firm in the Design of Corporate and Research Campuses</u>

The architectural firm that designed the first period of construction at NBS was a leader in the field. Voorhees, Walker, Smith, Smith, & Haines, the firm that would become HLW International, had developed a specialization in the design of research campuses. The firm's first research campus was completed in 1941 for Bell Telephone Laboratories. Some of the firms' cutting-edge innovations included the design of laboratories with moveable partitions. Architect Ralph Walker, a partner in the firm, advocated the use of moveable partitions in numerous articles he wrote during the 1950s.

Throughout the 1930s, the firm designed a number of prominent buildings in New York City in the Art Deco style. These buildings included the Western Union Building (1930) and the Irving Trust (1932) (Vosbeck et al. 2008:86).

Additional works included projects completed for the Department of the Army and ten projects for the 1939 World's Fair in New York City. During World War I, the firm designed Army hospitals and during World War II, the firm designed military facilities in the United States and the Caribbean (Moore et al. 2010:142). The U.S. Army War College at Carlisle Barracks, Pennsylvania, and the Night Vision Laboratory at Fort Belvoir, Virginia, were designed during the Cold War period (Moore et al. 2010:142).

Walker found employment with the firm McKenzie, Voorhees & Gmelin upon his discharge from the army following the end of World War I. The firm's name changed to Voorhees, Gmelin & Walker in 1926 when he was made partner. The firm underwent another name change after 1939 when it became Voorhees, Walker, Foley and Smith. As Voorhees, Walker, Foley and Smith, the firm developed a national specialization in the design of corporate campuses. Selected projects included Bell Telephone Laboratories, Murray Hill, New Jersey; General Foods, White Plains, New York; IBM Research Center, Poughkeepsie, New York; and, Argonne National Laboratories, Chicago, Illinois (Vosbeck et al. 2008:86). Walker served as president of the American Institute of Architects between 1949 and 1951 (Vosbeck et al. 2008:85).

The firm continues today as HLW International. Established in 1974, the firm has offices in New York, New York; Madison, New Jersey; Los Angeles, California; London, England; and, Shanghai, China. In addition to architectural and engineering services, services expanded to include interior design, sustainability, and planning across a broad spectrum of sectors, such as, media and entertainment, hospitality and retail, and science and technology, among others (HLW International n.d.).

Evaluation Results

A total of 74 buildings, structures, objects, and landscapes were documented under the current investigation. Analysis of archival and architectural data applying the National Register NRHP Criteria for Evaluation identified a cohesive collection of buildings, structures, and landscapes that represent a recognizable entity united by design and historical association with the initial construction of NIST (1961 – 1969).

The buildings constructed between 1961 and 1969 exhibit many of the hallmarks of postwar research campus design. These character-defining features include flexible workspace that could be configured in a variety of different ways to suit current research/laboratory needs regardless of the research discipline. The buildings were constructed incorporating administrative/laboratory modules. The buildings are linear in plan, housing modules across a double-loaded hallway. The back-to-back laboratories were across from the exterior-facing administrative spaces. Long hallways would encourage spontaneous discussions among colleagues. In this manner, scientists could collaborate and discuss research problems in informal settings. The acreage afforded by the suburban site was acquired, in part, to facilitate expansion, as necessary. Greenspace with formal landscaping was held to be conducive to scientific inquiry and created a working environment reminiscent of an academic campus.

Building 101 is the central focus of the campus and is a representative of the International Style applied to a principal building within a research complex. Similar to many private sector research campuses of the period, the principal building was the primary focus for public space and architectural elaboration; Building 101 became an icon for the agency. Curtain-wall construction, generous use of windows, and minimal ornamentation, hallmarks of the style, are employed on the building. Public space is incorporated in the large lobby and cafeteria, spaces designed to encourage social interaction. Other public spaces include auditoriums, providing forums for professional presentations.

A comprehensive site plan was designed and implemented for the campus. A grid street system provides access to the research laboratories. Lawn, mature specimen and deciduous trees, hardscapes, and storm water management ponds were incorporated in the landscape. The cohesive area capturing the design and operation of the campus during its initial period of development is defined by nine contributing resources, including the Administration Building, seven GPLs, and Building 304, encompassed by the area generally defined by East Drive to the east, the AML complex to the south, and Research Drive to the west. The northern edge of the historic district extends 205 feet from the north elevation of Building 226, which is the distance between the existing GPLs. The AML complex comprising Buildings 215, 216, 217, 218, and 219 are excluded from the proposed historic district.

The resources contained with the NIST Gaithersburg campus were analyzed applying the NRHP Criteria for Evaluation (36 CFR 60.4[a-d]). Site investigation and resource evaluation indicated that resources at the Gaithersburg campus are significant within the themes of Science and Technology and Postwar Research Campus Design (Criterion A). The facility also represents a significant and distinguishable entity whose components may lack individual distinction (Criterion C). Additionally, Building 101 individually possesses the significance and integrity for NRHP consideration under Criterion C as a representative example of the International Style. The accompanying DOE provides a more in-depth evaluation of the NIST resources.

9. Major Bibliographical References

Inventory No. M:20-47

See attached continuation sheet.

10. Geographical Data

Acreage of surveyed property	579.5
Acreage of historical setting	57.89
Quadrangle name	Gaithersburg
Quadrangle scale:	1:24,000

Verbal boundary description and justification

The cohesive area capturing the design and operation of the campus during its initial period of development is defined by nine contributing resources encompassing the area defined on the east by East Drive, the south by the AML complex, the west by Research Drive to Building 304. At this point, the boundary turns west to follow Research Drive until the intersection with Center Drive. The boundary turns north to align with the sidewalks along the west elevations of Buildings 224 and 226 and continues north to a point 205 feet from the north elevation of Building 226. The boundary then turns east to the west edge of the parking lot located northeast of Building 227. The boundary then turns south and connects to the access road leading to East Drive., which is the starting point. The choice of 205 feet represents the distance between the existing GPLs.

The boundaries are based on a specific time, visual barriers, and visual changes. Factors used to justify boundary delineation include the existing road network, which was implemented during the district's period of significance, and the presence of new construction. The AML complex serves as a visual barrier for the contributing resources in the historic district. The visual changes imposed by the AML complex represent a different architectural style and period from those resources included in the historic district. The proposed boundaries represent a significant concentration of resources from the district's period of significance while retaining the qualities of integrity that help convey the district's significance. The proposed historic district is contained within 57.89 acres.

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Surveyed Buildings at NIST

Building Number	Building Name	Construction Date	Resource Type
101	Administration Building	1962-1965	Building
103	Visitor's Center and Gate House	2009	Building (2)
B	Gate House	ca. 2009	Building
C	Gate House	ca. 2009	Building
F	Gate House	ca. 2009	Building
202	Engineering Mechanics	1961-1963	Building
203	Standard Reference Materials Facility	2012	Building
205	Large Fire Facility	1973-1975; 2014	Building
205E	Emissions Control Electrical	ca. 2000	Building
205M	Emissions Control Mechanical	ca. 2000	Building
205E#2	Emissions Control Electrical	ca. 2014	Building
205M2	Emissions Control Mechanical	ca. 2014	Building
2	Hopper	ca. 2014	Structure
3	Hopper	ca. 2000	Structure
206	Concreting Materials	1966-1968	Building
207	Robot Test Facility	2012	Building
208	Net-Zero Energy Residential Test Facility	2012	Building
215	Nanofabrication Facility	2002-2004	Building
216	Center for Nanoscience and Technology Instrument East	2001-2002	Building
217	AML Instrument West	2002-2004	Building
218	AML Metrology East	2000-2004	Building
219	AML Metrology West	2000-2004	Building
220	Metrology	1963-1966	Building
221	Physics	1963-1966	Building
222	Chemistry	1963-1966	Building
223	Materials	1963-1966	Building
224	Polymer	1963-1966	Building

Building Number	Building Name	Construction Date	Resource Type
225	Technology	1963-1966	Building
226	Building Research	1963-1966	Building
227	Advanced Chemical Sciences Laboratory	1999	Building
230	Fluid Mechanics	1967-1969	Building
231	Industrial	1966-1968	Building
233	Sound	1965-1968	Building
235	NCNR	1963-1967	Building
236	Hazards	1966-1968	Building
237	Non-magnetic Laboratory	1964-1968	Building
238	Non-magnetic Laboratory	1964-1968	Building
245	Physics	1962-1964	Building
301	Supply and Plant	1962-1964; 2013	Building
302	Steam and Chilled Water Generation Plant	1961-1964; ca. 1990s; ca. 2010	Building
303	Service	1962-1964	Building
304	Shops	1962-1964	Building
305	Cooling Tower	1961-1964; 2011	Structure
306	Potomac Electric Power Company (PEPCO) Electrical Substation	ca. 1970	Building
306A	PEPCO	1961-1964	Building
306B	PEPCO	1961-1964	Building
307	Hazardous Chemical Waste Storage	1970-1971	Building
308	Bowman House	1952-1953	Building
309	Grounds Maintenance	1974-1978	Building
310	Hazardous Materials Storage	1986-1987	Building
311	Grounds Storage Shed	1990	Building
312	Materials Processing Facility	1996	Building
313	Site Effluent Neutralization	1996	Building
314	Backflow Preventer Building	1998	Building
315	Backflow Preventer Building	1998	Building
316	Electrical Service Building	1998	Building

Building Number	Building Name	Construction Date	Resource Type
317	Cooling Tower	2010	Structure
1	Building associated with 317	2010	Building
318	ES Consolidated Facility	2014	Building
319	ES Storage Building	2014	Building
320	CCC	2013	Building
321	Liquid Helium Recovery Facility	Under construction	Building
Baseball Field 1		Late 1990s	Site
Baseball Field 2		Late 1990s	Site
Volley Ball Court		ca. 2009	Site
Picnic Area		Late 20th century	Site
Campus Landscape Plan (including Newtown Apple Tree)		1961-1969; 1966	Site (1)
Stormwater Management Pond 1		ca. 1965	Site
Stormwater Management Pond 2		ca. 1965	Site
Stormwater Management Pond 3		ca. 2006	Site
Flag pole		1965	Object
Entrance Gates		1976	Object (1)
Masonry Test Wall		1977	Object

Photo Log

MIHP# M:20-47
National Institute of Standards and Technology
Montgomery County, Maryland
Photos taken by: R. Christopher Goodwin & Associates, Inc.
Photos taken on: December 3 and 4, 2014; January 28, 2015; March 3, 2015, and May 14, 2015
Photo paper and ink: HP Vivera ink 97 Tri-Color cartridge, 101 Blue Photo cartridge, and 102 Gray Photo cartridge on Epsom Premium Photo Paper (high gloss)
Verbatim Ultralife Gold Archival Grade CD-R, PhthaloCyanine Dye

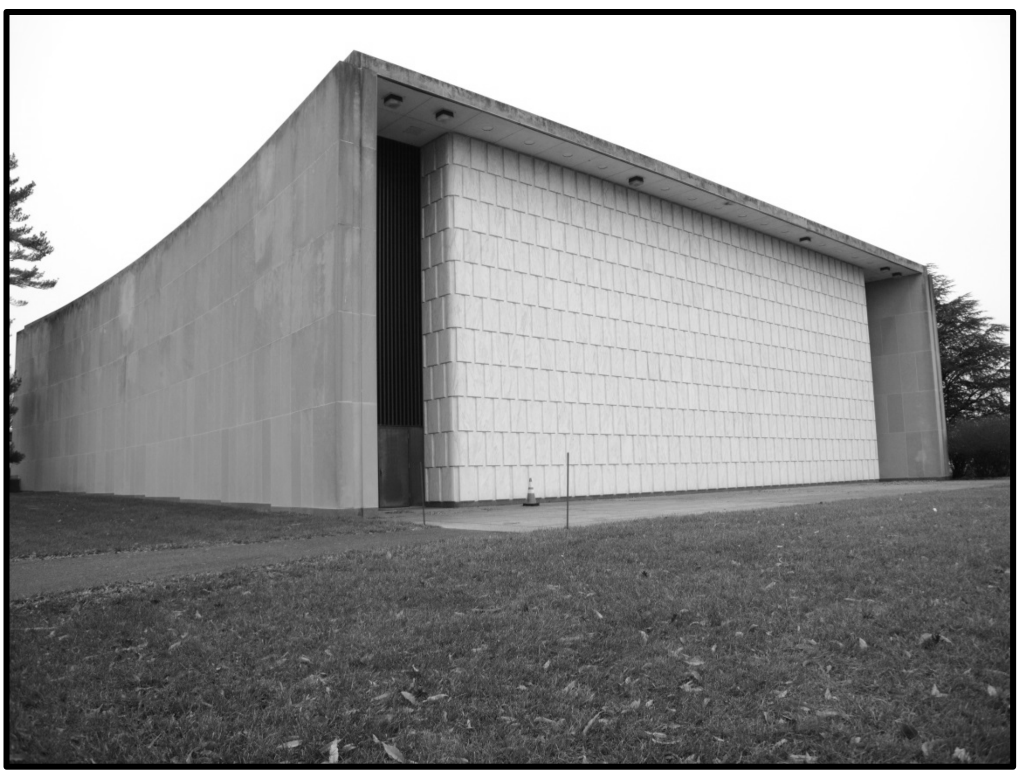
M_20_47_2014_12_03_001. Building 101, looking northwest
M_20_47_2014_12_03_002. Building 101, north elevation
M_20_47_2014_12_03_003 Building 101, library, north elevation
M_20_47_2014_12_03_004. Building 101, auditorium, south and east elevations
M_20_47_2015_05_14_005. Building 101, courtyard
M_20_47_2014_12_03_006. Walkway from Building 101 to Building 225, looking north
M_20_47_2014_12_04_007. Building 224, west and south elevations
M_20_47_2014_12_04_008. Building 227, east and south elevations
M_20_47_2014_12_04_009. Building 202, east elevation
M_20_47_2014_12_04_010. Building 203, north elevation
M_20_47_2015_01_28_011. Building 205, south elevation
M_20_47_2015_01_28_012. Building 206, west and south elevations
M_20_47_2015_01_28_013. Building 207, north and west elevations
M_20_47_2015_01_28_014. Building 208, south elevation
M_20_47_2014_12_04_015. Building 215, northwest elevation
M_20_47_2014_12_04_016. Building 216, west and south elevations
M_20_47_2014_12_04_017. Building 217, east and south elevations
M_20_47_2014_12_04_018. Building 219, looking east
M_20_47_2014_12_04_019. Building 230, east and north elevations
M_20_47_2014_12_04_020. Building 231, south and east elevations
M_20_47_2015_01_28_021. Building 233, south elevation
M_20_47_2015_01_28_022. Building 236, south elevation
M_20_47_2015_01_28_023. Building 237, south and east elevations
M_20_47_2015_01_28_024. Building 238, south and west elevations
M_20_47_2014_12_04_025. Building 245, north elevation
M_20_47_2014_12_04_026. Building 245, looking southwest
M_20_47_2015_03_03_027. Building 103, north elevation
M_20_47_2015_03_03_028. Building 318, north and east elevations
M_20_47_2015_05_14_029. Building 320, looking southwest
M_20_47_2014_12_03_030. Building 301, east elevation
M_20_47_2014_12_03_031. Building 301, south and east elevations
M_20_47_2014_12_03_032. Building 303, east and north elevations
M_20_47_2014_12_04_033. Building 304, south elevation
M_20_47_2014_12_03_034. Building 309, east elevation

M_20_47_2015_01_28_035. Building 312, east and south elevations
M_20_47_2015_05_14_036. Building 302, north elevation
M_20_47_2015_01_28_037. Building 305, north elevation
M_20_47_2015_01_28_038. Building 316, south and east elevations
M_20_47_2014_12_03_039. Building 306, north elevation
M_20_47_2015_01_28_040. Building 313, west and south elevations
M_20_47_2015_03_03_041. Building 315, east and south elevations
M_20_47_2015_01_28_042. Building 307, west elevation; Building 310, south elevation
M_20_47_2014_12_03_043. Building 311, north and east elevations
M_20_47_2015_01_28_044. Building 308, north elevation
M_20_47_2014_12_03_045. Newton apple tree, looking north
M_20_47_2014_12_03_046. Flagpole, looking southeast
M_20_47_2015_01_28_047. Masonry test wall, looking south
M_20_47_2014_12_04_048. Entrance gate, looking south
M_20_47_2015_05_14_049. Stormwater management pond,1 looking north
M_20_47_2015_05_14_050. Stormwater management pond 2, looking, northeast
M_20_47_2015_05_14_051. Baseball field 2, looking southeast
M_20_47_2015_05_14_052. Picnic area, looking northwest
M_20_47_2015_05_14_053. Volley ball court, looking northwest

M_20_47_2014_12_03_001. Building 101, looking northwest

M_20_47_2014_12_03_002. Building 101, north elevation

M_20_47_2014_12_03_003 Building 101, library, north elevation



M_20_47_2014_12_03_004. Building 101, auditorium, south and east elevations

M_20_47_2015_05_14_005. Building 101, courtyard

M_20_47_2014_12_03_006. Walkway from Building 101 to Building 225

M_20_47_2014_12_04_007. Building 224, west and south elevations

M_20_47_2014_12_04_008. Building 227, east and south elevations

M_20_47_2014_12_04_009. Building 202, east elevation

M_20_47_2014_12_04_010. Building 203, north elevation

M_20_47_2015_01_28_011. Building 205, south elevation

M_20_47_2015_01_28_012. Building 206, west and south elevations

M_20_47_2015_01_28_013. Building 207, north and west elevations

M_20_47_2015_01_28_014. Building 208, south elevation

M_20_47_2014_12_04_015. Building 215, northwest elevation

M_20_47_2014_12_04_016. Building 216, west and south elevations

M_20_47_2014_12_04_017. Building 217, east and south elevations

M_20_47_2014_12_04_018. Building 219, looking east

M_20_47_2014_12_04_019. Building 230, east and north elevations

M_20_47_2014_12_04_020. Building 231, south and east elevations

M_20_47_2015_01_28_021. Building 233, south elevation

M_20_47_2015_01_28_022. Building 236, south elevation

M_20_47_2015_01_28_023. Building 237, south and east elevations

M_20_47_2015_01_28_024. Building 238, south and west elevations

M_20_47_2014_12_04_025. Building 245, north elevation

M_20_47_2014_12_04_026. Building 245, looking southwest

M_20_47_2015_03_03_027. Building 103, north elevation

M_20_47_2015_03_03_028. Building 318, north and east elevations

M_20_47_2015_05_14_029. Building 320, looking southwest

M_20_47_2014_12_03_030. Building 301, east elevation

M_20_47_2014_12_03_031. Building 301, south and east elevations

M_20_47_2014_12_03_032. Building 303, east and north elevations

M_20_47_2014_12_04_033. Building 304, south elevation

M_20_47_2014_12_03_034. Building 309, east elevation

M_20_47_2015_01_28_035. Building 312, east and south elevations

M_20_47_2015_05_14_036. Building 302, north elevation

M_20_47_2015_01_28_037. Building 305, north elevation

M_20_47_2015_01_28_038. Building 316, south and east elevations

M_20_47_2014_12_03_039. Building 306, north elevation

M_20_47_2015_01_28_040. Building 313, west and south elevations

M_20_47_2015_03_03_041. Building 315, east and south elevations

M_20_47_2015_01_28_042. Building 307, west elevation; Building 310, south elevation

M_20_47_2014_12_03_043. Building 311, north and east elevations

M_20_47_2015_01_28_044. Building 308, north elevation

M_20_47_2014_12_03_045. Newton apple tree, looking north

M_20_47_2014_12_03_046. Flagpole, looking southeast

M_20_47_2015_01_28_047. Masonry test wall, looking south

M_20_47_2014_12_04_048. Entrance gate, looking south

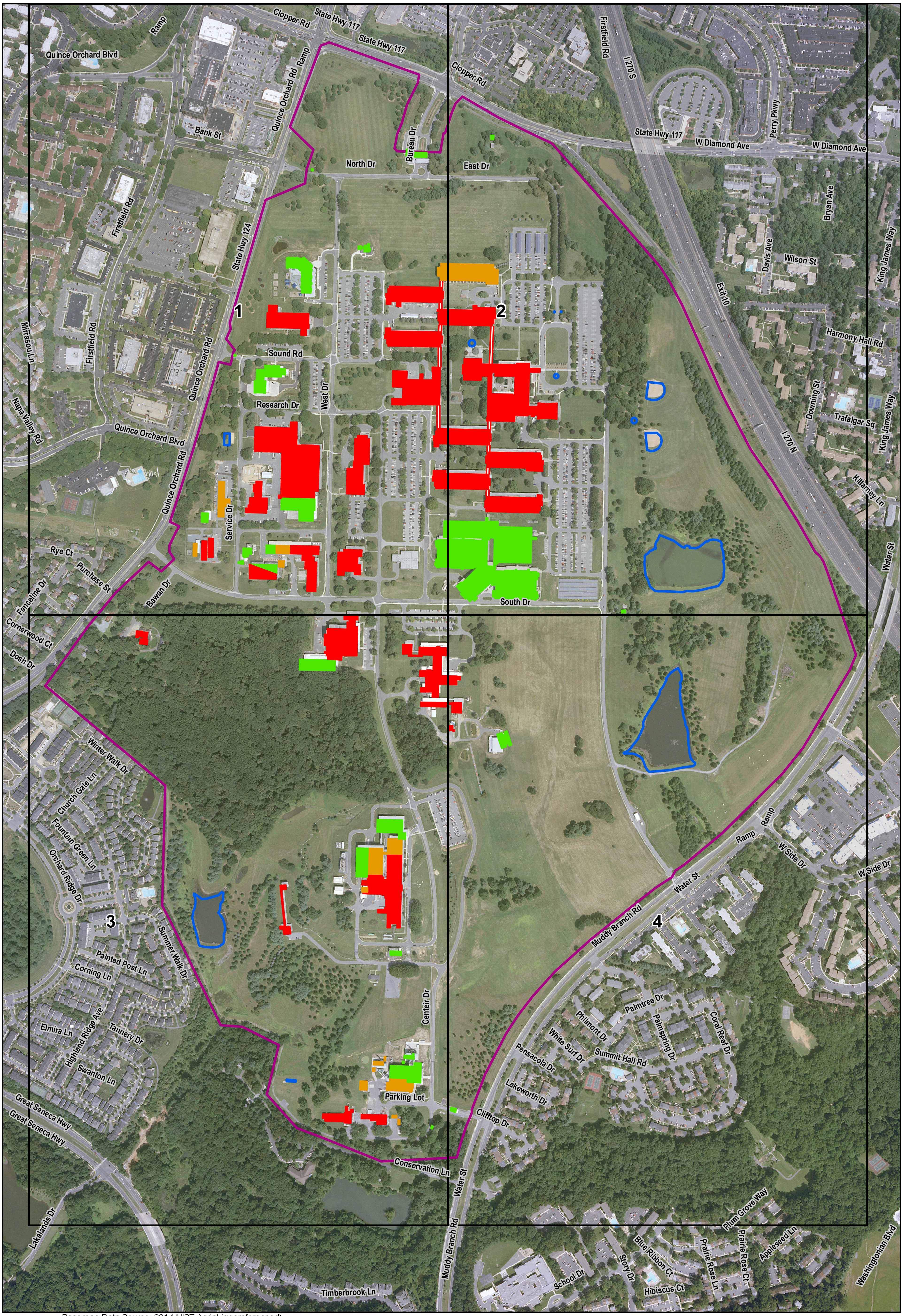
M_20_47_2015_03_03_049. Stormwater management pond,1 looking north

M_20_47_2015_05_14_050. Stormwater management pond 2, looking, northeast

M_20_47_2015_05_14_051. Baseball field 2, looking southeast

M_20_47_2015_05_14_052. Picnic area, looking northwest

M_20_47_2015_05_14_053. Volley ball court, looking northwest



Basemap Data Source: 2014 NIST Aerial (georeferenced)
MSR: 1:7,500
SRS: UTM Zone 18 / NAD 83

Meters: 0, 50, 100, 150
Feet: 0, 200, 400, 600

Building Construction Period
- 1960-1969
- 1970-1999
- 2000-2015
- Above Ground Walkway

- NIST Campus Boundary
- Map Sheet Boundary
- Landscape Feature

The landscape plan as a resource includes the original plan prepared by HLW International and incorporates the planting materials, objects, Building 101 courtyard, sidewalks, and road network.

Historic Assessment
National Institute of Standards and Technology
Gaithersburg, Maryland
NIST Campus Overview Map

R. Christopher Goodwin & Associates Inc. | 241 East Fourth Street, Suite 100 | Frederick, MD 21701 | Prepared By: KFM | Date: 3.10.2015

Historic Assessment
National Institute of Standards and Technology
Gaithersburg, Maryland

NIST Campus
Map: 1

R. Christopher Goodwin & Associates Inc. | 241 East Fourth Street, Suite 100 | Frederick, MD 21701 | Prepared By: KFM | Date: 3.10.2015

Basemap: 2014 NIST Aerial (georeferenced)
MSR: 1:3,500
SRS: UTM Zone 18 / NAD 83

0 25 50 75 Meters
0 100 200 300 Feet

Building Construction Period
- 1960-1969
- 1970-1999
- 2000-2015

- Above Ground Walkway
- NIST Campus Boundary
- Landscape Feature

The landscape plan as a resource includes the original plan prepared by HLW International and incorporates the planting materials, objects, Building 101 courtyard, sidewalks, and road network.

Historic Assessment
National Institute of Standards and Technology
Gaithersburg, Maryland

NIST Campus
Map: 2

R. Christopher Goodwin & Associates Inc. | 241 East Fourth Street, Suite 100 | Frederick, MD 21701 | Prepared By: KFM | Date: 3.10.2015

Basemap: 2014 NIST Aerial (georeferenced)
MSR: 1:3,500
SRS: UTM Zone 18 / NAD 83

N W E S

Meters: 0 25 50 75

Feet: 0 100 200 300

Building Construction Period
- 1960-1969
- 1970-1999
- 2000-2015

- Above Ground Walkway
- NIST Campus Boundary
- Landscape Feature

The landscape plan as a resource includes the original plan prepared by HLW International and incorporates the planting materials, objects, Building 101 courtyard, sidewalks, and road network.

Historic Assessment
National Institute of Standards and Technology
Gaithersburg, Maryland

NIST Campus
Map: 3

R. Christopher Goodwin & Associates Inc. | 241 East Fourth Street, Suite 100 | Frederick, MD 21701 | Prepared By: KFM | Date: 3.10.2015

Basemap: 2014 NIST Aerial (georeferenced)
MSR: 1:3,500
SRS: UTM Zone 18 / NAD 83

N E S W

0 25 50 75 Meters

0 100 200 300 Feet

Building Construction Period
- 1960-1969
- 1970-1999
- 2000-2015

- Above Ground Walkway
- NIST Campus Boundary
- Landscape Feature

The landscape plan as a resource includes the original plan prepared by HLW International and incorporates the planting materials, objects, Building 101 courtyard, sidewalks, and road network.

Historic Assessment
National Institute of Standards and Technology
Gaithersburg, Maryland

NIST Campus
Map: 4

R. Christopher Goodwin & Associates Inc. | 241 East Fourth Street, Suite 100 | Frederick, MD 21701 | Prepared By: KFM | Date: 3.10.2015

MARYLAND HISTORICAL TRUST
DETERMINATION OF ELIGIBILITY FORM

NR Eligible: yes ___
no ___

Property Name: National Institute of Standards and Technology (NIST) Inventory Number: M:20-47

Address: 100 Bureau Drive City: Gaithersburg Zip Code: 20899

County: Montgomery USGS Topographic Map: Gaithersburg and Rockville

Owner: United States of America Is the property being evaluated a district? X yes

Tax Parcel Number: P440 Tax Map Number: FT31 Tax Account ID Number: 00777838

Project: N/A Agency: N/A

Site visit by MHT Staff: X no ___ yes Name: _____ Date: _____

Is the property located within a historic district? ___ yes X no

If the property is within a district District Inventory Number: _____

NR-listed district ___ yes Eligible district ___ yes District Name: _____

Preparer's Recommendation: Contributing resource ___ yes ___ no Non-contributing but eligible in another context ___

If the property is not within a district (or the property is a district)

Preparer's Recommendation: Eligible X yes ___ no

Criteria: X A ___ B X C ___ D Considerations: ___ A ___ B ___ C ___ D ___ E ___ F ___ G ___ None

Documentation on the property/district is presented in:

Description of Property and Eligibility Determination: *(Use continuation sheet if necessary and attach map and photo)*

Property Description

The National Institute of Standards and Technology (NIST) encompasses approximately 578 acres in the City of Gaithersburg, in Montgomery County, Maryland (National Institute of Standards and Technology [NIST] 2014a). The campus comprises multiple buildings located on a formally landscaped campus organized by a grid network of internal roads. Large-scale, multi-story, monumental buildings separated by expansive parking areas and mowed lawn define the campus. The internal road network consists of roads running in north/south and east/west directions. The publically-restricted road network creates large superblocks occupied by research buildings. The primary research areas are clustered around the Administrative Building (Building 101) and the General Purpose Laboratories (GPLs).

Principal north/south roads include East, West, and Center drives. Center Drive provides access to the southern portion of the campus. North and South drives provide east/west access. Access to the support buildings is via Sound, Research, and Steam drives, and Service Drive, which runs in a north/south direction. No

MARYLAND HISTORICAL TRUST REVIEW
Eligibility recommended ___ **Eligibility not recommended** ___
Criteria: ___ **A** ___ **B** ___ **C** ___ **D** **Considerations:** ___ **A** ___ **B** ___ **C** ___ **D** ___ **E** ___ **F** ___ **G** ___ **None**
Comments:

Reviewer, Office of Preservation Services **Date**

Reviewer, NR Program **Date**

distinction in terms of design, landscaping, or road width is made between the service roads and the principal roads.

Summary History

Since its creation in 1901 as the National Bureau of Standards (NBS) in 1900, NIST has been at the cutting edge of scientific standardization and measurement. Work by NIST scientists has resulted in the standardization and measurement of nearly every facet of scientific inquiry. A small sampling of the testing and evaluation conducted by NIST scientists includes the development of standards for firefighting equipment; electricity and public utilities; and materials such as paints, cements, ceramics, rubber, paper, and leather products. The standards developed by NIST scientists have been widely adopted by private-sector industry. NIST also is an important research facility and scientists at the Gaithersburg campus conduct research and publish on a wide variety of topics. Selected areas of scientific investigation include fire research, environment and climate, physics, and law enforcement. NIST scientists continuously have made important contributions advancing scientific inquiry. Agency scientists have been recognized through numerous awards, including a number of Department of Commerce Gold Medals, an Emmy, and four Nobel Prizes.

NIST established an architectural identity for the agency when it constructed a research campus in Gaithersburg, Maryland, beginning in 1961. The agency selected the nationally preeminent architectural firm in the design of research and corporate campuses for the Gaithersburg campus. The firm of HLW International is recognized as national experts in the design of postwar research campuses.[1] The agency, in collaboration with the architects, participated in thoughtful and intensive architectural programming to design a campus that met the agency's needs and those of its scientists. The result was a research campus similar in design to campuses constructed for the public and private sectors during the 1950s and 1960s, but unique to the demands of the NIST mission. The existing campus was constructed during three major periods of development: Initial Construction (1961-1969), Second Period (1970-1999), and Third Period (2000-2015). Buildings completed during the Initial Construction period were designed in the International Style. Character-defining features of the style include curtain-wall construction, ample use of glass, clean monolithic forms, and minimal ornamentation. Buildings constructed in support of the NIST mission and representative of buildings constructed for postwar research campuses include administrative/laboratory buildings, special purpose laboratories, and support buildings. Recreational resources and an example of postwar domestic architecture also are included in the NIST inventory.

Additional information on the history of NIST can be found in the accompanying Maryland Inventory of Historic Properties (MIHP) form and in the technical report, *Historic Assessment, National Institute of Standards and Technology*, prepared by R. Christopher Goodwin & Associates, Inc. (2015).

Evaluation Results

A total of 74 buildings, structures, objects, and landscapes were documented under the current investigation. Analysis of archival and architectural data applying the National Register of Historic Places (NRHP) Criteria for Evaluation (36 CFR 60.4[a-d]) identified a cohesive collection of buildings, structures, and landscapes that represent a recognizable entity united by design and historical association within the Initial Construction period of the NIST campus (1961 – 1969).

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[1] The architectural firm that designed the Gaithersburg campus, Voorhees Walker Smith Smith & Haines, underwent a number of name changes since it was established. Name changes also occurred during the design and construction of the facility. For simplification and to avoid confusion, HLW International (the firm's current name" will be sued for all future references to the original design team.

At the time of its construction, the NIST Gaithersburg campus incorporated current innovations and approaches to the design of research campuses. Its suburban setting; formal landscape; greenspace; ample parking; large-scale, monumental buildings; and, general and specialized laboratories are hallmarks of postwar research campus design. Importantly, the GPLs included modular administrative/laboratory space, which maximized flexibility and ensured that the buildings were easily adaptable to changing research needs. Movable or demountable walls were an easy, quick, and cost effective way to modify laboratory space based on project need and requirements. Spatial flexibility was important to an agency devoted to scientific evaluation, testing, and experimentation. By the time HLW International designed the NIST campus, the firm had almost 30 years of experience designing research facilities. It had developed protocols and best practices for close client involvement. These practices included surveying scientists to ascertain needs, design review and development using scaled models, and building-specific programming for specialized laboratories.

The buildings constructed between 1961 and 1969 exhibit many of the hallmarks of postwar research campus design. These character-defining features include flexible workspaces that could be configured in a variety of different ways to suit current research/laboratory needs regardless of the research discipline. The buildings were constructed incorporating administrative/laboratory modules. The buildings are linear in plan, housing modules across a double-loaded hallway. The back-to-back laboratories were across from the exterior-facing administrative spaces. Long hallways would encourage spontaneous discussions among colleagues. In this manner, scientists could collaborate and discuss research problems in informal settings. The acreage afforded by the suburban site was acquired, in part, to facilitate expansion, as necessary. Greenspace with formal landscaping was held to be conducive to scientific inquiry and created a working environment reminiscent of an academic campus.

Following the construction of the original buildings in accordance with the plans prepared by HLW International, few large-scale buildings were constructed. The majority of construction projects completed during the Second Period of development expanded earlier buildings through major additions. Smaller-scale new buildings also were added during the period. Construction of the AML complex during the first decade of the twenty-first century initiated a major new building campaign.

Building 101 is the central focus of the campus and is a representative of the International Style applied to a principal building within a research complex. Similar to many private-sector research campuses of the period, the principal building was the primary focus for public space and architectural elaboration; Building 101 became an icon for the agency. Curtain-wall construction, generous use of windows, and minimal ornamentation, hallmarks of the style, are employed on the building. Public space is incorporated in the large lobby and cafeteria, spaces designed to encourage social interaction. Other public spaces include auditoriums that provide forums for professional presentations.

A comprehensive site plan was designed and implemented for the campus. A grid street system provides access to the research laboratories. Lawn, mature specimen and deciduous trees, hardscapes, and storm water management ponds were incorporated in the landscape. The cohesive area capturing the design and operation of the campus during its initial period of development is defined by nine contributing resources, including the Administration Building, seven GPLs, and Building 304, encompassed by the area generally defined by East Drive to the east, the AML complex to the south, and Research Drive to the west. The northern edge of the historic district extends 205 feet from the north elevation of Building 226, which is the distance between the existing GPLs. The AML complex comprising Buildings 215, 216, 217, 218, and 219 are excluded from the proposed historic district. The interconnected buildings, while incorporating similar building materials as the GPLs, were designed as a complex unique from the general purpose labs architecturally, structurally, and in sophistication of the environmental controls systems. Two of the buildings are entirely underground.

Additionally, the buildings were constructed during the past thirteen years. Insufficient time has elapsed to enable evaluation of the complex under National Register Criteria A and C. The complex does not appear to rise to the level of exceptional significance as defined under Criteria Consideration G.

The proposed NIST historic district is significant under Criterion A for its association with events that have made important contributions to the broad patterns of history under the theme of Science and Technology and under Criterion C as a recognizable entity that embodies the characteristics of Postwar Research Campus design. Buildings in the historic district were designed by an architecture and engineering firm with an established national practice specializing in research campuses. HLW International was the acknowledged expert in designing research laboratories and was a design innovator in the field. The NIST campus is representative of the firm's body of work.

Thirteen resources are included in the NRHP-eligible historic district; two of the resources (Building 227 and the Entrance Gates) are non-contributing. The designed landscape, including the Newton apple tree, is a contributing resource to the district. In addition to contributing to the NRHP, Building 101 individually is eligible for listing in NRHP for the quality of its architectural design as the campus administrative headquarters (Criterion C). All contributing resources in the proposed NIST historic district were completed between 1965 and 1966. Contributing buildings the NRHP-eligible historic districted are identified in the attached table.

Resources excluded from the historic district generally comprise support and utility buildings, such as Buildings 301 and 302, which did not directly support the agency's scientific mission, recently constructed buildings, or buildings with major recent additions. The NRHP-eligible historic district is depicted in on the attached maps. Campus-wide resource evaluations are presented in the accompanying tables.

Summary and Conclusion

The resources contained with the NIST Gaithersburg campus were analyzed applying the NRHP Criteria for Evaluation (36 CFR 60.4[a-d]). Site investigation and resource evaluation indicated that resources at the Gaithersburg campus are significant within the themes of Science and Technology and Postwar Research Campus Design (Criterion A). The facility also represents a significant and distinguishable entity whose components may lack individual distinction (Criterion C). Additionally, Building 101 individually possesses the significance and integrity for NRHP consideration under Criterion C as a representative example of the International Style.

Prepared by:	Kirsten Peeler Senior Project Manager R. Christopher Goodwin & Associates, Inc. 241 East Fourth Street Frederick, MD 21701	Date Prepared:	June 2015

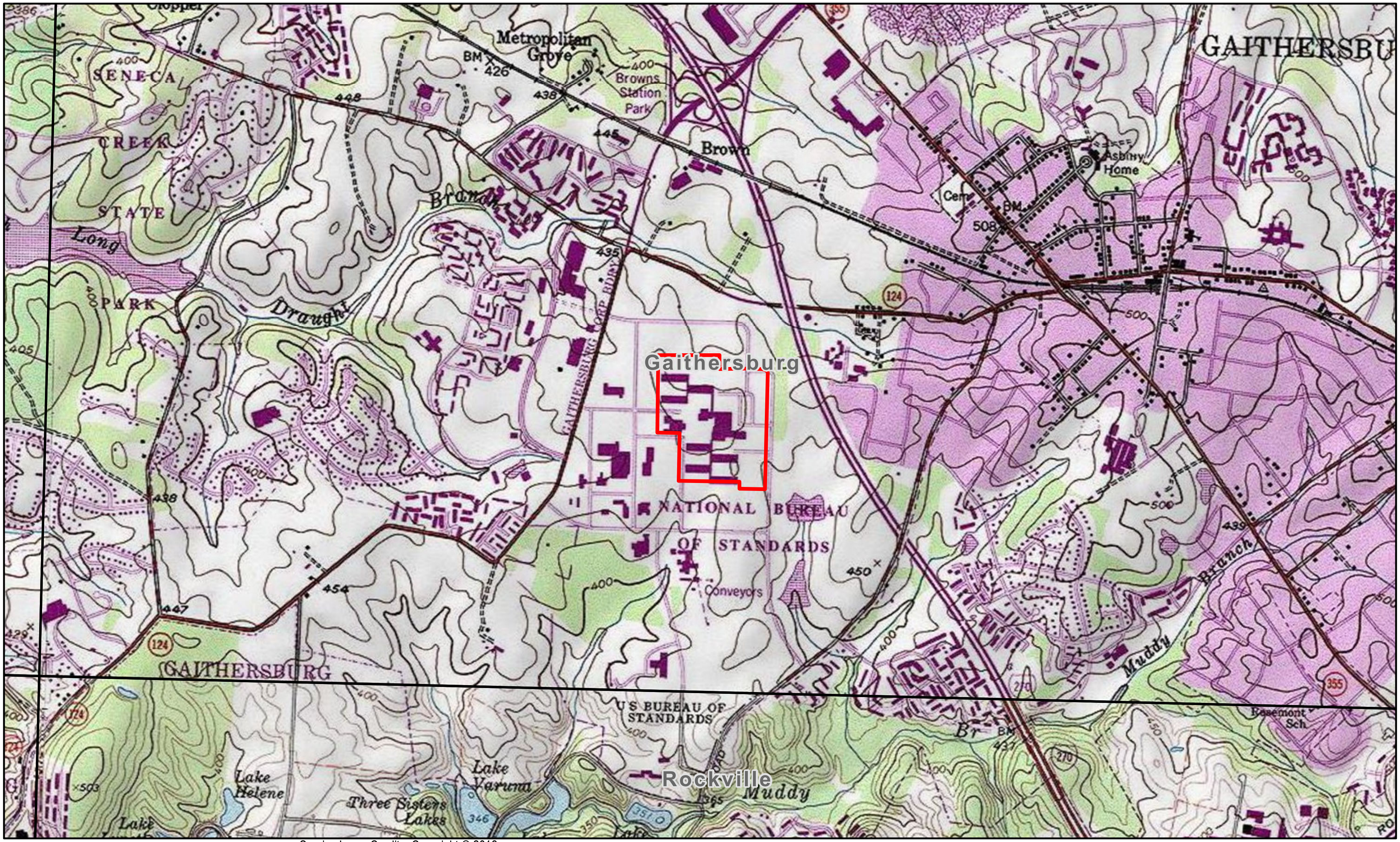
Contributing and Non-Contributing Resources – NIST Historic District

Building Number	Building Name	Construction Date	Resource Evaluation
101	Administration Building	1962-1965	Contributing and individually eligible under A and C
220	Metrology	1963-1966	Contributing
221	Physics	1963-1966	Contributing
222	Chemistry	1963-1966	Contributing
223	Materials	1963-1966	Contributing
224	Polymer	1963-1966	Contributing
225	Technology	1963-1966	Contributing
226	Building Research	1963-1966	Contributing
227	Advanced Chemical Sciences Laboratory	1999	Non-contributing
304	Shops	1962-1964	Contributing
Campus Landscape Plan (including Newton Apple Tree)		1961-1969; 1966	Contributing
Flag Pole		1965	Contributing
Entrance Gates		1976	Non-contributing

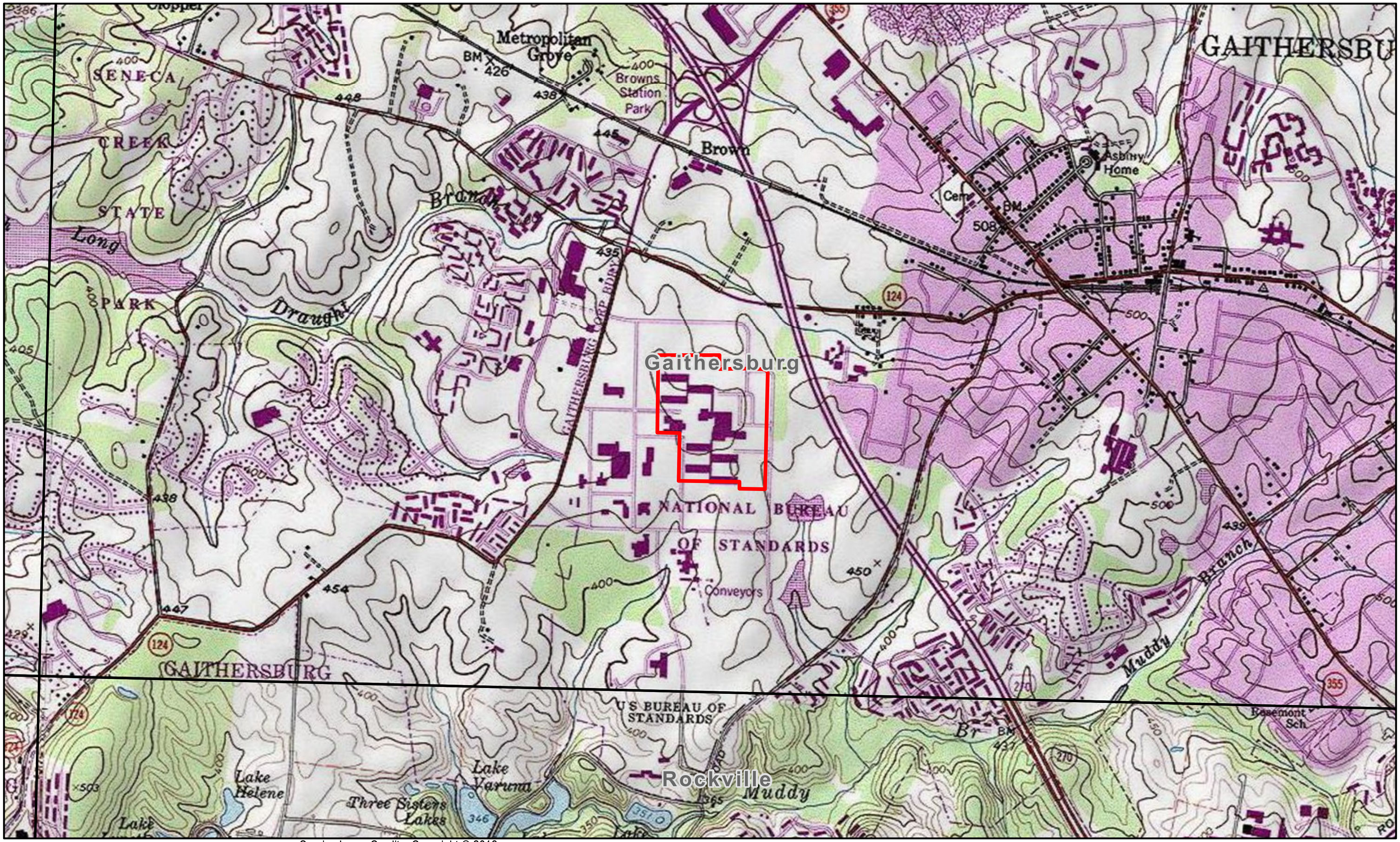
National Register Eligibility – NIST Gaithersburg Campus

Building Number	Building Name	Construction Date	Resource Evaluation
103	Visitor's Center and Gate House	2009	Not eligible
B	Gate House	ca. 2009	Not eligible
C	Gate House	ca. 2009	Not eligible
F	Gate House	ca. 2009	Not eligible
202	Engineering Mechanics	1961-1963	Not eligible
203	Standard Reference Materials Facility	2012	Not eligible
205	Large Fire Facility	1973-1975; 2014	Not eligible
205E	Emissions Control Electrical	ca. 2000	Not eligible
205M	Emissions Control Mechanical	ca. 2000	Not eligible
205E#2	Emissions Control Electrical	ca. 2014	Not eligible
205M2	Emissions Control Mechanical	ca. 2014	Not eligible
2	Hopper	ca. 2014	Not eligible
3	Hopper	ca. 2000	Not eligible
206	Concrete Materials	1966-1968	Not eligible
207	Robot Test Facility	2012	Not eligible
208	Net-Zero Energy Residential Test Facility	2012	Not eligible
215	Nanofabrication Facility	2002-2004	Not eligible under Criteria or Criteria Consideration G
216	Center for Nanoscience and Technology (Instrument East)	2001-2002	Not eligible under Criteria or Criteria Consideration
217	AML Instrument West	2002-2004	Not eligible under Criteria or Criteria Consideration
218	AML Metrology East	2000-2004	Not eligible under Criteria or Criteria Consideration
219	AML Metrology West	2000-2004	Not eligible under Criteria or Criteria Consideration
230	Fluid Mechanics	1967-1969	Not eligible
231	Industrial	1966-1968	Not eligible
233	Sound	1965-1968	Not eligible
235	NCNR	1963-1967	Not eligible
236	Hazards	1966-1968	Not eligible
237	Non-magnetic Laboratory	1964-1968	Not eligible
238	Non-magnetic Laboratory	1964-1968	Not eligible
245	Radiation Physics	1962-1964	Not eligible

Building Number	Building Name	Construction Date	Resource Evaluation
301	Supply and Plant	1962-1964; 2013	Not eligible
302	Steam and Chilled Water Generation Plant	1961-1964; ca. 1990s; ca. 2010	Not eligible
303	Service	1962-1964	Not eligible
305	Cooling Tower	1961-1964;2011	Not eligible
306	Potomac Electric Power Company (PEPCO) Electrical Substation	ca. 1970	Not eligible
306A	PEPCO	1961-1964	Not eligible
306B	PEPCO	1961-1964	Not eligible
307	Hazardous Chemical Waste Storage	1970-1971	Not eligible
308	Bowman House	1952-1953	Not eligible
309	Grounds Maintenance	1974-1978	Not eligible
310	Hazardous Materials Storage	1986-1987	Not eligible
311	Grounds Storage Shed	1990	Not eligible
312	Materials Processing Facility	1996	Not eligible
313	Site Effluent Neutralization	1996	Not eligible
314	Backflow Preventer Building	1998	Not eligible
315	Backflow Preventer Building	1998	Not eligible
316	Electrical Service Building	1998	Not eligible
317	Cooling Tower	2010	Not eligible
1	Building associated with 317	2010	Not eligible
318	ES Consolidated Facility	2014	Not eligible
319	ES Storage Building	2014	Not eligible
320	CCC	2013	Not eligible
321	Liquid Helium Recovery Facility	Under construction	Not eligible
Baseball Field 1		Late 1990s	Not eligible
Baseball Field 2		Late 1990s	Not eligible
Volley Ball Court		ca. 2009	Not eligible
Picnic Area		Late 20th century	Not eligible
Stormwater Management Pond 1		ca. 1965	Not eligible
Stormwater Management Pond 2		ca. 1965	Not eligible
Stormwater Management Pond 3		ca. 2006	Not eligible
Masonry Test Wall		1977	Not eligible



Historic Assessment
National Institute of Standards and Technology
Gaithersburg, Maryland
Quad Locator Map



SRS: UTM Zone 18 / NAD 83
MSR: 1:24,000

0 0.25 0.5 0.75 1 Kilometers

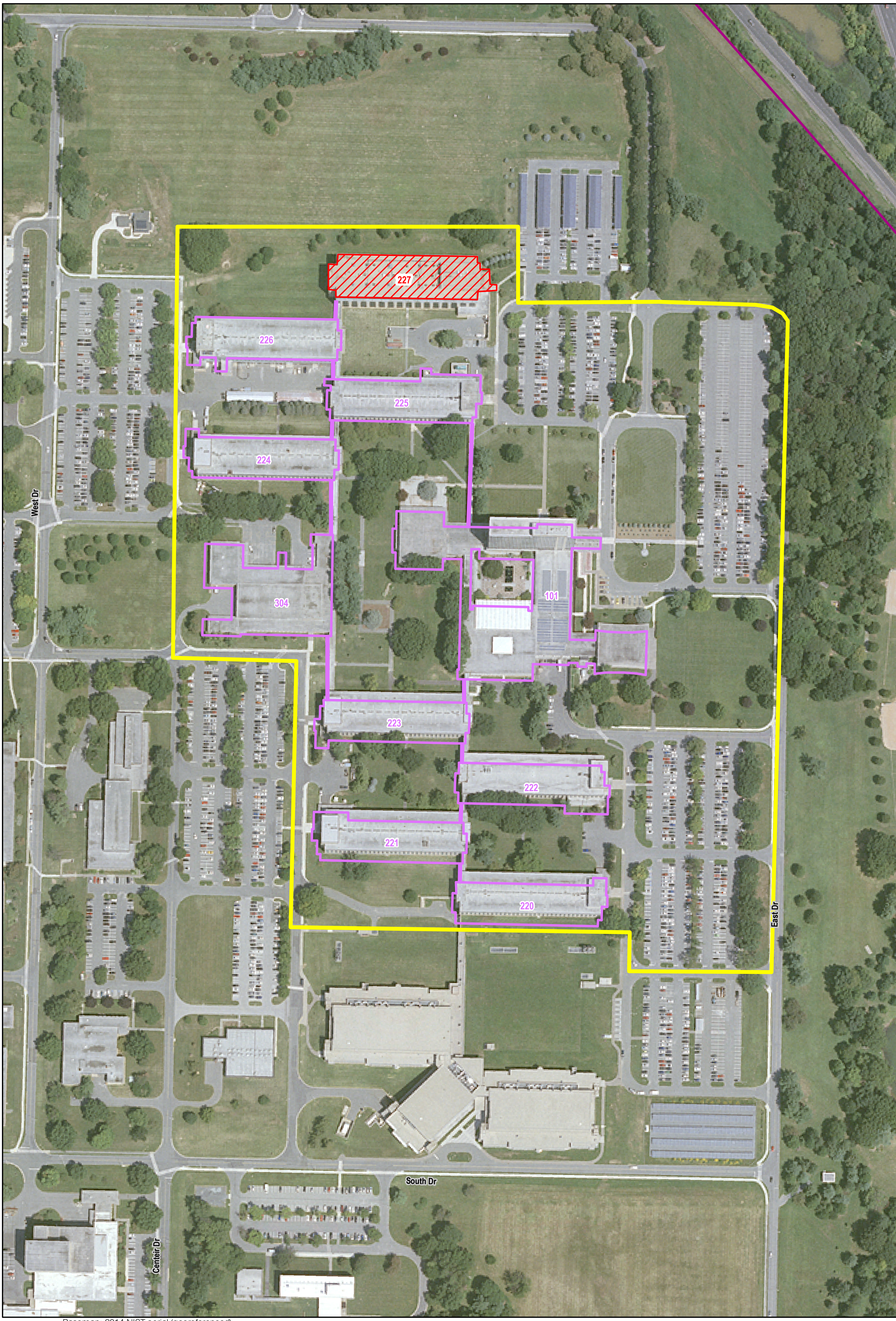
0 0.25 0.5 0.75 1 Miles

Historic District Boundary

USGS 24k Topo Map Boundaries

Historic Assessment
National Institute of Standards and Technology
Gaithersburg, Maryland
Quad Locator Map

R. Christopher Goodwin & Associates Inc. | 241 East Fourth Street, Suite 100 | Frederick, MD 21701 | Prepared By: KFM | Date: 6.3.2015



Basemap: 2014 NIST aerial (georeferenced)
MSR: 1:2,800
SRS: UTM Zone 18 / NAD 83

Meters: 0 10 20 30
Feet: 0 50 100 150

- Contributing Building
- Non-contributing Building
- Proposed Historic District Boundary
- NIST Campus Boundary

Historic Assessment
National Institute of Standards and Technology
Gaithersburg, Maryland
Proposed Historic District

R. Christopher Goodwin & Associates Inc. | 241 East Fourth Street, Suite 100 | Frederick, MD 21701 | Prepared By: KFM | Date: 6.3.2015

APPENDIX II

RESUMES OF KEY PROJECT PERSONNEL

KATHRYN M. KURANDA, M. ARCH.HIST.

SENIOR VICE PRESIDENT
HISTORICAL & ARCHITECTURAL SVCS.

Ms. Kathryn M. Kuranda, M. Arch. Hist., Senior Vice-President – Architectural and Historical Services, directs the architectural history and history programs of R. Christopher Goodwin & Associates, Inc. Ms. Kuranda holds a Bachelor of Arts degree in American Studies from Dickinson College and a Master of Architectural History degree from the University of Virginia. Ms. Kuranda's professional qualifications exceed those established by the Secretary of the Interior in the field of architectural history. She is a court-qualified architectural historian.

Ms. Kuranda has managed heritage resource investigations across the United States, in the Caribbean, and in Europe. Her early career with the Colorado Department of Highways and the Nevada State Historic Preservation Office provided hands-on experience in the identification, evaluation, and management of active and historic mining resources and landscapes. Since joining R. Christopher Goodwin & Associates, Inc. as a Senior Project Manager in 1989, Ms. Kuranda has served as Principal Investigator on numerous cultural resource investigations involving large and complex properties. These properties have ranged from the Mississippi Basin Model, the last physical model employed by the U.S. Army Corps of Engineers; to DoD's nationwide Capehart Wherry Housing Programs, to the Enrico Fermi Atomic Power Plant.

She has directed architectural survey projects ranging in scale from single building, to multi-component industrial facilities, to state- and nation-wide multiple-property efforts covering thousands of properties. She has designed and directed nationwide Cultural Heritage Studies in support of holistic Federal agency compliance with the National Historic Preservation Act of 1966, as amended , including historic contexts for the evaluation of Department of Defense Cantonments constructed between 1790 and 1940, for the Navy Guided Missile Program, for World War II Permanent Military Construction, for Army Fixed Wing Air Fields, and for DoD Ammunition Production and Storage, and Unaccompanied Housing (UPH). These studies have become standard references in the field.

Ms. Kuranda possesses particular expertise in American vernacular architectural history, preservation technologies, and historic preservation applied practice. She has extensive working knowledge in fulfilling the provisions of 36 CFR Part 800, Protection of Historic Properties, and in supporting the development of agreement documents (MOAs and PAs) to avoid, limit, or mitigate effects under Section 106 of the National Historic Preservation Act of 1966, as amended. Her staff of architectural historians and historians is comprised of seasoned practitioners in the field.

KIRSTEN G. PEELER, M.S., B.A. — SENIOR PROJECT MANAGER

Kirsten Peeler, M.S., Senior Project Manager, received a Master of Science degree in Historic Preservation from Columbia University. While at Goodwin & Associates, Inc., Ms. Peeler completed numerous historic contexts representing a broad spectrum of property types. These include the development of a historic context for the National Air and Space Administration's (NASA) Goddard Space Flight Center (GSFC). Many of the GSFC architectural resources date from the recent past and are associated with complex testing to support space missions. Due to the specialized and unique NASA missions, the historic context required a synthesis and presentation of complex scientific concepts and terminology.

Ms. Peeler also prepared historic contexts for Department of Defense clients including two nationwide contexts on family housing constructed between 1949 and 1962 by the Departments of the Army, Air Force, and Navy. These historic contexts were a component in an innovative strategy developed by the Departments of the Army, Air Force, and the Navy and Advisory Council on Historic Preservation for compliance with Section 106 of the National Historic Preservation Act of 1966, as amended. As part of the project, she developed design guidelines for Army neighborhoods built during the 1950s and early 1960s and a tax credit brochure for the Departments of the Air Force and the Navy summarizing the federal Rehabilitation Tax Credit program. A 20-minute broadcast quality video documentary on three Army neighborhoods also was produced as part of the project. Serving as producer, Ms. Peeler wrote the script and provided project oversight on all aspects of the project including the filming and editing process. She also developed a historic context for the Washington Air National Guard. Ms. Peeler conducted field investigation at seven Washington Air National Guard facilities and analyzed and synthesized the report.

Ms. Peeler prepared a number of Integrated Cultural Resources Management Plans (ICRMPs) for federal agencies including NASA's Goddard Space Flight Center and the Department of the Air Force. ICRMPs prepared for the Air Force include the Georgia Air National Guard at Savannah / Hilton Head International Airport, Georgia; Otis Air National Guard Base, Massachusetts; 148 Fighter Wing, Duluth International Airport, Minnesota; and 114 Fighter Wing, Joe Foss Field, South Dakota. The documents were completed to support the Air National Guard's cultural resources management program, which requires the identification and evaluation of resources, implementation of protection and compliance actions for historic properties, and collaboration with internal and external stakeholders.

Ms. Peeler participated in the architectural survey for the National Register nomination for Baltimore East/South Clifton Park Historic District. She prepared National Register nominations for the Cardiff-Whiteford Historic District and the Fort Belvoir Historic District. She also conducted architectural investigations and resource evaluations for NASA's Goddard Space Flight Center, a late twentieth-century facility. The data were presented in a Maryland Inventory of Historic Properties form and a Determination of Eligibility form. Additionally, Ms. Peeler has conducted surveys and evaluations applying the National Register criteria on numerous projects in Maryland, Texas, Georgia, Arizona, Ohio, Virginia, Vermont, Tennessee, Washington, Michigan, North Carolina, Pennsylvania, and Missouri.

Prior to joining Goodwin & Associates, Inc., Ms. Peeler was the historic preservation planner for the City of Frederick. While at the City, she provided technical assistance to the Historic District Commission and property owners in the Frederick Town Historic District; authored design guidelines for the Frederick Town Historic District; and wrote a quarterly newsletter that summarized technical information on the care and maintenance of historic properties in a practical, easy-to-read format.

Ms. Peeler gained her practical preservation experience while at the Historic Warehouse District Development Corporation (HWDDC), a non-profit community development organization in Cleveland, Ohio. In Cleveland, Ms. Peeler staffed the organization's design review committee and represented the non-profit at Cleveland Landmarks Commission hearings. While at HWDDC, she managed the City's Storefront Renovation Program, a city program that provides technical and financial assistance to property owners undertaking rehabilitation projects.

KATHERINE E. GRANDINE, M.A. SENIOR PROJECT MANAGER / SENIOR HISTORIAN

Ms. Katherine Grandine, Senior Project Manager/Senior Historian, received a Master of Arts degree in American Civilization with Emphasis on Historic Preservation in 1983 from the George Washington University, Washington, D.C. She has been professionally active in the field of historic preservation since 1981. Ms. Grandine has extensive experience in conducting historical research for a wide variety of projects and applications. Her project experience includes historic research for nationwide context studies and for local history, architectural surveys in numerous states, Historic American Buildings Survey documentation, National Register of Historic Places nominations, local landmark and historic district nominations, historic property mitigation documentation, and cultural resources planning documents.

Ms. Grandine is especially proud of her contributions to the development of nationwide military historic contexts, including the National Historic Context for Department of Defense (DoD) Installations from 1790 to 1940, support and utility structures from 1917 to 1946, and Air Force and Navy Wherry and Capehart housing. She also conducted research and managed cultural resource investigations for 36 state parks and wildlife management areas for the Maryland Department of Natural Resources. She has performed numerous reconnaissance-level and intensive-level architectural surveys in a variety of urban and rural settings in Maryland, Virginia, Pennsylvania, Ohio, North Carolina, New York, and at numerous DoD installations nationwide. She has conducted literature searches for Phase I archeological surveys and undertaken in-depth archival research for Phase II and Phase III archeological studies in the Mid-Atlantic region. She has extensive experience in researching in local primary documents including land records, deeds, wills, and tax records to support archeological and architectural documentation projects. She has managed numerous architectural survey and evaluation projects and written National Register nominations for individual properties and large historic districts. She has co-authored integrated cultural resources management plans and numerous technical reports, and provided technical support for a variety of cultural resources projects.