

HISTORIC STRUCTURE REPORT

NATIONAL BUREAU OF STANDARDS RADIO BUILDING (BUILDING 1)

U.S. Department of Commerce Boulder Laboratories
Boulder, Colorado

July 2018

Prepared by

studiotrope Design Collective (sDC)
2942 Welton Street
Denver, Colorado 80205

AECOM
6200 S. Quebec Street
Greenwood Village, Colorado 80111

Prepared for

U.S. Department of Commerce
National Institute of Standards and Technology
Boulder Laboratories
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Project Data

Location

The National Bureau of Standards (NBS) Radio Building (Building 1) is within the U.S. Department of Commerce Boulder Laboratories at 325 Broadway Street in Boulder, Boulder County, Colorado.

Ownership

Building 1 is owned by the U.S. Department of Commerce National Institute of Standards and Technology (NIST).

National Register of Historic Places Status

NIST determined that Building 1 is eligible for listing in the National Register of Historic Places (NRHP) under Criteria A and C. Building 1 is significant under NRHP Criterion A for its associations with the broad patterns of history of the NBS. The building is associated with the growth and expanding research activities of the NBS and the Central Radio Propagation Laboratory in the post-World War II era, when agency activities began to play a key role in Cold War technology and research. When Building 1 was completed, it was considered the flagship building of the Boulder site. With its prominent and visible location along Broadway Street and its cutting edge architecture, Building 1 conveyed the NBS's image as a progressive and modern agency. The building is significant under NRHP Criterion C as a good example of the International style and of the post-World War II research campus model.

Project Participants

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Executive Summary

ES1. Purpose and Scope

Between 2012 and 2016, the National Institute of Standards and Technology (NIST) completed improvements to Wings 3 and 6 of Building 1, an undertaking under Section 106 of the National Historic Preservation Act (54 US Code 206108). Subsequent to the commencement of those improvements, Building 1 was determined eligible for listing in the National Register of Historic Places (NRHP) in consultation with the Colorado State Historic Preservation Officer (SHPO) for its significance to the history of science and its architectural design. NIST consulted with the SHPO and the City of Boulder pursuant to 36 Code of Federal Regulations (CFR) Part 800, the regulations implementing Section 106, and NIST and SHPO concurred that the undertaking resulted in adverse effects to Building 1. NIST notified the Advisory Council on Historic Preservation (ACHP) of the undertaking in accordance with 36 CFR Part 800.6(a)(1) and ACHP chose to participate in the consultation process pursuant to 36 CFR Part 800.6(a)(1)(iii). In order to mitigate the adverse effect, a memorandum of agreement was subsequently drafted, which stipulated the development of a historic structure report (HSR) with preservation zone plans prior to the implementation of any future phase of improvements to Building 1. This report was completed to fulfill that stipulation.

ES2. Goals of the Historic Structure Report

This HSR was prepared to provide documentary, graphic, and physical information about the history of Building 1 and its existing condition. The goal of this report is to provide NIST with a guide for future improvements to Building 1. This HSR documents the history, construction, and evolution of the building; its historic significance; and its current condition. It also provides historic preservation objectives, selected treatments as defined by the Secretary of the Interior's Standards for the Treatment of Historic Properties (Standards) (National Park Service [NPS] 2017), and recommendations for work.

ES3. Methodology

The HSR was prepared pursuant to the guidelines set forth in *Preservation Brief 43: The Preparation and Use of Historic Structure Reports* (Slaton 1995). AECOM's team included of an architectural historian and a historic architect who meet the Secretary of the Interior's Professional Qualification Standards for Architectural History and Historic Architecture, respectively, as defined in 36 CFR Part 61. The architectural historian and historic architect were supported by AECOM structural, mechanical, and electrical engineers and studiotrope Design Collective (sDC) architects.

The team conducted an extensive exterior and interior investigation and condition assessment of Building 1. Historical research was conducted using documents obtained from NIST library in Gaithersburg, Maryland; documents, architectural drawings, and historic photos provided by NIST Boulder Laboratories, and archives located at the Carnegie Library for Local History in Boulder.

ES4. Report Findings

ES4.1 Brief Physical Description

Building 1 is located within the NIST Boulder campus at 325 Broadway Street (State Route 93) on the south side of Boulder in Boulder County, Colorado. Access to the campus is by way of a two-lane paved roadway known as Rayleigh Road, which branches off of Broadway Street to the west. Building 1 includes a front portion, known as the "Front of the House", and three pairs of wings (Wings 1 through 6) radiating outward from a central Spine. Building 1 is on a

northeast/southwest axis, with the Front of the House facing northeast and the end of the Spine facing southwest.

Building 1, including the Front of the House, the Spine, and Wings 1 through 4, was completed in 1954, and Wings 5 and 6 were completed in 1962 and 1959, respectively. The building is constructed of cast-in-place, reinforced concrete posts and beams and with a precast concrete tee-joint roof system. The exterior walls are a combination of cast-in-place concrete built using oiled plywood forms and native sandstone. The flat roof is clad with composition roofing in most locations. The Front of the House is on the north end of the Spine and the wings intersect the Spine at equidistant intervals to the south of the Front of the House. The building was constructed on a slight grade and gradually steps up the sloping terrain while the roof of the Spine remains at a constant level.

Building 1 is an example of Modernist architecture with design elements of the International style, which was considered cutting edge in the early 1950s. Those elements include cast-in-place concrete and concrete block construction, a horizontal orientation, a flat roof, horizontal bands of windows, and minimal exterior ornamentation. The building also possesses elements of Functionalism, a variation of the International style based on the theory that building design should emphasize functional efficiency. The building was designed to accommodate the entire laboratory, support, and administrative functions of the Central Radio Propagation Laboratory (CRPL) in one building, with architectural detailing focused on the public and common areas in the Front of the House and more utilitarian design in the Spine and wings to be used as laboratory and office spaces. The building's architects also appear to have been influenced by Organic Architecture, an American response to European Modernist architecture initiated by Frank Lloyd Wright. This influence is reflected in the architects' use of the existing terrain in the design of the building, the use of native stone details in the Front of the House, and the low profile of the building designed to preserve views of the Flatirons beyond (City of Phoenix Historic Preservation Office and Ryden Architects 2010).

ES4.2 Condition Assessment

The condition of the building was assessed as good, fair, or poor, with good defined as intact and structurally sound; fair defined as early signs of wear; and poor defined as no longer performing its intended purpose. Building 1 is generally in good condition, including the building envelope, exterior architectural finishes, and weather protection components (joints, windows, and roofing systems), as well as the interior architectural finishes (floors, doors, and ceilings). A few places have been observed to be in fair and poor condition, including portions of the roof, the original windows, exterior doors and hardware, and some concrete finishes. Damages to the concrete include spalling, staining, cracks, and exposed corroding reinforcing bars. Due to the age of the building, numerous mechanical and plumbing features were found to be non-compliant with current codes.

ES4.3 Historic Character-Defining Features

All extant original exterior elements of Building 1 contribute to its character and its eligibility for listing in the NRHP. On the interior, character-defining features are concentrated in the Front of the House, which, as the original public entrance to the campus and the location of the building's common areas, possesses all the building's architectural ornamentation while the rest of the building is more utilitarian in design. To support the scientific mission of the NBS and the CRPL, alterations to the interior of Building 1 began soon after the building was constructed and have continued throughout the building's history. The historic integrity of the laboratory and office spaces in the Spine and wings has been compromised by these alterations, and the only character-defining features that remain intact in the interior of the Spine and wings are the configuration of the double-loaded corridors. Major character-defining features are described in detail in the following sections.

Site

- The spatial relationship of the Building 1 footprint, the lawns and landscaped exterior courtyard at the Front of the House, and the outdoor spaces between the wings.
- The setting of the building within the topography of the site, including the Spine's position within the existing slope and the ascending intersections of the wings.
- The axial siting of the building toward Broadway Street.

Exterior

- Modernist architecture with design elements of the International Style, Organic architecture, and Functionalism.
- Overall configuration, massing, and scale as a singular large resource with common areas with expansive office and laboratory wings.
- Exterior wall finishes, including native sandstone and cast-in-place concrete.
- Low, horizontal orientation emphasized by flat roofs, horizontal bands of windows, bays formed by exposed concrete structural post and beam, rooftop monitor clerestories in the wings, and contrasting vertical divisions in the Front of the House.
- Extant concrete sunshades above the windows on the Spine and Wings 1, 2, and 4.

Interior

- The north, south, and central division floor plan in the Front of the House and the north end of the Spine including the auditorium, library, and lobby/entrance space.
- Extant original Interior finishes in the Front of the House including:
 - terrazzo flooring and baseboards;
 - travertine wall panels;
 - original single- and double-leaf wood doors;
 - exposed native sandstone walls;
 - birch and walnut plywood paneling;
 - built-in display cases in the foyer;
 - jagged/sloping pattern of east and west auditorium walls
- Configuration of the double-loaded corridors (central corridors with offices and laboratory spaces on either side) in the Spine and the wings.

ES4.4 Historic Preservation Objectives and Work Recommendations

The Standards identify four treatment approaches for historically significant resources such as Building 1 – Preservation, Rehabilitation, Restoration, and Reconstruction. Given the goals of NIST, the most appropriate treatment approach for Building 1 is Rehabilitation, which would preserve materials and features that convey the building's historical and architectural values, while allowing for the necessary repairs and upgrades.

As part of its 2017 Master Plan (Metropolitan Architects and Planners 2017a), NIST initiated a phased renovation and upgrade program for Building 1 to replace outdated systems and meet the performance level required for NIST's research. The renovations of Wings 3 and 6 were previously completed. Future projects to renovate the remaining sections of the building, including the Front of the House, the Spine, and Wings 1, 2, 4, and 5, should be designed and executed in accordance with the appropriate recommended NPS standards and guidelines for rehabilitation (NPS 2017). Future designs should be analyzed on a case-by-case basis by professionals meeting the Secretary of the Interior's Professional Qualification Standards for History and Architectural History, as well as Historic Architecture, if warranted, to determine if those projects meet the appropriate recommended Standards.

Specific work recommendations were made for the structural, mechanical and plumbing, and electrical aspects of Building 1, including repairs to the structural concrete; recommendations for seismic retrofit and occupancy and uses; replacement of original windows and doors with in-kind or compatible types; and other recommendations regarding insulation, roof assemblies; heating, ventilation, and air conditioning (HVAC); plumbing, and electrical systems.

ES5. Organization of the Report

The HSR is organized into three parts as follows:

Part 1 – Developmental History

- Chapter 1 provides the historical background and context of Building 1, including a brief history of the property, its context, and its designers and builders.
- Chapter 2 provides a chronology of development and use, including a description of original construction, modifications, and uses, based on historical documentation and physical evidence.
- Chapter 3 provides a physical description and condition assessment.
- Chapter 4 includes a statement of significance, identifies character-defining features, and provides an assessment of historic integrity.

Part 2 – Treatment and Work Recommendations

- Chapter 5 provides a description and rationale for the recommended treatment approach, and how it meets the project goals for Building 1. It also includes an explanation of the historic preservation treatment zones and the areas of the building assigned to each zone.
- Chapter 6 provides a description of the requirements for work, and presents tasks recommended to realize the proposed treatment approach.

Part 3 – Bibliography and Appendices

- Chapter 7 provides information about the sources used in preparing the report.
- Five appendices are included in this report as follows:

Appendix A – NIST Historic Assessment Report

Appendix B – Architectural Drawings

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ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
ADA	Americans with Disabilities Act
AEC	Atomic Energy Commission
AIA	American Institute of Architects
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
CFR	Code of Federal Regulations
CMU	concrete masonry units
CRPL	Central Radio Propagation Laboratory
CUP	Central Utility Plant
DOAS	dedicated outdoor air system
FM	frequency modulation
ESSA	Environmental Science Service Administration
GSA	U.S. General Services Administration
HSR	Historic Structure Report
HVAC	Heating, Ventilation, and Air Conditioning
IBC	International Building Code
IECC	International Energy Conservation Code
IRPL	Interservice Radio Propagation Laboratory
LEED	Leadership in Energy and Environmental Design
Low-E	low emissivity
LPD	lighting power densities
MEMS	Micro-Electromechanical Systems
NBS	National Bureau of Standards
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRHP	National Register of Historic Places
NTIA	National Telecommunications and Information Administration
OSHA	Occupational Safety and Health Administration
PBS	Public Buildings Service
psf	pounds per square foot
psi	pounds per square inch
sDC	studiotrope Design Collective
SHPO	State Historic Preservation Officer
Standards	Secretary of the Interior's Standards
TPO	thermoplastic polyolefin
UHF	ultra-high frequency
VCT	vinyl composition tile
VHF	very high frequency

PART 1: DEVELOPMENTAL HISTORY

1. Historical Background and Context

The National Bureau of Standards (NBS) Radio Building (Building 1) is located at 325 Broadway Street (State Route 93) on the south side of Boulder in Boulder County, Colorado (**Figure 1-1**). The NBS constructed Building 1 to serve as the headquarters of its Central Radio Propagation Laboratory (CRPL) division in 1954. Building 1 is significant for its associations with the growth and expanding research activities of the NBS and the CRPL in the post-World War II era, when agency activities began to play a key role in Cold War technology and research. At the time of its construction, the Modernistic architecture of Building 1 was cutting edge, and with its prominent and visible location along a major thoroughfare (State Route 93/Broadway Street) in Boulder, the building conveyed the NBS's image as a progressive and modern agency. The building also is significant as a good example of Modernist architecture and the post-World War II research campus model.

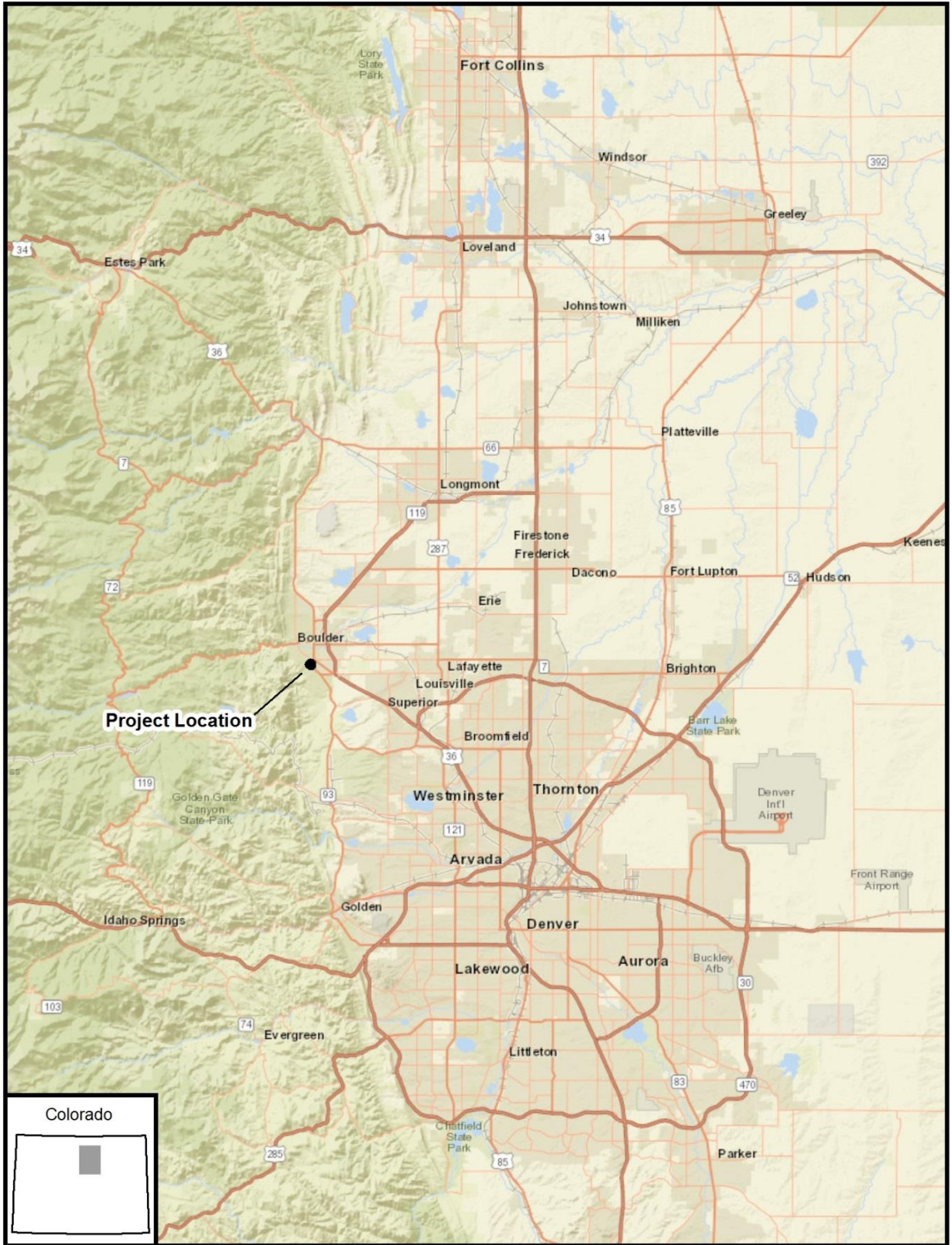
A detailed historical background and context of the NBS, the U.S. Department of Commerce National Institute of Standards and Technology (NIST), the Boulder Campus, and Building 1 is included in the report titled *Historic Assessment Department of Commerce Boulder Laboratories for National Institute of Standards and Technology, Boulder, Colorado* prepared for NIST in April 2016 by R. Christopher Goodwin & Associates of Frederick, Maryland (Gatewood and others 2016; **Appendix A**). A concise summary of the historical background and context of Building 1 was developed using information obtained from that report and other primary and secondary sources and is provided below.

1.1 National Bureau of Standards – 1901 to World War II

Congress established the NBS in 1901 to serve as the national standards laboratory for the United States. The new agency assumed the duties of the Office of Standard Weights and Measures, which was founded in 1836 as part of the Coast and Geodetic Survey to develop standardized measurements for the assessment of goods shipped both across state lines and internationally. The NBS was initially part of the Department of the Treasury, but two years later was transferred to the Department of Commerce and Labor. In 1913, the Department of Commerce and Labor was divided into separate agencies, and NBS was placed within the Department of Commerce. The NBS headquarters was located in Washington, D.C., and the agency was initially divided into three research divisions – Division 1, which included weights and measures, heat and thermometry, lights and optical instruments, engineering instruments, instrument shop, and administration; Division 2 for electricity; and Division 3 for chemistry (Gatewood and others 2016).

Radio research began at the NBS in the early twentieth century with research into the practical applications of radiotelegraphy. During World War I, NBS radio research contributed to the war effort, including the development of an improved radio direct finder used to locate enemy positions. In 1913, the Radio Laboratory Section of the NBS was established and designated as Section 6 of the Electricity Division (DeWeese and others 2004; Gatewood and others 2016).

After the war, Secretary of Commerce Herbert Hoover redefined the NBS mission to support domestic economic recovery through the establishment of standards of quality, simplification of articles of commerce, reduction of unnecessary varieties, and development of uniform business documents. Standards were developed for building construction materials and codes, fuel economy, and auto safety. The agency also created methods to test fire endurance of buildings and improved dental materials. Radio research in the post-World War I era included investigations into standardized radio frequencies for the advancement of the home radio and the development of a radio guiding system for aircraft (Gatewood and others 2016).



Base map source: DeLorme World Base. 2009. Esri Web Services, Redlands, California, use authorized by Esri license

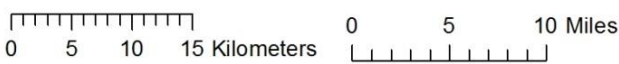


Figure 1-1. General Project Location

Research during the Depression era was generally redirected to standards and improved methods of measurement, but research of radio transmission and receiving continued. In 1923, the NBS constructed a radio station, with the call sign WWV, in Beltsville, Maryland, to continuously transmit official United States government frequency and time signals. The station is still in use and currently the oldest continuously operating radio station in the country. Other radio research efforts focused on the study of radio interference in the layers of the upper atmosphere and the linkage between long-distance radio interruptions and sun eruptions. Other research involved studies on X-rays, radium, and atomic studies, including early development efforts of the atomic bomb (Gatewood and others 2016).

During World War II, research conducted by NBS scientists and engineers supported the war effort and military objectives. This classified research resulted in a dramatic increase in the numbers of NBS staff and in the agency's budget. Many wartime projects focused on radio research, including the improvement of radio direction finders and the study of radio propagation, aerial navigation, radio-telegraphy, and radar. Utilizing funding it received from the military, the NBS established a new division of the agency known as the Interservice Radio Propagation Laboratory (IRPL) in 1942. The mission of the IRPL was to predict the behavior of transmitted radio waves to facilitate the selection of radio frequencies and military communications planning (Gatewood and others 2016; Passaglia 1999).

1.2 Central Radio Propagation Laboratory – 1946 to 1954

Technological advancements made during World War II transformed the fields of science and technology. After the war, the NBS served as the federal government's principal agency for research in physics, mathematics, chemistry, and engineering. By 1950, the NBS had 3,100 personnel staffing 15 research divisions containing 107 sections, and a budget of \$20 million (Gatewood and others 2016).

After World War II, the military and government agencies requested that the work of the IRPL expand to focus primarily on radio research for civilian use. In 1946, the CRPL was created and consumed the former IRPL. The new division was administered by the NBS and directed by an executive council, including members from the military and government agencies (Army, Army Air Forces, Navy, Federal Communications Commission, Civil Aeronautics Administration, Coast Guard, and NBS) and the private radio industry (Radio Technical Planning Board). With the establishment of the CRPL, the NBS combined its research on radio propagation and radio standards and forecasting into one division. During World War II, microwave radio was recognized for its contributions to the military, and during the subsequent Cold War, scientific research refined microwave radio for use in surveillance, navigation, and communication. Post-war activities of the CRPL included research on line-of-sight microwave propagation, new ranges of radio frequencies, and the troposphere and ionosphere as media for the propagation of radio waves, as well as the development and maintenance of the national primary standards for radio frequency measurements (Gatewood and others 2016; Kamper 1992; Passaglia 1999). Just one year after its establishment, the CRPL had become the largest division in the NBS with a staff of 414 and received 30 percent of the agency's Congressional funding (Schooley 2006).

As the staff of the CRPL and other NBS divisions grew, the agency realized that its Washington, D.C. campus was no longer adequate to house the CRPL. No building on the campus was large enough to house the entire CRPL, and necessary upgrades to bring existing buildings up to current research standards would have been costly. Radio studies in Washington, D.C. also were impaired by interference from large amounts of radio traffic in the surrounding city and the lack of an unobstructed horizon to study line-of-sight radio propagation (Kamper 1992). In October 1949, Congress authorized the expenditure of \$4.4 million for the construction of a new radio building. The Secretary of Commerce and the NBS director were placed in charge of selecting the building site (Snyder and Bragaw 1986). In addition to radio quiet and

unobstructed horizons, the selected site also needed to be near a university with a strong electrical engineering program and have room for expansion. Congress also stipulated that the building location be outside of Washington, D.C. as a precaution against nuclear attack. Boulder, Colorado was selected as a finalist due to its compatible environment for CRPL programs and its proximity to the University of Colorado at Boulder. In February 1950, the Boulder Chamber of Commerce formed the Bureau of Standards Committee, which initiated a campaign to raise \$70,000 to purchase 217 acres south of Boulder for the construction of the NBS facility (**Figure 1-2**). By the end of April, the committee had raised more than \$90,000 from local citizens and purchased the property. NBS subsequently selected the Boulder site and on June 14, 1950, the Chamber of Commerce transferred the deed to the land to the United States government (Gatewood and others 2016; Kamper 1992).

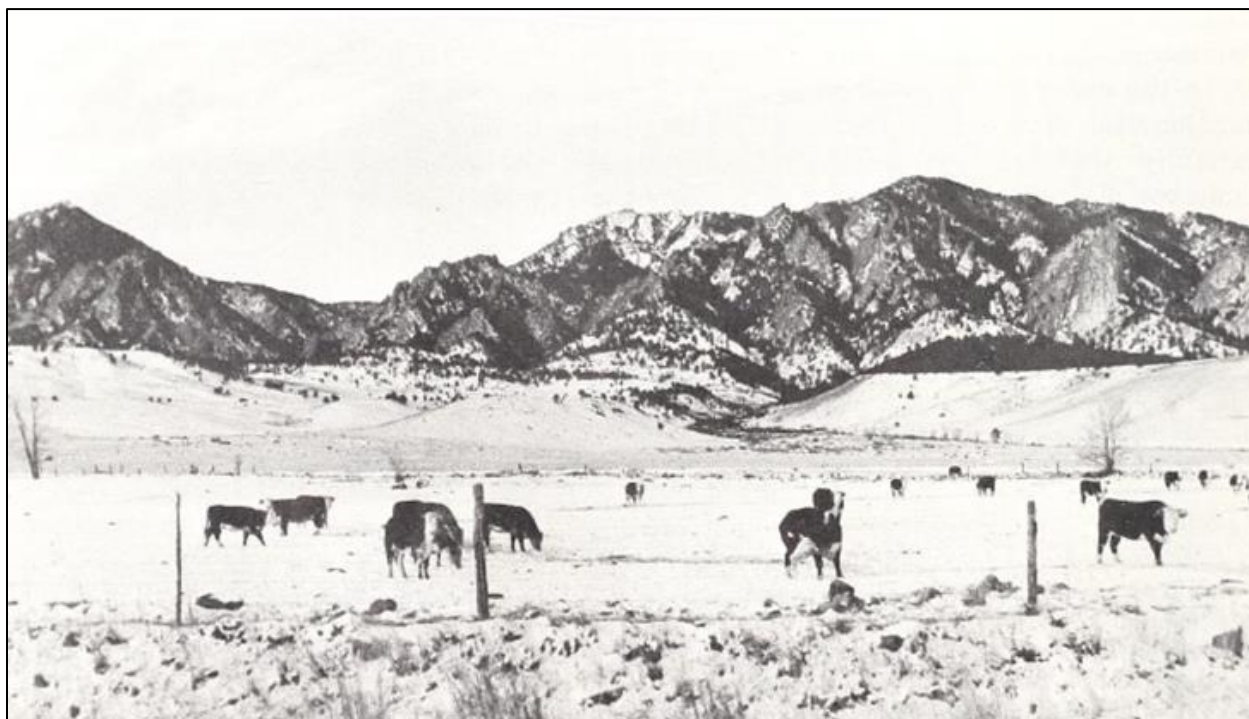


Figure 1-2. Boulder Site Prior to the Construction of NBS Facilities; Published in the *Boulder Daily Camera* on December 15, 1949 (Snyder and Bragaw 1986)

Preliminary design of Building 1 began almost immediately after Congress authorized the expenditure. The new building would accommodate the entire laboratory, support, and administrative functions of the CRPL in one structure and was initially planned to be the only building on the Boulder campus. However, following the acquisition of the Boulder property, President Truman announced the intent of the United States to build a “super” bomb and the continuation of the development of atomic weapons for national security. Because the Boulder campus was close to the Atomic Energy Commission’s (AEC) new Rocky Flats Plant, the AEC asked Congress to authorize the construction of cryogenic and liquid hydrogen plants on the Boulder campus. These plants, which became Buildings 2 and 3, respectively, were constructed in 1951 as the NBS Cryogenic Engineering Laboratory/Division at Boulder prior to construction of Building 1. Building 4, or the Camco Building also was constructed at this time (Gatewood and others 2016; Schooley 2006; Snyder and Bragaw 1986).

Some NBS staff had arrived in Colorado as early as 1950, when the CRPL initiated the Cheyenne Mountains projects to study tropospheric propagation in the Colorado Springs area. Other staff arrived in Boulder in the spring of 1951 and temporarily occupied the Colorado National Guard Radar Armory and warehouse on the north side of Boulder until Building 1 was

complete. Construction of Building 1 began in the late spring of 1952 and was complete by the fall of 1954. NBS staff began to move into Building 1 in late April 1954. In early May and throughout the summer, staff of the CRPL and other NBS divisions arrived in Boulder from Washington, D.C. Because the CRPL Radio Standards Division was the keeper of the National Standard of Frequency and Time Interval, the national standard also had to be moved from Washington, D.C. to Building 1. At that time, the national frequency standards were a set of quartz crystal oscillators that had to be kept at a consistent temperature. Radio frequencies were determined by the rate at which a charge of electricity made thin slices of the quartz vibrate and were used to calibrate frequency measuring instruments and control the frequencies broadcast by NBS radio stations in Maryland and Hawaii. The standards were hand carried by CRPL staff to the Washington, D.C. airport, transported by air to Denver, where they were met by Colorado CRPL staff (Gatewood and others 2016; Passaglia 1999; Perkin 1954; Snyder and Bragaw 1986).

In a ceremony held on September 14, 1954, President Dwight D. Eisenhower formally dedicated Building 1 at the NBS Boulder campus (**Figure 1-3**). Prior to the dedication, NBS held week-long scientific conferences. At the time of the building's completion, it was the nation's largest and most modern radio propagation laboratory (*The Boulder Daily Camera* 1954a).



Figure 1-3. President Dwight Eisenhower at the dedication of Building 1 on September 14, 1954 (photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

1.3 NBS Boulder Laboratories – 1954 to 1965

After the CRPL moved to the Boulder campus, it was reorganized into three divisions – (1) Radio Propagation Physics, (2) Radio Propagation Engineering, and (3) Radio Standards (Kamper 1992). CRPL research was principally concerned with radio propagation and national primary standards at radio frequencies (Passaglia 1999). Propagation research included studies on the (1) effects of terrain on radio waves and the directivity of directional antennas, (2) effects of storms occurring in the ionosphere on radio waves, (3) thermal and gravitational effects in Earth’s atmosphere, (4) investigation of the phenomenon of “forward scatter propagation” experienced at very high frequencies, and (5) the effects of terrestrial and extra-terrestrial noise of radio waves. Noise research resulted in the development of a receiver that became the international standard measuring device. In 1956, studies of cosmic noise determined the planet Jupiter was a source of radio noise, which, along with studies of the effects of solar flares on radio waves, introduced the scientific study of radio astronomy (Gatewood and others 2016).

After World War II, popularity of frequency modulation (FM) broadcasting and television led to a significant upsurge of radio communication, which resulted in considerable demand for space in the frequency spectrum, particularly in the very high frequency (VHF) and ultra-high frequency (UHF) ranges. The CRPL Radio Standards Division provided standards, measurement methods, and calibration services to the radio field. Increased demand for calibration services resulted in the construction of another wing to Building 1, which was designated as Wing 6. At the request of the Air Force, the new wing included facilities for the calibration of direct current and low frequency standards and instruments. Construction of Wing 6 began in 1956 and completed by 1958 (Passaglia 1999; Snyder and Bragaw 1986; *The Boulder Daily Camera* 1955a).

NBS research of primary frequency standards led to the laboratory development of the atomic clock, which eventually replaced quartz resonators as the national frequency and time standard. NBS completed its first accurate frequency measurement of the cesium clock resonance in 1952 with the development of its first atomic clock, NBS-1, which was moved from Washington, D.C. to Boulder in 1954 (**Figure 1-4**). By 1959, NBS-1 was in regular service as NBS’s primary frequency standard. Work continued on increasing the precision of the clock, which resulted in the development of a more precise definition of the unit of time known as the second. That definition became the international standard in 1964. In 1960, NBS scientists unveiled the NBS-2, which could function unsupervised for longer periods and was used to calibrate standards for the unit of time known as the second (**Figure 1-5**). In 1963, NBS-3 was introduced with improved accuracy and stability. Other experiments with laser technology also introduced the potential for more precise measurements (Gatewood and others 2016; Passaglia 1999; NIST 2016).

In 1960, NBS developed its computer program with the purchase the Control Data Corporation Model 1604 binary computer in an effort to speed up data processing. Expansion of the computer program led to the construction of the last wing to Building 1 in 1962, which was designated as Wing 5 or the Computation Facility (Boulder Laboratories 1961; Snyder and Bragaw 1986).

1.4 U.S. Department of Commerce Boulder Laboratories – 1965 to the Present

In October 1965, all CRPL divisions were administratively transferred to the Department of Commerce’s newly established Environmental Science Service Administration (ESSA) and the CRPL ceased to exist. The Boulder campus was renamed the U.S. Department of Commerce Boulder Laboratories. Building 1 was occupied by both the NBS and the ESSA. In 1970, the ESSA became the National Oceanic and Atmospheric Administration (NOAA), and technical radio sections formally assigned to the CRPL were reassigned to a new agency known as the

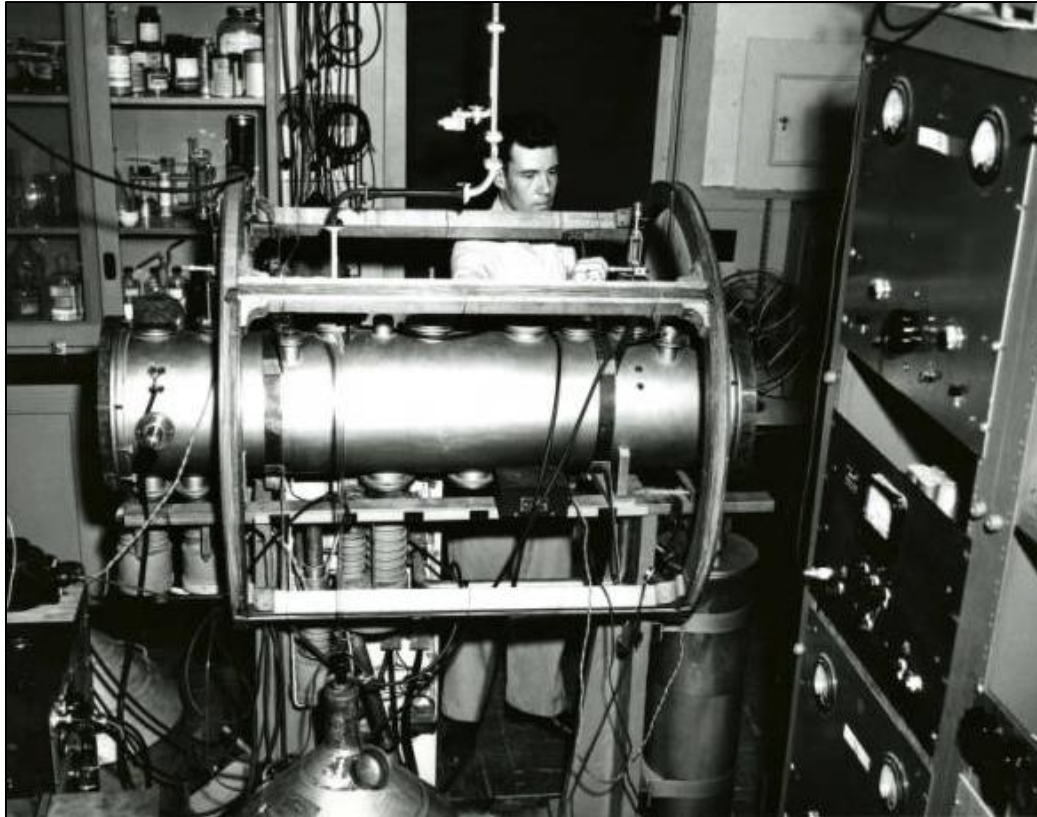


Figure 1-4. Atomic Clock NBS-1 (NIST Digital Archives, Gaithersburg, MD 20899)

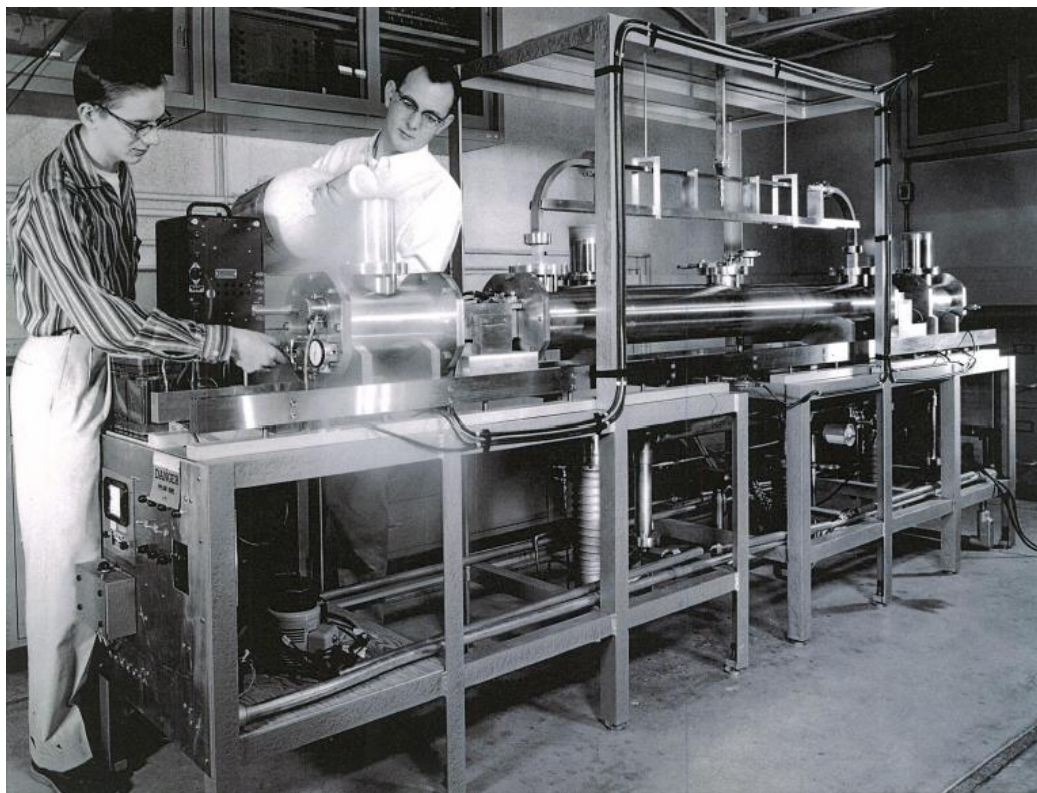


Figure 1-5. Atomic Clock NBS-2 (photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

Office of Telecommunications. Eight years later, the Office of Telecommunications became part of the National Telecommunications and Information Administration (NTIA) (DeWeese and others 2004; Gatewood and others 2016; Metropolitan Architects and Planners 2017).

In 1988, the U.S. government redefined the role and mission of the NBS to include a responsibility to contribute to the revitalization of United States trade as Japan and Germany gained technological superiority. As part of that new mission, the NBS was renamed NIST. Today, the Boulder campus continues to house the research programs of the NIST, NOAA, and NTIA (DeWeese and others 2004; Gatewood and others 2016; Metropolitan Architects and Planners 2017).

After the dissolution of the CRPL, scientists at Boulder Laboratories continued atomic clock research. In the 1970s, two more versions of the atomic clock were completed, including the NBS-5, an advanced cesium beam device, and NBS-6 (**Figure 1-6**), one of the world's most accurate atomic clocks. NIST-7 was introduced in 1993 and eventually became 20 times more accurate than NBS-6. Six years later NIST-F1 began operation as one of the most accurate clocks ever made, with accuracy of about one second in 20 million years (NIST 2016).

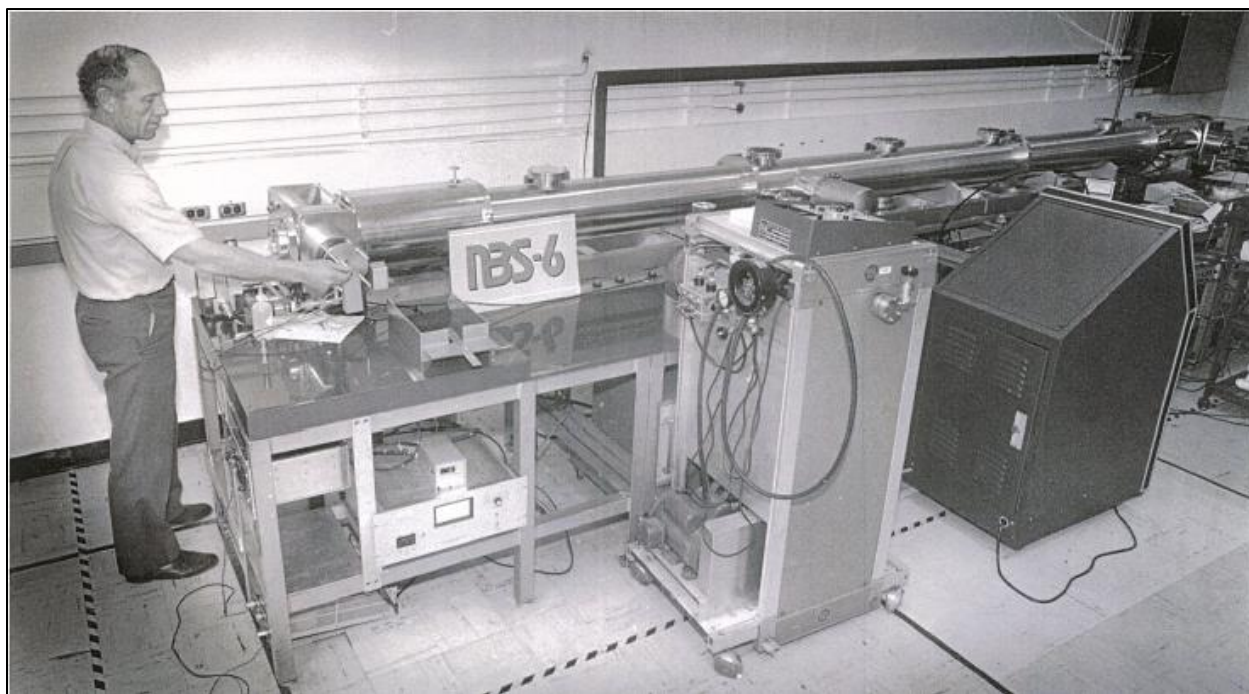


Figure 1-6. Atomic Clock NBS-6 (photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

Since 1997, four NIST scientists who worked within Building 1 have won the Nobel Prize, including three in physics and one in chemistry.

- William D. Phillips (1997): laser cooling and trapping of atoms
- Jan Hall (2005): development of laser-based precision spectroscopy, including the optical frequency comb
- Dan Shechtman (2011): discovery of quasicrystals
- Dave Wineland (2012): experimental quantum mechanics (NIST 2018)

2. Chronology of Development and Use

The NBS constructed Building 1 as the CRPL Building or Radio Building in 1954 on land donated to the NBS by the Boulder Chamber of Commerce. Construction of the building began in the late spring of 1952 and completed in the fall of 1954. Wings 5 and 6 were constructed as additions to Building 1 in 1962 and 1958, respectively. Since construction, both interior and exterior spaces have been renovated and altered to meet evolving technology and scientific advancements.

The information contained within this chapter was obtained from primary sources including historic photographs, architectural drawings, NIST archives, and newspaper and journal articles published at the time. Secondary sources included books, articles, and other documents published by NIST that describe the history of the NBS and the Boulder campus. The 2016 historic property assessment (Gatewood and others 2016) completed for Boulder Laboratories is also referenced.

2.1 Planning

As built, the design of Building 1 is representative of Modernist architecture, but initial design concepts for the building were Classical in design. The design took a more Modernist direction when Hugh Odishaw, the assistant to the NBS director, suggested that the design incorporate the building into the existing landscape. In December 1950, architect Frank W. Cole of Washington, D.C prepared an initial descriptive design that was simple and functional, and maximized laboratory and office spaces. NBS selected the architectural and engineering firm of Pereira & Luckman of Los Angeles, California, and architect Jesse Earl Stanton of Beverly Hills, California, to create the detailed design. Robert William Ditzen of Boulder served as an associate architect for the project (Gatewood and others 2016; Snyder and Bragaw 1986).

William L. Pereira and Charles Luckman established Pereira & Luckman in 1950 and went on to design several notable buildings in California, including CBS “Television City” and the IBM building in Los Angeles; J.W. Robinson’s department stores in Beverly Hills, Pasadena, and Palm Springs; and Marineland of the Pacific in Palos Verdes. The firm also was involved in master planning projects, such as the Los Angeles International Airport Master Plan, which included the design of the iconic Theme Building. After the firm dissolved in 1958, both architects established separate firms. Pereira continued to work on master plans and designed the Transamerica Tower in San Francisco. By 1961, Luckman’s new firm was one of the five largest architectural firms in the world. Architect Jesse Earl Stanton designed residential, public, and government buildings primarily in California, and associate architect Robert William Ditzen of Boulder designed educational, religious, residential, and public buildings in Colorado (Gatewood and others 2016; Los Angeles Conservancy 2016).

The detailed design was released for public review on March 12, 1952. The building was designed using the research campus model to accommodate the entire laboratory, support, and administrative functions of the CRPL in one building. Like other research campuses at the time, Building 1 was a low-rise building with landscaping and expansive parking areas. The building featured a front entrance area (Front of the House) that connected to a central Spine (**Figure 2-1; refer to the full set of architectural drawings in Appendix B**). Single-story wings stemmed from the central Spine at parallel, right angles behind the Front of the House. Because the building was designed with the existing sloped terrain in mind, the central Spine featured four stories in the front and two in the back, with low-profiled and terraced wings to preserve the view of the foothills (the Flatirons) in the background. The building was to be constructed of reinforced concrete with natural stone accents in the main entrance area. As was typical of contemporary laboratory design, the laboratories in Building 1 incorporated a “use module

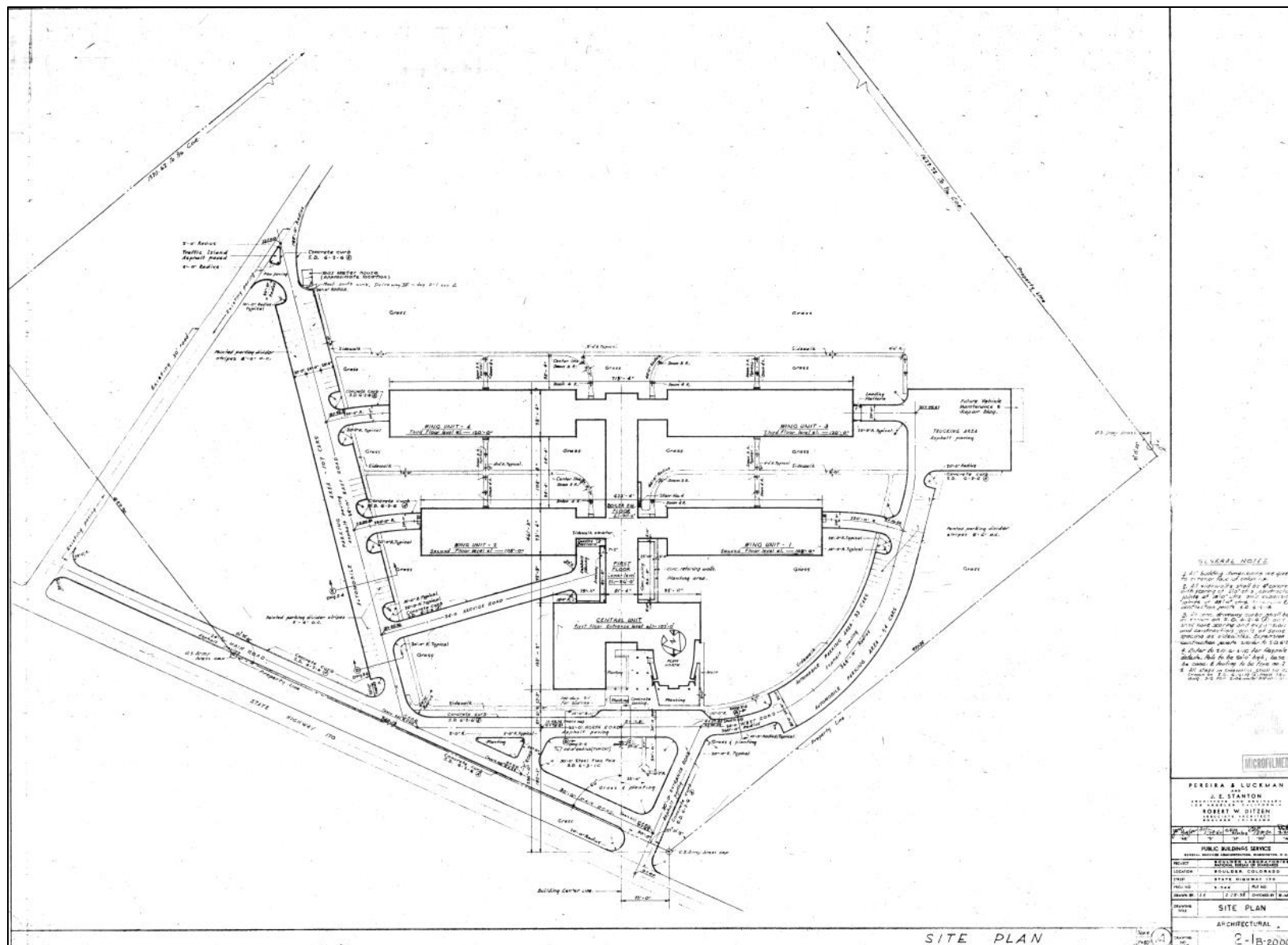


Figure 2-1. Building 1 Site Plan, Drawing A-2-1, February 22, 1952 (Pereira & Luckman, Stanton, and Ditzen 1952)

design” to accommodate future growth and changes in research programs. To facilitate future expansions, the architects design included the installation of adequate mechanical and electrical systems to accommodate future projects (*Architectural Forum* 1955; Gatewood and others 2006; *The Boulder Daily Camera* 1952a).

The design also included concrete sunshades above the windows on both the Spine and the wings, which were designed to control the amount of natural light, heat, and glare entering the laboratories and computation rooms (**Figures 2-2 and 2-3**). Pereira & Luckman designed the sunshades based on data they obtained using a helidon¹ and a model of the building to duplicate the solar conditions at the building site. NBS conducted its own experiments by constructing a scaled model of the building on the Boulder site and comparing photographs taken on site during different times of the day over a period of several days to photographs taken of the model on the helidon (*Architectural Forum* 1955; *The Boulder Daily Camera* 1952a).

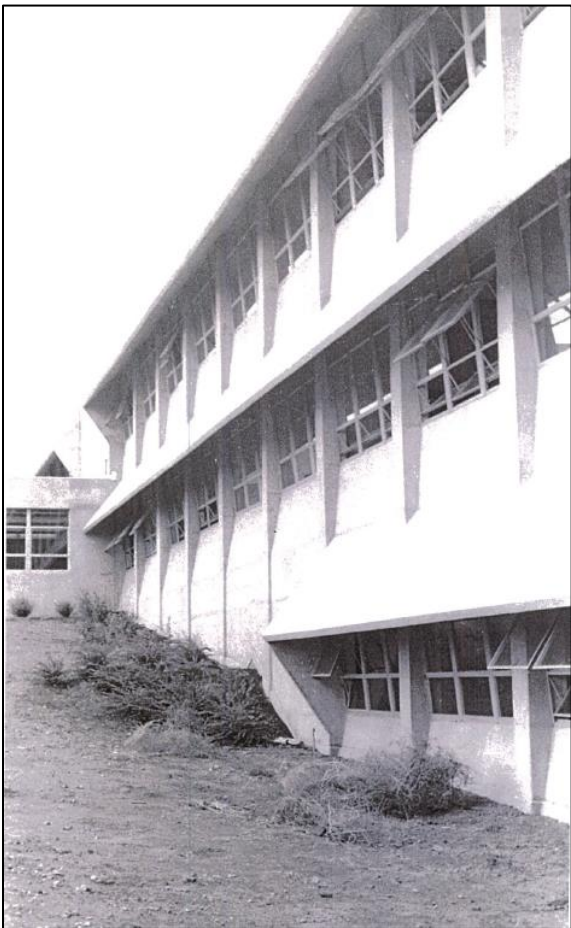


Figure 2-2. Concrete Sunshades on the Spine (photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Museum of Boulder Collection)

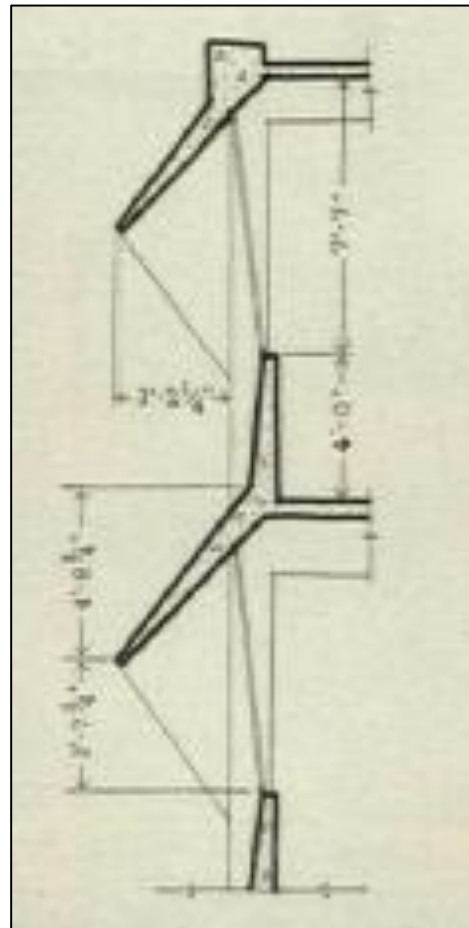


Figure 2-3. Drawing of Concrete Sunshades (*Architectural Forum* 1955)

¹ A helidon is a device used by architects to simulate sunlight direction in relation to a building model. It consists of a flat surface and a beam of light that can be adjusted to replicate the behavior of the sun at specific latitudes at various times of the day and months of the year.

Construction of Building 1 was completed by a private contractor under the direction of the Public Buildings Service of the General Services Administration (GSA) (Snyder and Bragaw 1986). On April 4, 1952, contractors were invited to bid on the construction of Building 1. On May 22, 1952, *The Boulder Daily Camera* announced that Mead and Mount of Denver, Colorado, was the low bidder and had won the work. However, about one month later on June 23, 1952, it was revealed that Olson Construction Company of Denver was to be the builder. Olson Construction Company had amended its original bid, which was lower than that of Mead and Mount, but it was not considered during the original evaluation because it did not reach the GSA before the deadline. The GSA determined that the delay was caused by messenger error, and Olson Construction's low bid was reconsidered and accepted (*The Boulder Daily Camera* 1952b, 1952c, 1952d).

2.2 Construction

In June 1952, Olson Construction began preparing the building site for construction, and on July 21, NBS director Dr. Allen V. Astin officiated the ground breaking and gave the official notice to proceed (*The Boulder Daily Camera* 1952e). One year later, the building was nearing 50 percent completion (**Figure 2-4**). In September 1953, window installation was in progress and approximately 90 percent of the "cement work" was finished (**Figure 2-5**; *The Boulder Daily Camera* 1953a, 1953b).

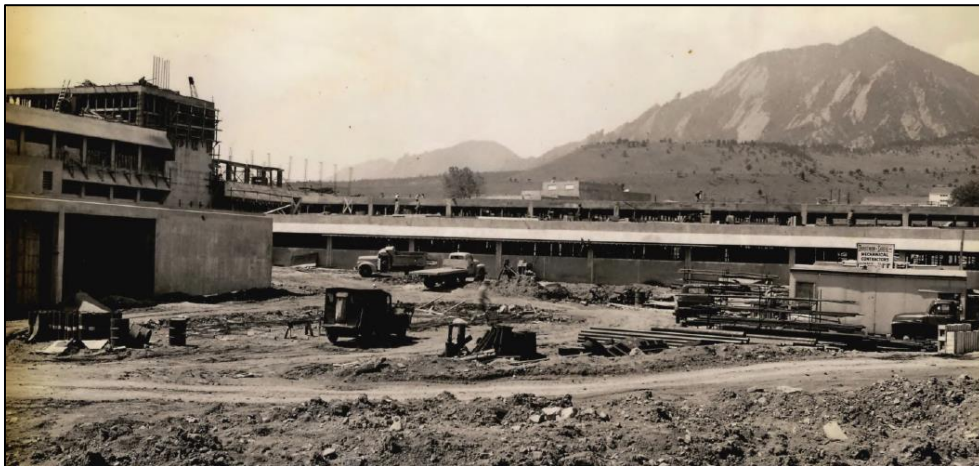


Figure 2-4. Building 1 under Construction, June 2, 1953, view southwest (photograph courtesy of Department of Commerce Boulder Laboratories)



Figure 2-5. Wing 3 and Spine under Construction, September 1, 1953, view southeast (photograph courtesy of Department of Commerce Boulder Laboratories)

By February 1954, the building was about 90 percent complete (**Figure 2-6**). The final cost was projected at \$3,375,000. The Front of the House included a lobby, reception area, library, and auditorium, and connected to the central Spine. Staircases adjacent to the reception desk provided access to a basement, which housed a boiler room, transformer room, a locker room, and space for a future cafeteria; and upstairs access to the central Spine that created a circulation network to two pairs of wings (Wings 1 through 4). A penthouse on the roof of the Spine contained machinery rooms. The central Spine and wings featured double-loaded corridors with offices on one side and laboratories on the other. Electronics laboratories were located in Wings 1, 2, and 4, and Wing 3 originally housed instrumentation shops (Gatewood and others 2016; Worcester 1954). An additional pair of wings (Wings 5 and 6) were part of the original design, but were excluded from the initial construction contract to save costs (Gatewood and others 2016; Worcester 1954). In addition to the concrete sunshades, special features of Building 1 included exact temperature and humidity controls, radio shielded rooms, radio platforms, and an open-roof laboratory (Cielinski and Tebay 1955).

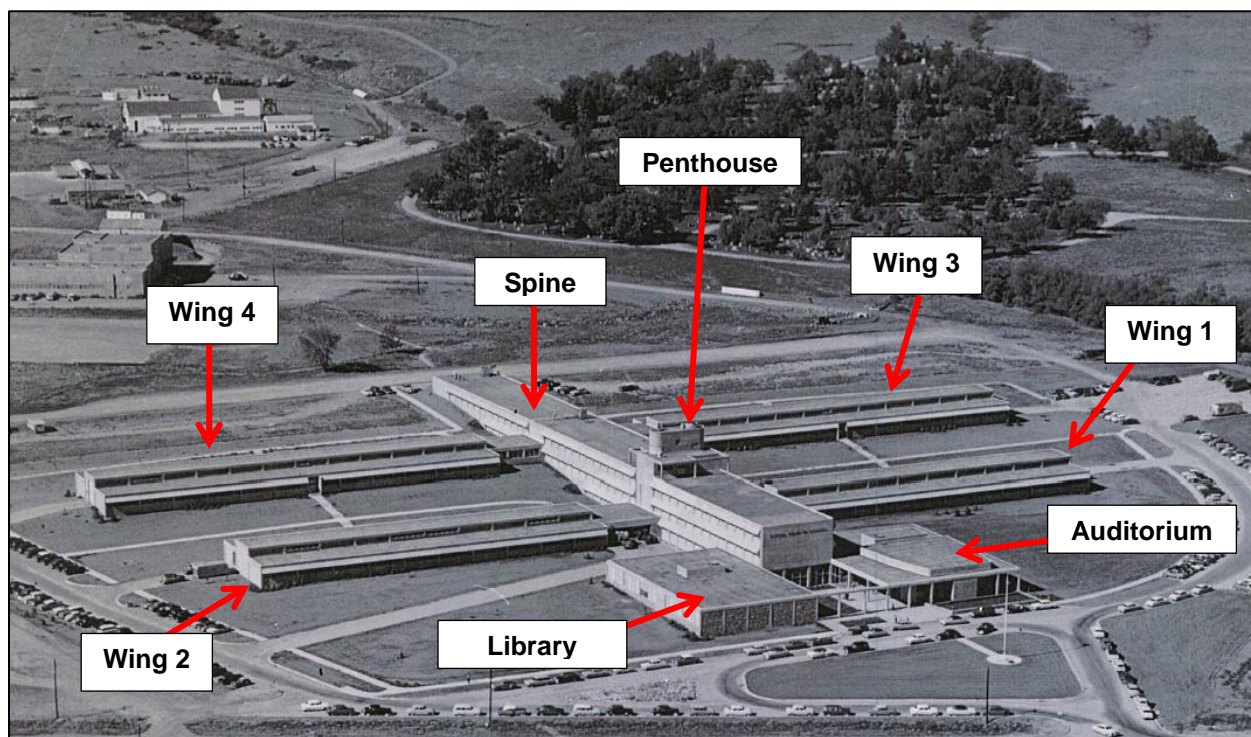


Figure 2-6. Building 1 in the Mid-1950s (view west; annotations added by sDC and AECOM; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

In 1954, the architects of Building 1 were awarded with an Award of Merit from the American Institute of Architects (AIA) for their design of the building (Gatewood and others 2016). Building 1 also was featured in the “Buildings in Review” section of the March 1955 issue of *Architectural Forum* magazine. The magazine described Building 1 as a “massiveness of concrete” and a “giant” with “a mild, efficient personality,” and likened its unpolished concrete façades to Le Corbusier’s Marseilles skyscraper. The article compared the concrete sunshades to “the vizor on a medieval helmet” and described the lobby as the “only extroverted part of the building” (*Architectural Forum* 1955: 158-159).

In the mid-1950s, the 84th Congress authorized the construction of an additional wing to Building 1 to house a unique facility designed specifically for a large-scale calibration operation, which would be designated as the Electronic Calibration Center or Wing 6. Wing 6 was

designed by Boulder architect, James M. Hunter, who worked as a draftsman for Boulder architect Glen H. Huntington in 1936, and four years later became a partner in the firm Huntington, Jones, and Hunter. After World War II, Hunter formed his own firm and designed academic complexes, as well many commercial, civic, educational, and residential buildings in Boulder. Wing 6 was constructed on the southeast side of the Spine, southwest of Wing 4. Construction of the Wing began in 1956 and completed by 1958 (**Figures 2-7 and 2-8**; Colorado Historical Society 2006; Passaglia 1999; Snyder and Bragaw 1986; *The Boulder Daily Camera* 1955a, 1955b).

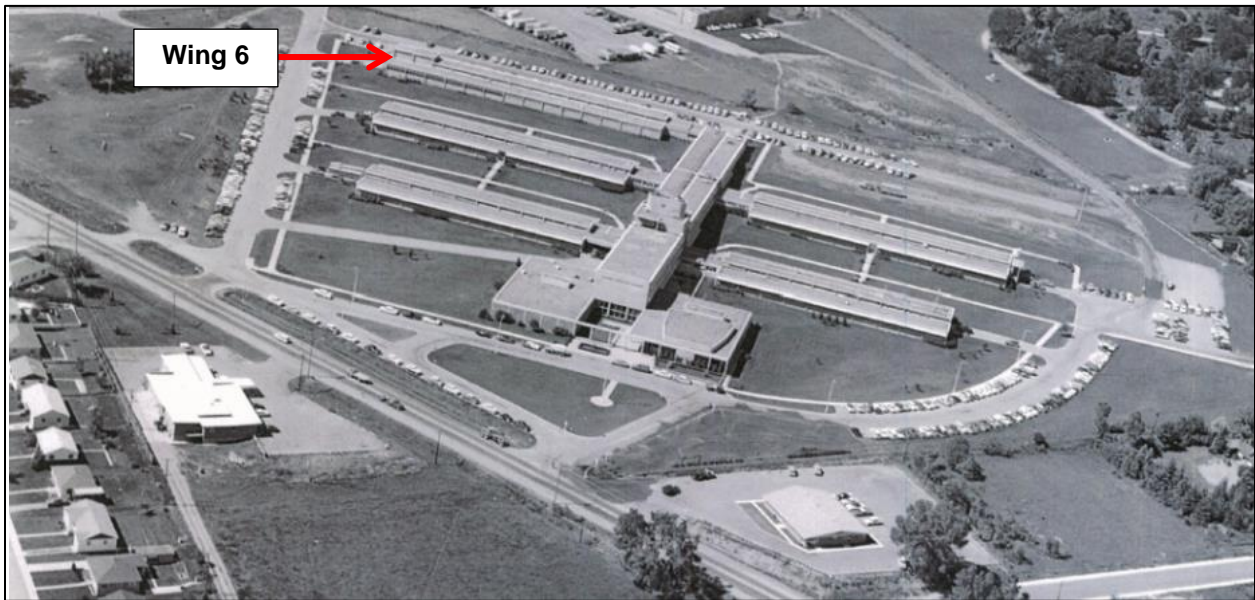


Figure 2-7. Building 1 Circa 1960 (view southwest; annotations added by studiotrope Design Collective [sDC] and AECOM; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)



Figure 2-8. Wing 6 under Construction circa 1956, view north (photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

In 1959, NBS hired mathematician John J. Sopka Jr. as a consultant to develop a computer program to speed up data processing. The Control Data Corporation Model 1604 binary computer was purchased one year later. Expansion of the computer program led to the construction of the last wing to Building 1 in 1962. Wing 5 was designated as the Computation Facility and constructed on the northwest side of the Spine southwest of Wing 3 (**Figure 2-9**). The NBS hired architects G. Meredith Musick, Jr. and Clayton C. Musick of Denver to design the new wing, and awarded the construction contact to Ross E. Cox on Cañon City, Colorado. The Musick brothers were the sons of noted Denver architect G. Meredith “Mark” Musick, whose building designs incorporated the Art Deco, Art Moderne, and International styles. The new wing reflected the symmetry of the other five wings, but was larger with three-stories and a partial basement. In the Cold War era, the CPRL had continued to grow with the development of the electronics industry and space exploration research, and the new wing provided much needed floor space. Areas of the building not specifically constructed for the computer program were used by existing and new programs (Boulder Laboratories 1961; Colorado Historical Society 2007; Snyder and Bragaw 1986).



Figure 2-9. Building 1 after the Construction of Wing 5 (view southwest; annotations added by sDC and AECOM; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

The 1952 plans prepared by Pereira & Luckman, Stanton, and Ditzen include specifications for parking areas; streets, including curbs and gutters; and grass and planting areas. The plans indicated expansive lawns on both sides of the Front of the House and a large grassy area with a flagpole between the Front of the House and Broadway Street. Grassy lawns also were planned for the outdoor spaces between the wings. Preparation of the grounds, construction of the streets and parking areas, and the planting of grass was included in the construction contract awarded to Olson Construction. Bids for a separate contract to plant trees and shrubs was opened on April 27, 1954, that called for 35 varieties and a total of 4,225 individual trees and shrubs. Nuzum Nurseries of Boulder was awarded the landscaping contract in the amount of \$7,732.55 on May 15, 1954 and the landscaping was subsequently completed (Klein 1954; *The Boulder Daily Camera* 1953b, 1954b).

2.3 Original Appearance

This section describes the original appearance of both the interior and exterior of Building 1 based on architectural drawings and photographs. **The full set of architectural drawings is attached in Appendix B.** The building is on a northeast/southwest axis, with the Front of the

House facing northeast and the end of the Spine facing southwest (**Figure 2-10**). In this and the following sections, the northeast elevation is referred to as the north elevation or plan view north, the southwest elevation as the south elevation or plan view south, the northwest elevation as the west elevation or plan view west, and the southeast elevation as the east elevation or plan view east.

The building was constructed of cast-in-place, reinforced concrete posts and beams with a precast concrete tee-joint roof system. The exterior walls were a combination of cast-in-place concrete built using oiled plywood forms and native sandstone. The flat roof was clad with composition roofing in most locations. The Front of the House was located on the north end of the Spine and the wings intersected the Spine at equidistant intervals. The building was constructed on a slight grade and gradually stepped up the sloping terrain while the roof of the Spine remained at a constant level.

2.3.1 Exterior Description

2.3.1.1 Spine

The Spine was designed as a rectangular-shaped concrete structure with four levels and a flat roof (**Figure 2-11**). The short ends of the Spine (north and south elevations) were 50 feet wide (two, 25-foot bays) and the long sides of the Spine (east and west elevations) were a maximum of about 552 feet long (refer to architectural drawings in Appendix B). The long sides included a series of 12-foot bays formed by the post-and-beam construction, separated by vertical concrete columns, and infilled with solid concrete or a combination of windows and concrete (**Figure 2-12**). The Front of the House was connected to the north end of the Spine at what the architectural drawings refer to as the “lobby level,” which was the midpoint between Levels 1 and 2 of the Spine. The first 60 feet or 12 bays on the north end of the Spine made up the center of the Front of House.

Level 1 of the Spine was mostly below grade (**Figure 2-13**). Level 1 was approximately 252 feet or 21 bays long and did not extend the full length of the Spine, terminating about 60 feet south of the intersection of Wings 1 and 2, which intersected the Spine at Level 2 approximately 144 feet south of the Front of the House. Level 2 was about 372 feet or 31 bays long. Most of Level 2 was above grade, except for 72 feet (6 bays) on the south end which gradually descended below grade as the ground sloped. Level 2 terminated below grade at the Spine’s intersection with Wings 3 and 4.

On the north end of the Spine, Levels 3 and 4 rose two stories above the Front of the House (refer to Figure 2-11). Level 3 extended about 552 feet or 46 bays from north to south. Wings 2 and 4 intersected the Spine about 340 feet south of the Front of the House at Level 3 (refer to Figure 2-13). About 160 feet from the south end of the Spine, the ground began to slope and conceal portions of the exterior of Level 3 (**Figure 2-14**). The last 40 feet of Level 3 on the south end of the Spine was below grade. Level 4 was the same length as Level 3 but remained above grade for its entire length.

Most bays on the long sides (west and east elevations) of the Spine featured horizontal bands of windows shaded by cast concrete sunshades (refer to Figures 2-2 and 2-12). Each bay included a set of three steel-framed windows. Each window contained three lights, with narrower lights on the top and bottom framing a larger light in the middle. The top light was fixed, the middle light was an awning window, and the bottom light was a hopper window. All windows were slightly canted (angled) toward the ground.

One-story hyphens were constructed to connect the Spine to the intersecting wings (refer to Figures 2-11 and 2-12). The hyphens had flat roofs and were approximately 37 feet wide and 45 feet long. The north elevation of the hyphen between the Spine and Wing 1 had one set of three steel-framed awning windows and two sets of three grouped tripartite windows like those

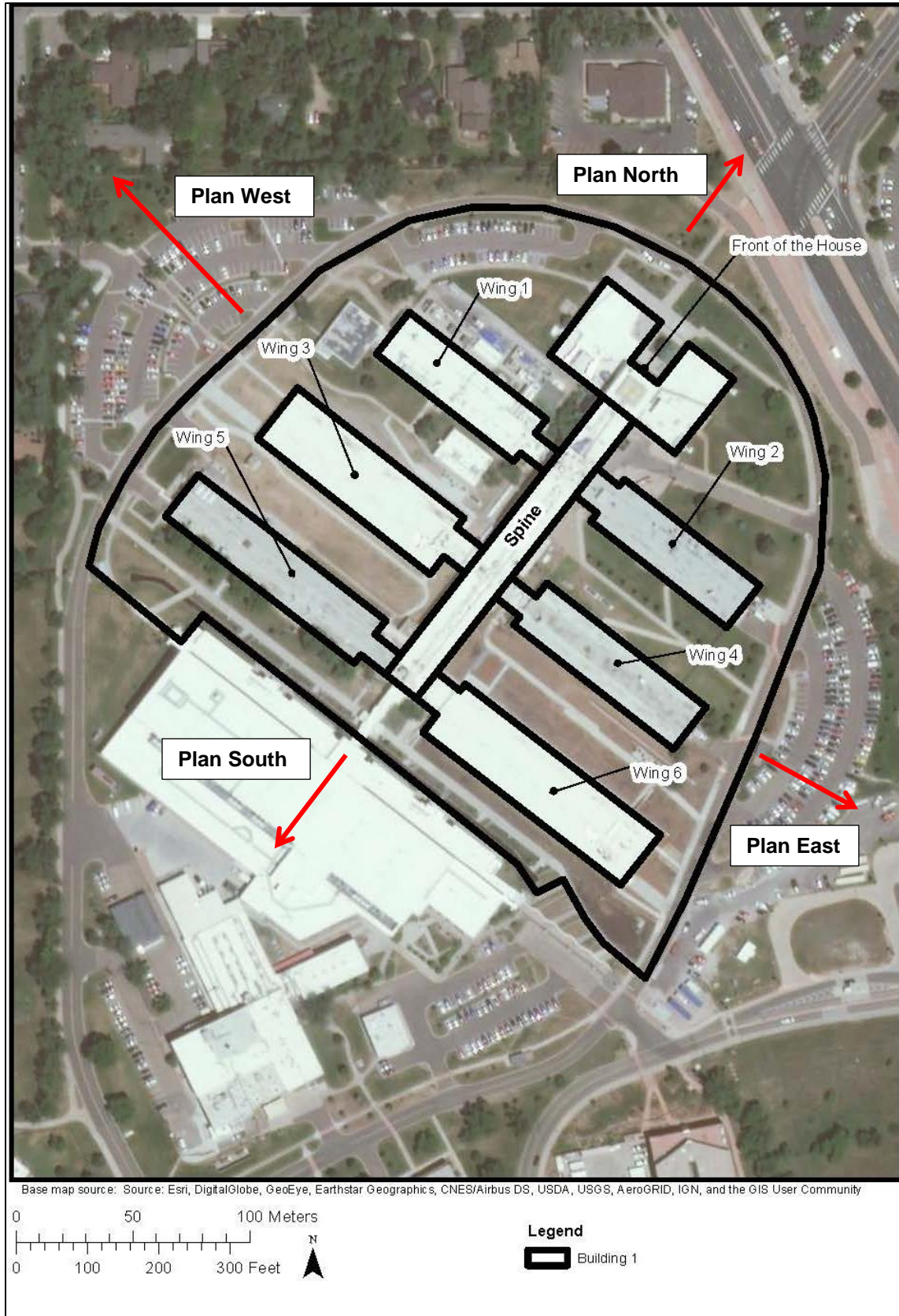


Figure 2-10. Aerial Photograph of Building 1

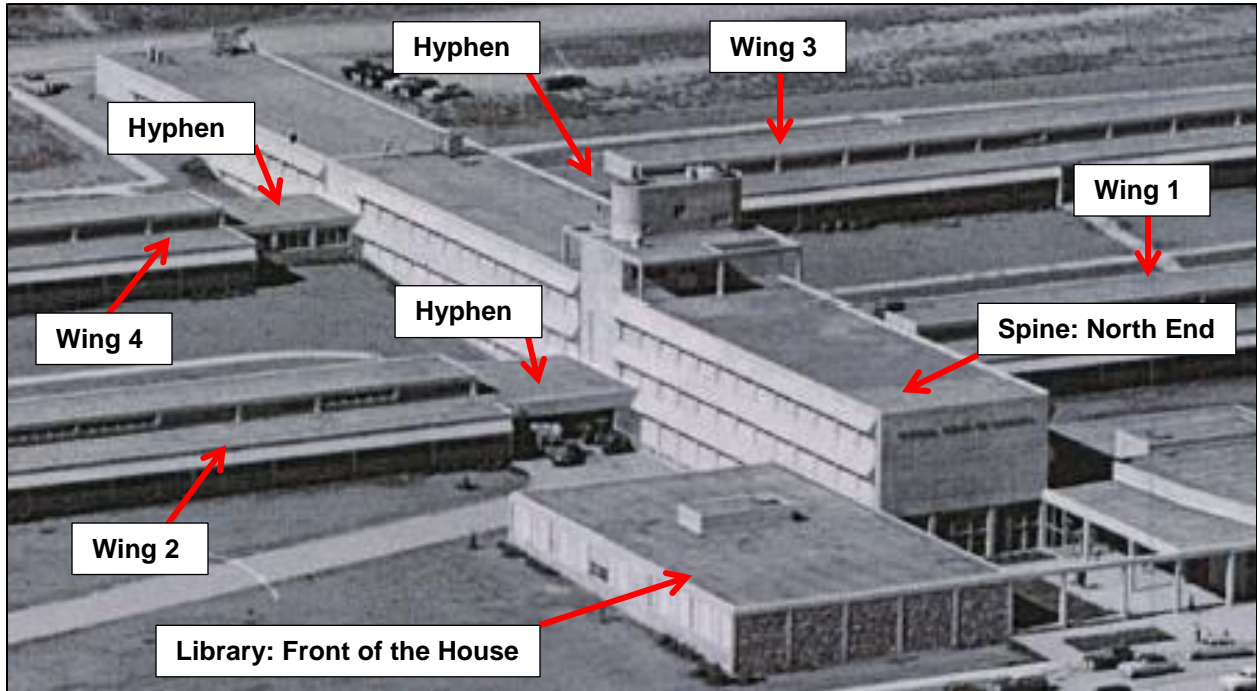


Figure 2-11. Building 1 in the Mid-1950s (view west; cropped and enlarged to show detail; annotations added by sDC and AECOM; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

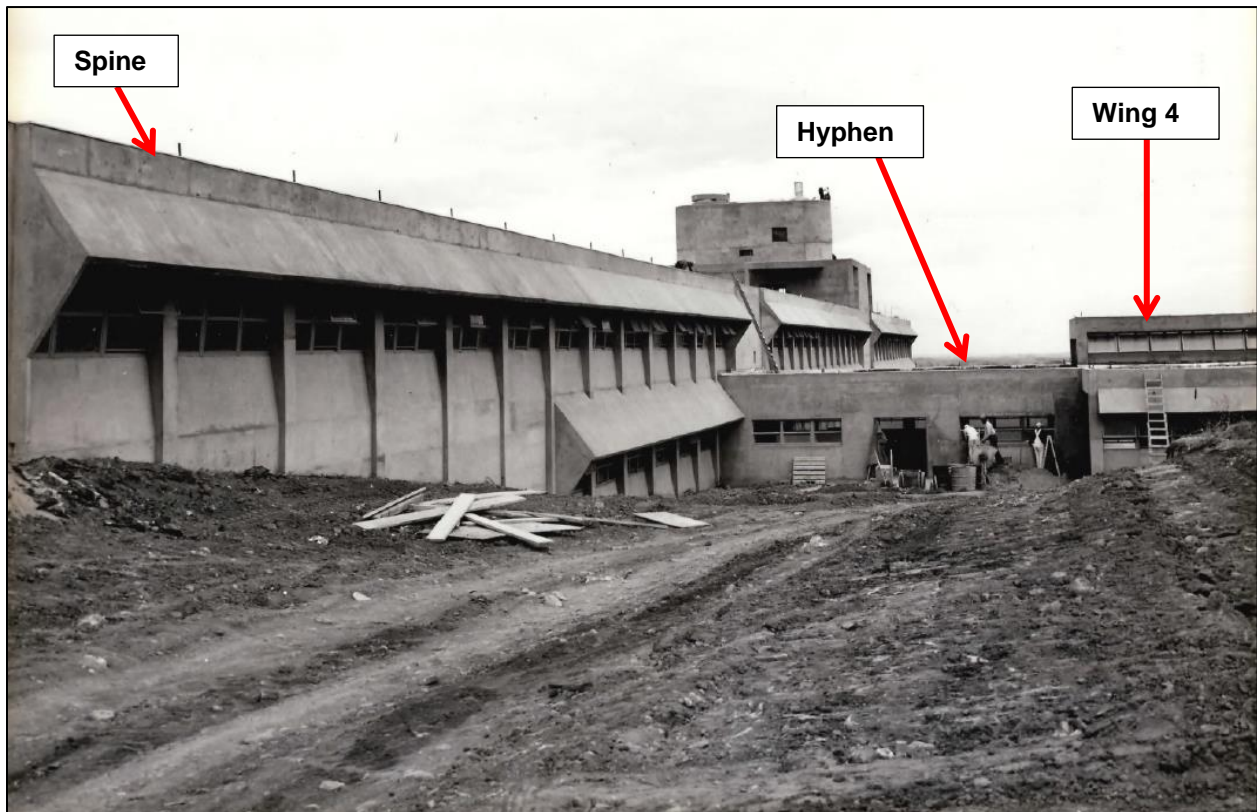


Figure 2-12. East Side of the Spine South of Wing 4, Under Construction, November 2, 1953 (view north; annotations added by sDC and AECOM; photograph courtesy of Department of Commerce Boulder Laboratories)

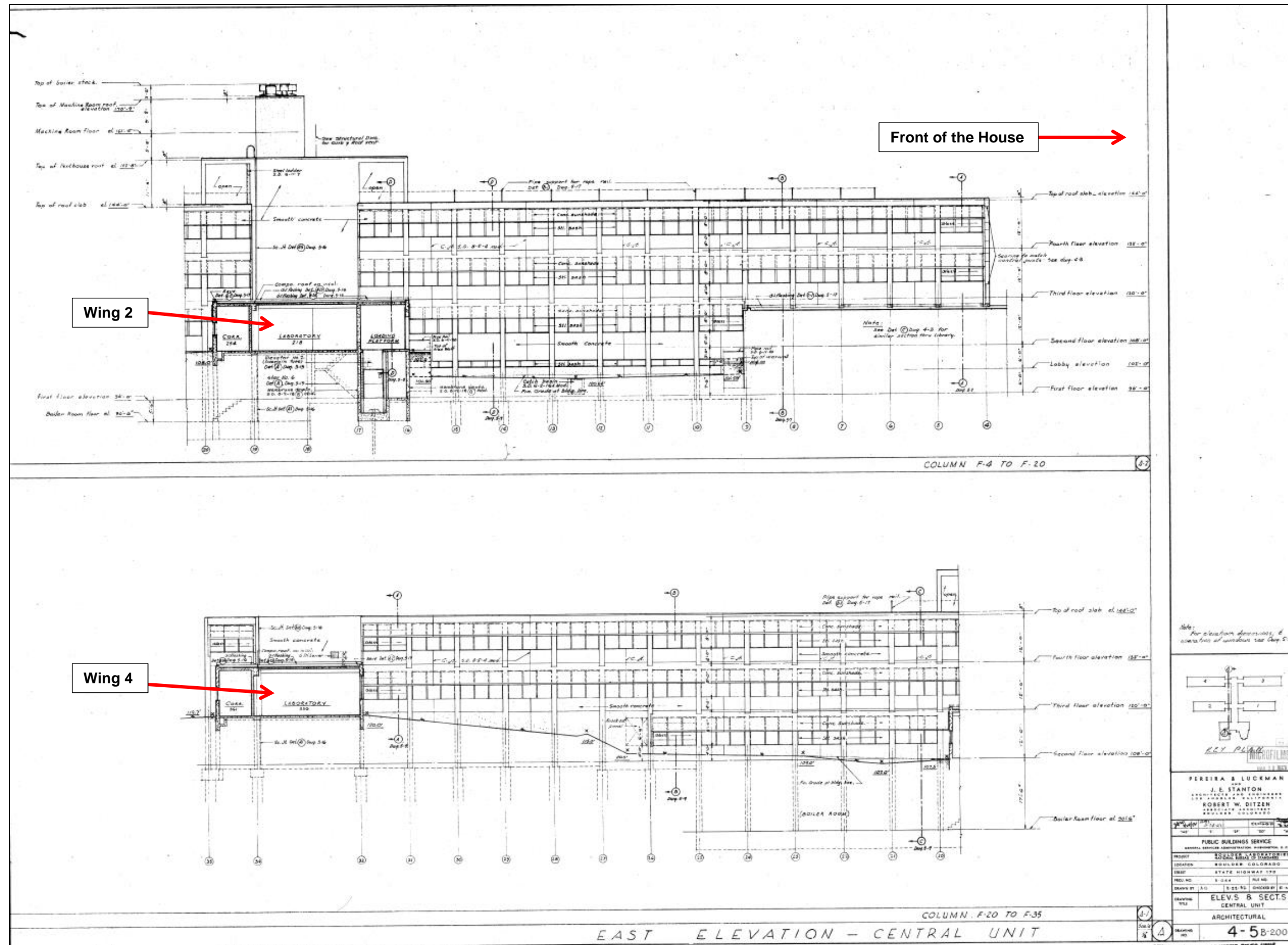


Figure 2-13. East Elevation of Spine, Drawing A-4-5, February 22, 1952 (annotations added by sDC and AECOM; Pereira & Luckman, Stanton, and Ditzen 1952)

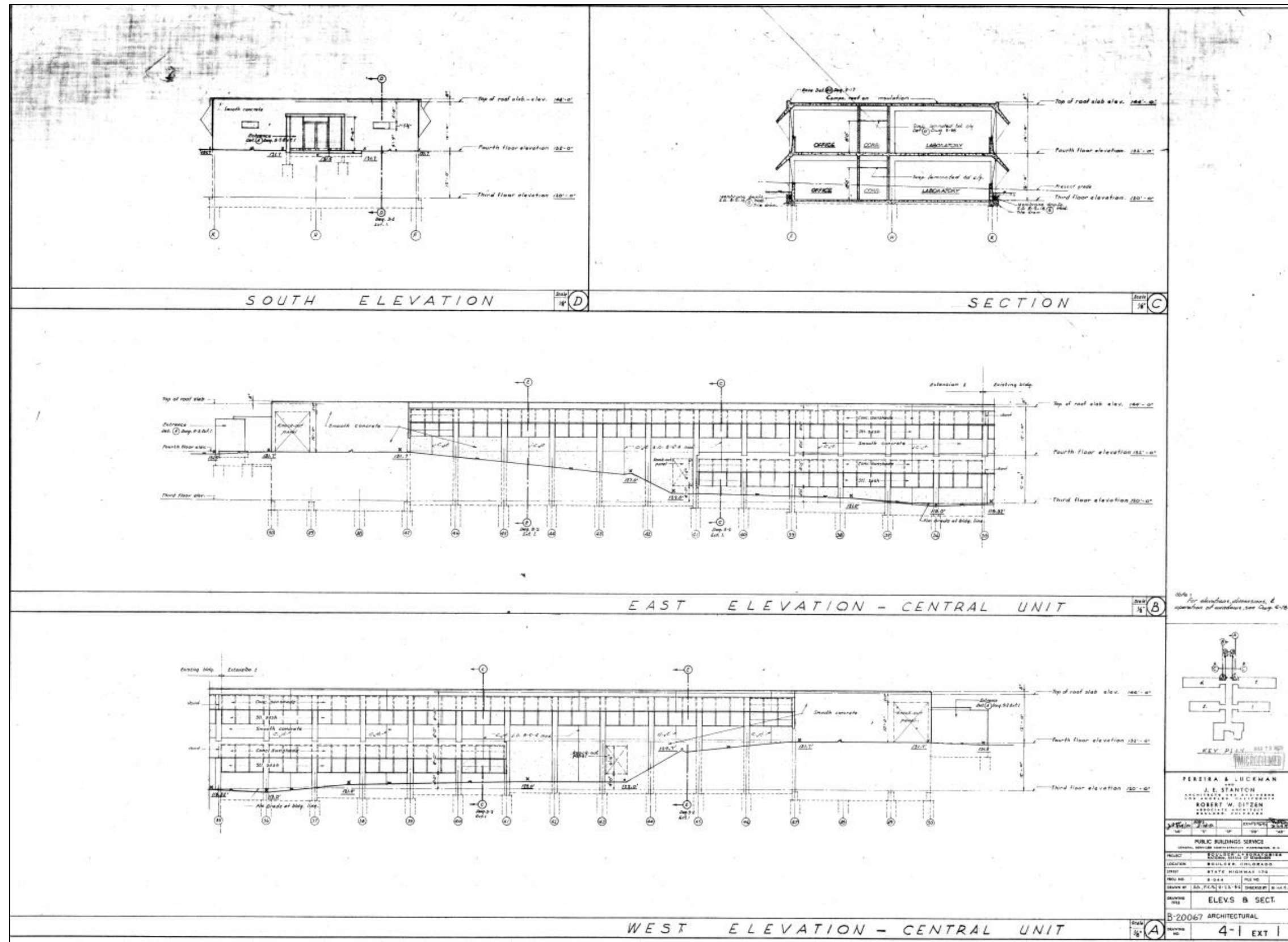


Figure 2-14. Spine Elevations, Drawing A-4-1, Ext.1, February 22, 1952 (Pereira & Luckman, Stanton, and Ditzen 1952)

on the long sides of the Spine, with a narrow fixed light the top, a wider awning window in the center, and a narrow hopper window on the bottom. The north elevation of the hyphen connecting Wing 2 to the Spine featured a loading dock, two sets of three grouped tripartite windows, and a single-leaf door (refer to Drawing A-4-7 in Appendix B). The north elevation of the hyphen between the Spine and Wing 4 featured three sets of tripartite windows and the north elevation of the hyphen between the Spine and Wing 3 had three sets of three awning windows (refer to Drawing A-4-9 in Appendix B). The south elevations of all four hyphens had double-leaf doors with half lights centered between three awning windows (refers to Drawings A-4-8 and A-4-10 in Appendix B).

At the intersection of Wings 1 and 2, the exterior walls of the Spine above the hyphens were smooth concrete with no openings (refer to Figure 2-11). The building's boiler stack extended above the roof in this location, and a concrete penthouse structure was constructed around the stack to house temperature control equipment (**Figure 2-15**).



Figure 2-15 Rooftop Penthouse and Boiler Stack, 1954 (view southwest; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Museum of Boulder Collection)

The segment of the boiler stack that extended above the penthouse roof was housed inside a stadium-shaped concrete structure (refer to Drawing A-3-9 in Appendix B). The boiler stack structure was ventilated with louvered vents and the boiler stack protruded from its rooftop. The north elevation of the penthouse included a set of three, 3-light steel-sash windows and double-leaf metal doors with half lights. The south elevation had a double-leaf metal door with half lights and a steel ladder attached to the exterior wall to provide access to the roof of the penthouse and the boiler stack. Both the north and south elevations of the penthouse had cantilevered terraces, and the rooftop north of the penthouse was tiled for open-air rooftop experiments. The exterior walls of the Spine above the hyphens at intersection of Wings 3 and 4 also were smooth concrete with no openings (refer to Figure 2-11).

Because the terrain sloped upward, the south elevation of the Spine had only one level at grade – Level 4 (Level 3 was present below grade in this location). This elevation featured a double-leaf door with a transom light and sidelights and two narrow rectangular windows (**Figure 2-16**; refer to 2-13). The exterior wall surface was smooth concrete.



Figure 2-16. South End of the Spine under Construction, November 30, 1953 (view northeast; photograph courtesy of Department of Commerce Boulder Laboratories)

2.3.1.2 Front of the House

The Front of the House was at the north end of the Spine and faced northeast toward Broadway Street. It was the original public entrance to the campus and had the most exterior architectural detail. The front façade featured three vertical divisions that included a library (east division), an open courtyard that led to the lobby (central division), and an auditorium (west division) (**Figures 2-17** and **2-18**). The exterior walls are a combination of concrete and native sandstone. The front or north elevation of the Front of the House was 14 bays wide. The bays were formed by the cast-in-place concrete posts and beams, and each bay was 16 to 18 feet wide.

Central Division

The central vertical division or courtyard was three bays wide, measured 50 feet by 72 feet, and was adjacent to the north end of the Spine, which made up the interior portion of the central division (refer to Figure 2-17). The courtyard featured exposed aggregate paving and a large planting area with stone seating. At the lobby elevation, each of the three bays on the short end of the Spine were infilled with plate glass windows divided into six lights by vertical and horizontal steel muntins (**Figure 2-19**). Levels 3 and 4 of the Spine extended above the Front of the House and served as the backdrop for the Building 1's identifying signage. The exterior walls were smooth concrete scored with a rectangular pattern. Fifteen-inch tall bronze letters were attached to the east elevation below the top of the roofline spelling "National Bureau of Standards."

East Division

The east vertical division was five bays wide, measured 80 feet by 132 feet, and contained the library, a corridor, and two large administrative rooms (refer to Figures 2-17 and 2-18). The west elevation that faced the central courtyard had three bays, one that was infilled with sandstone and the other two with windows. Each window bay included five central narrow awning windows bordered by larger fixed plate glass windows on the top and bottom. The front or north elevation of the library was five bays wide. Each of the five bays were infilled with native sandstone (**Figure 2-20**; refer to Figures 2-17 and 2-18).

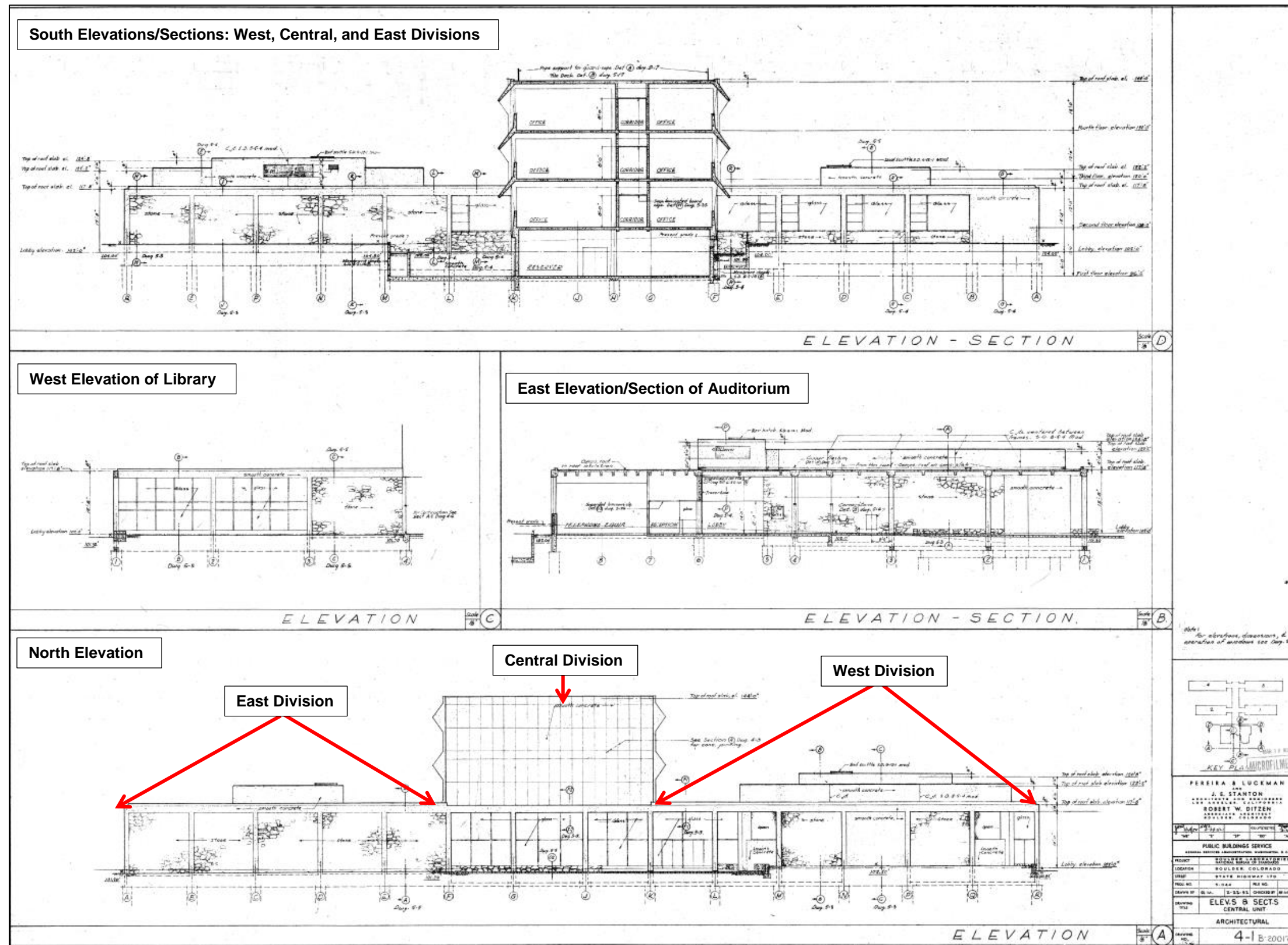


Figure 2-17. Front of the House Elevations and Sections, Drawing A-4-1, February 22, 1952 (annotations added by sDC and AECOM; Pereira & Luckman, Stanton, and Ditzen 1952)

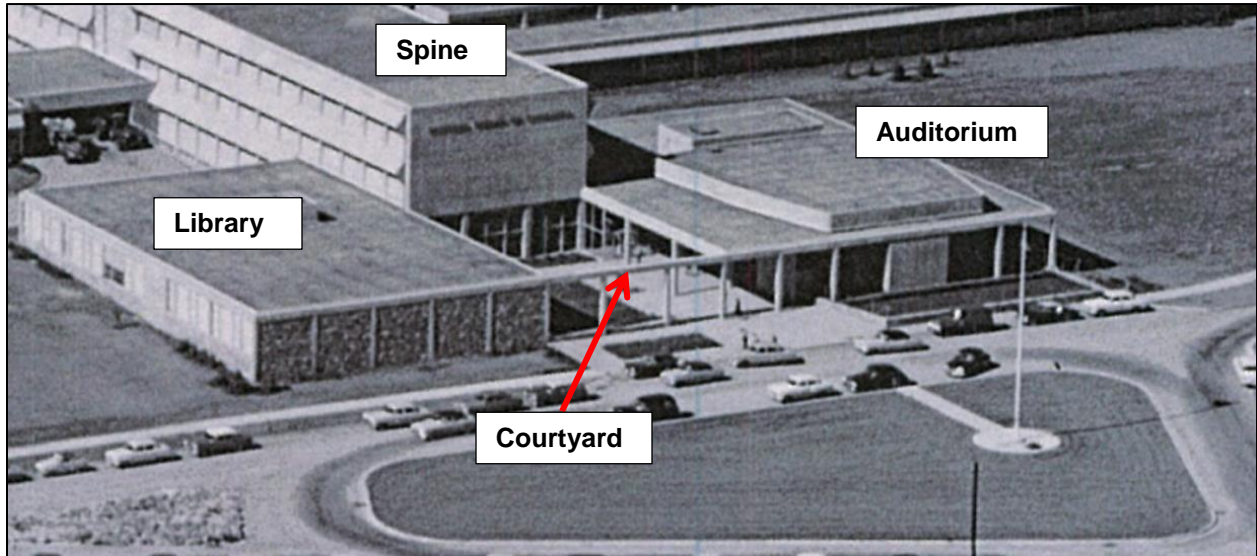


Figure 2-18. Building 1 in the Mid-1950s (view west; cropped and enlarged to show detail; annotations added by sDC and AECOM; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)



Figure 2-19. North End of the Spine at the Front of the House, January 31, 1954 (view southwest; photograph courtesy of Department of Commerce Boulder Laboratories)



Figure 2-20. North Elevation of the Library at the Front of the House under Construction, June 2, 1953 (view southwest; photograph courtesy of Department of Commerce Boulder Laboratories)

The bays on the east elevation were infilled with windows, sandstone, and concrete (**Figure 2-21**). Four bays included two vertical rows of four windows – two fixed lights and two awning windows – separated by two larger panes of fixed plate glass windows. One bay was infilled with windows and a steel louver. The south elevation was five bays wide, with one bay infilled with concrete and the other four with sandstone and windows of the same type as those on the east elevation. There was a small concrete fan room on the roof.



Figure 2-21. East Elevation of the Library at the Front of the House in 1954 (view west; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Museum of Boulder Collection)

West Division

The west portion of the Front of the House was six bays wide, measured 96 feet by 132 feet, and contained the auditorium, entry vestibule, the reception desk, and two lecture rooms (refer

to Figures 2-11 and 2-17). On the east elevation facing the central courtyard, a waffle slab exposed concrete ceiling extended over two bays to form an open patio lit by fixtures mounted to the surface of the exposed roof joists (**Figure 2-22**). The exposed aggregate concrete paving present in the courtyard extended into this area. The open patio led to the main entrance vestibule, which encompassed 1.5 bays (refer to Figure 2-17). The first bay from the east included two sets of double-leaf glass doors with sidelights below two fixed plate glass windows with steel frames. The adjacent half bay was infilled with two fixed plate glass windows with steel frames.

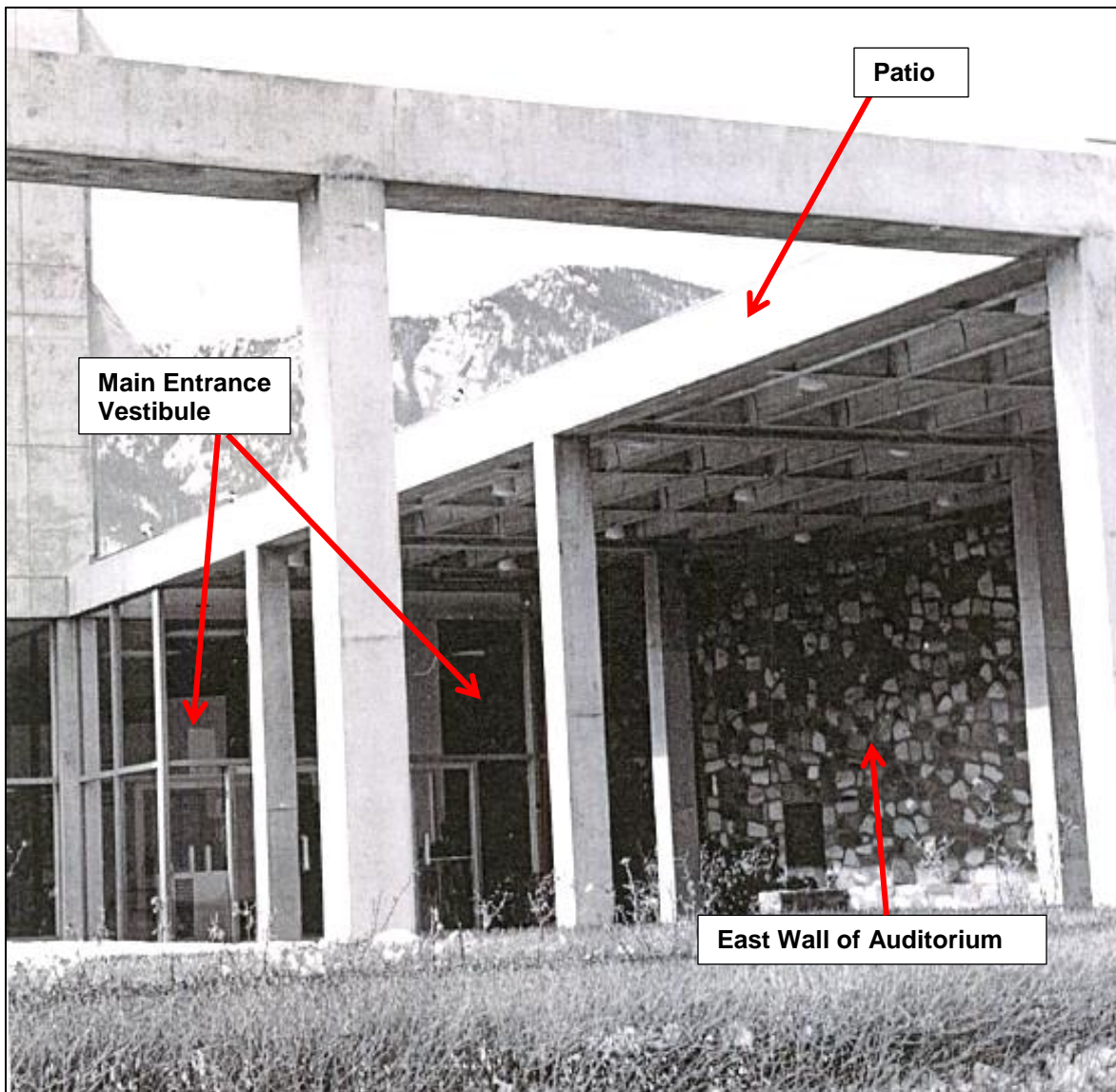


Figure 2-22. Open Patio and Main Entrance Vestibule, 1954 (view southwest; annotations added by SDC and AECOM; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Museum of Boulder Collection)

The exterior walls on the east elevation of the auditorium were sandstone (refer to Figure 2-22) and the granite cornerstone was placed on this elevation. A concrete ramp adjacent to the east elevation with a sandstone retaining wall provided access to the east stage door vestibule from the courtyard and patio area. At the end of the ramp, a single-leaf wood exterior door was inset in a one-story concrete box, which was concealed on the east elevation by an angled concrete “butterfly” screen wall with chamfered corners (**Figure 2-23**).

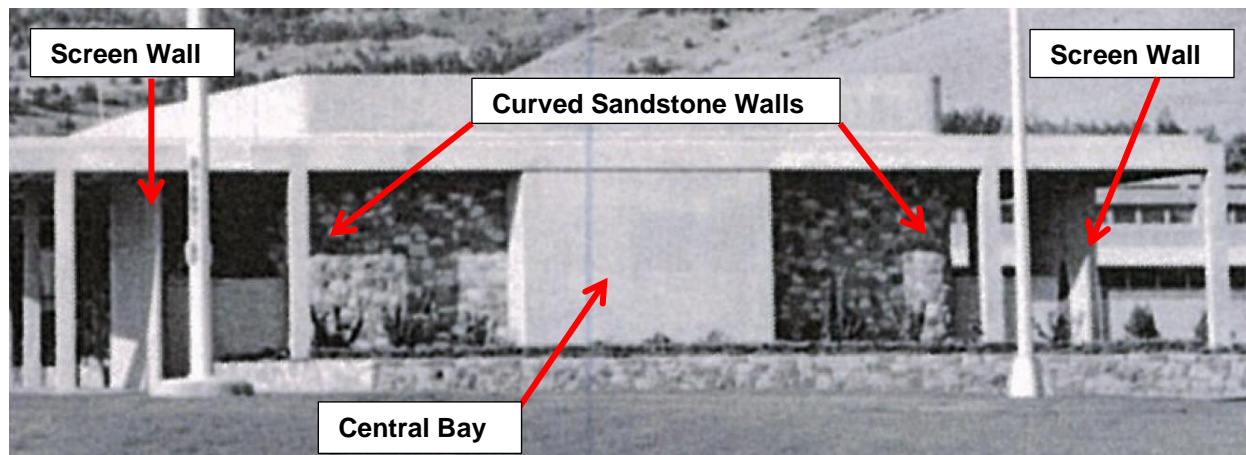


Figure 2-23. Auditorium Section of the Front of the House in the 1950s (view southwest; cropped and enlarged to show detail; annotations added by SDC and AECOM; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

The sandstone wall curved around the northeast corner and continued within the first bay on the north elevation, which was three bays wide (refer to Figure 2-23). The central bay was infilled with concrete and protruded from the surface of the structural columns to accommodate sound equipment on the interior. The third bay was infilled with sandstone and curved around the northwest corner to the west elevation.

The exterior walls on the west elevation were sandstone for about 2.5 bays from the northwest corner. At this point, the wall was intersected by a single-leaf, north-facing door below a steel-framed plate glass window, and then continued for a short distance into the building's interior. Another sandstone wall framed the north side of the door. The next bay to the south was infilled with fixed plate glass windows, and the remaining three bays on the west elevation were infilled with concrete. There also was concrete ramp adjacent to the west elevation to the west stage door that mirrored the ramp on the east elevation, including the retaining wall, exterior single-leaf wood door, and "butterfly" screen wall. The retaining wall on the west elevation was constructed of both brick and sandstone.

Five of the six bays on the south elevation were infilled with sandstone, and the other bay was infilled with sandstone and windows of the same type as those on the east and south elevation of the library section. There was a large equipment room on the roof of the auditorium.

The original landscaping near the Front of the House included expansive lawns adjacent to the library and auditorium sections. Rectangular planting areas were constructed within the pavement north of the courtyard and auditorium, and a large grassy area with a flagpole was constructed between the Front of the House and Broadway Street (see Figures 2-6 and 2-18).

2.3.1.3 Wings 1 through 4

Wings 1, 2, 3, and 4 intersected the Spine south of the Front of the House (refer to Figure 2-6). Wings 1 and 2 intersected the Spine at Level 2 and Wings 3 and 4 at Level 3. The wings were one-story rectangular structures with flat roofs and monitor clerestories that lit internal high-bay laboratories. Like the Spine, the long sides of the wings had horizontal bands of windows shaded by concrete sunshades and separated by vertical concrete columns (**Figures 2-24, 2-25, 2-26, and 2-27**).

Within the wings, the bays formed by the structural post-and-beam construction were each 24 feet wide and 8- to 10-inches deep. Wings 1 and 2 were 10 bays (240 feet) long and Wings 3 and 4 were 12 bays (288 feet) long. The clerestory windows were 1-light awning windows.

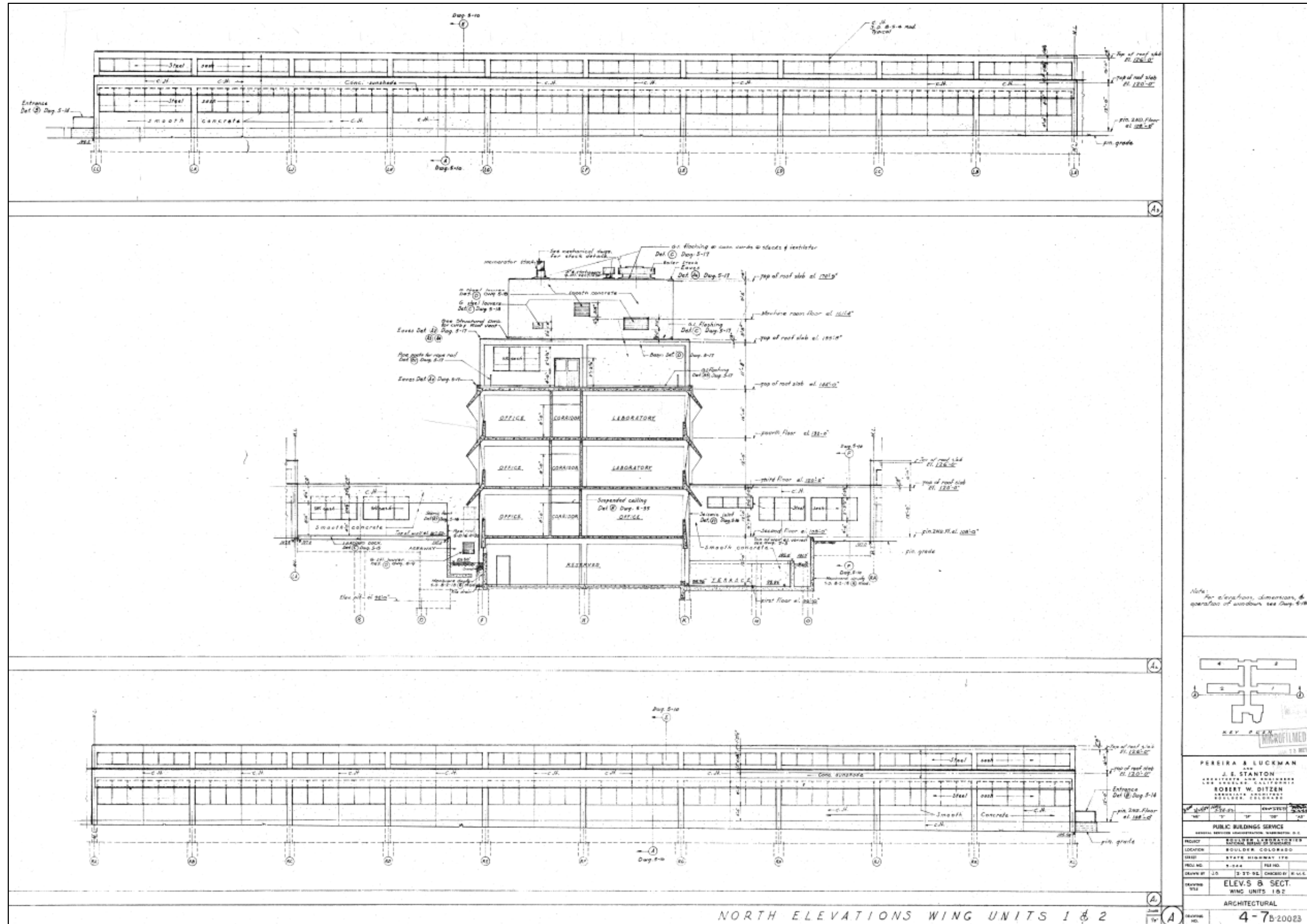


Figure 2-24. North Elevations Wings 1 and 2, Drawing A-4-7, February 22, 1952 Pereira & Luckman, Stanton, and Ditzen 1952)

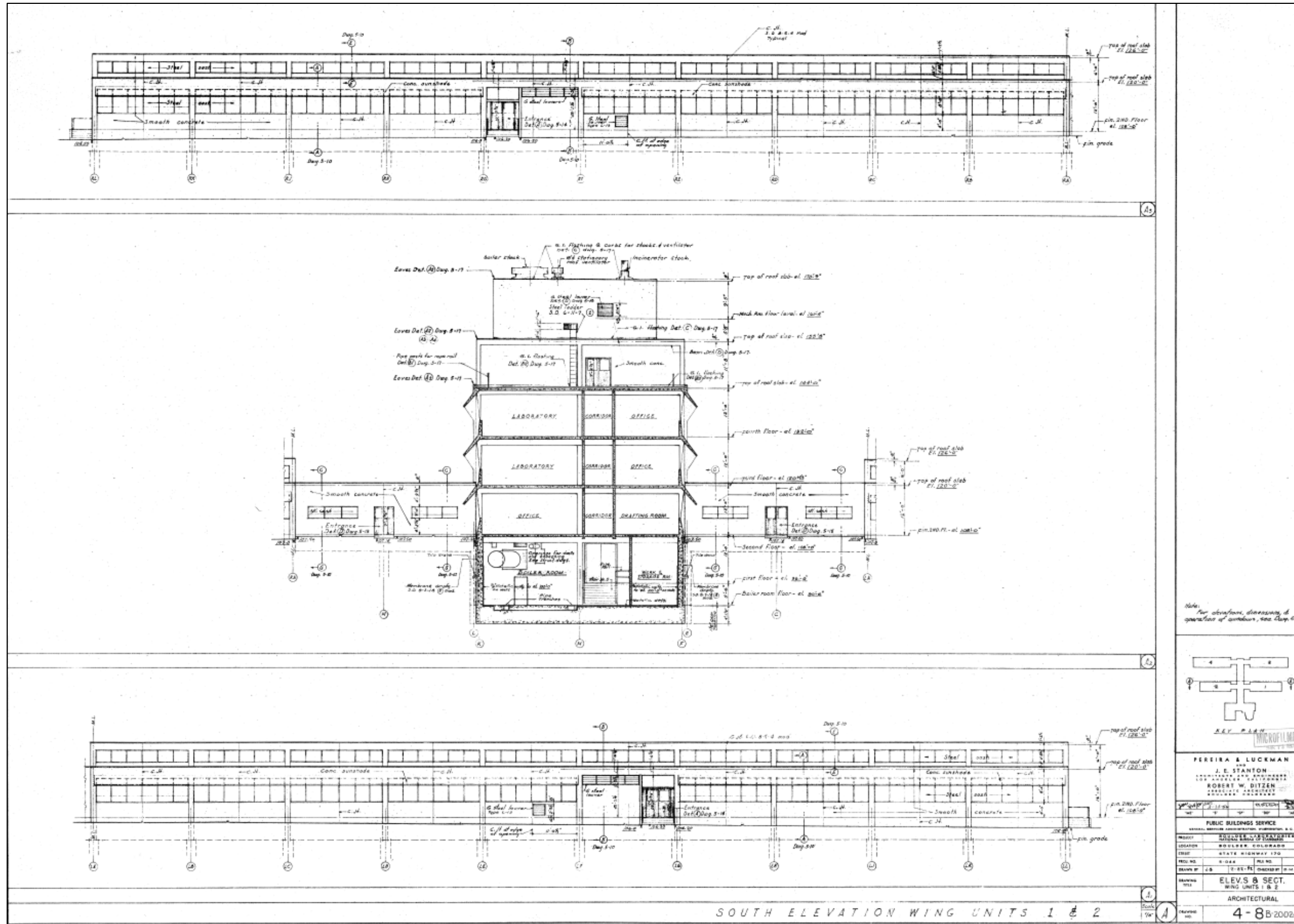
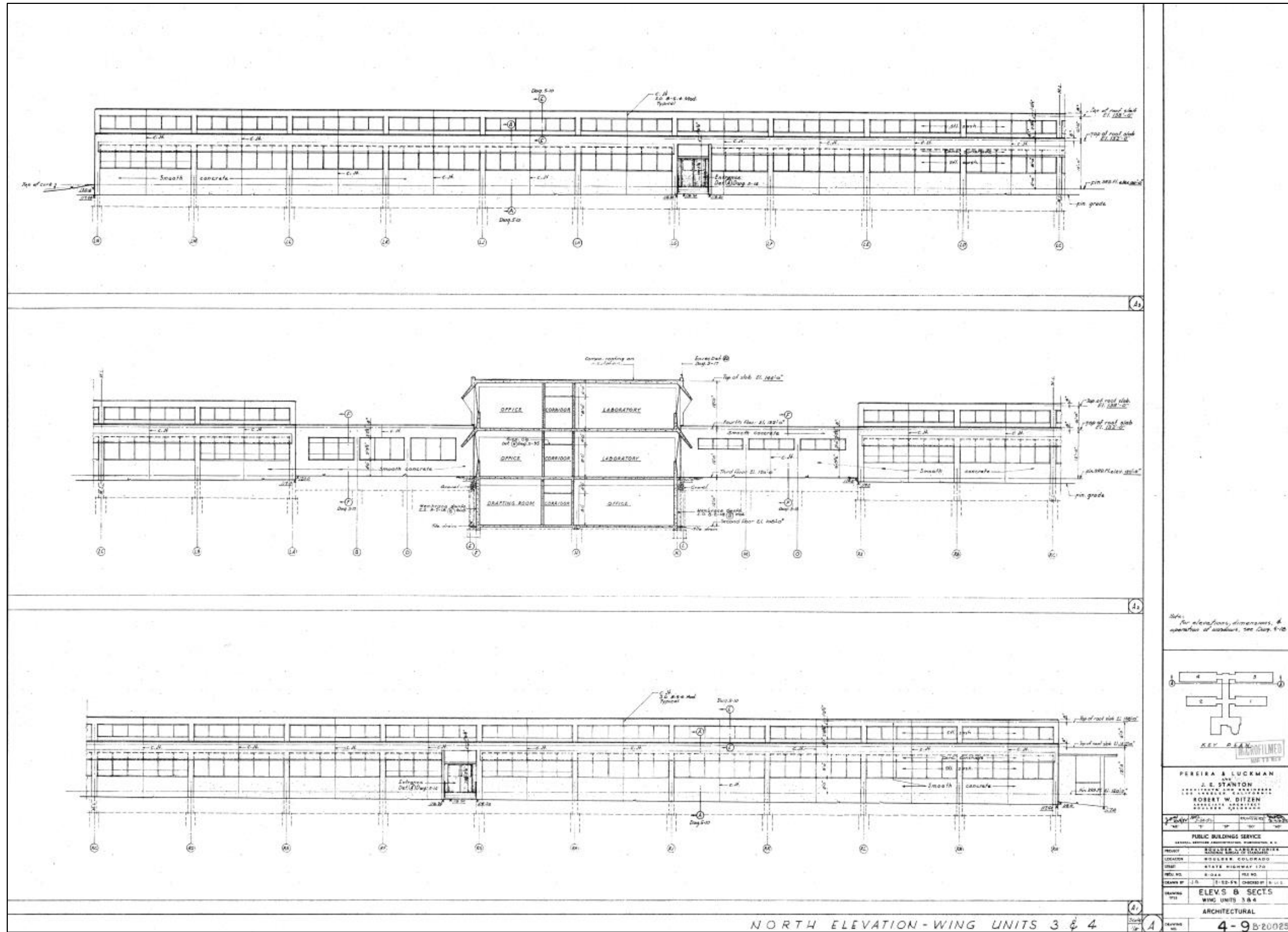


Figure 2-25. South Elevations Wings 1 and 2, Drawing A-4-8, February 22, 1952 Pereira & Luckman, Stanton, and Ditzen 1952)



Notes:
For elevations, dimensions, &
orientation of windows, see Chap. 4-10

KEY PLAN

PEREIRA & LUCKMAN
AND
J. E. STANTON
1115 LEXINGTON ST. BOULDER, CO.
ROBERT W. DITZEN
1015 1/2 W. 10TH ST. BOULDER, CO.

NO.	DATE	REVISIONS
1	2-22-52	AS SHOWN

PUBLIC BUILDINGS SERVICE
GENERAL SERVICE ADMINISTRATION, DEPARTMENT OF COMMERCE

PROJECT	BUILDING 1, BOULDER
LOCATION	BOULDER, COLORADO
DATE	STATE HIGHWAY 170
DESIGN NO.	B-1248
FILE NO.	
DESIGNED BY	J. E. STANTON
CHECKED BY	R. W. DITZEN

DRAWING TITLE
ELEVATIONS & SECTIONS
WING UNITS 3 & 4

ARCHITECTURAL

4-9B-20025

Figure 2-26. North Elevations Wings 3 and 4, Drawing A-4-9, February 22, 1952 Pereira & Luckman, Stanton, and Ditzen 1952)

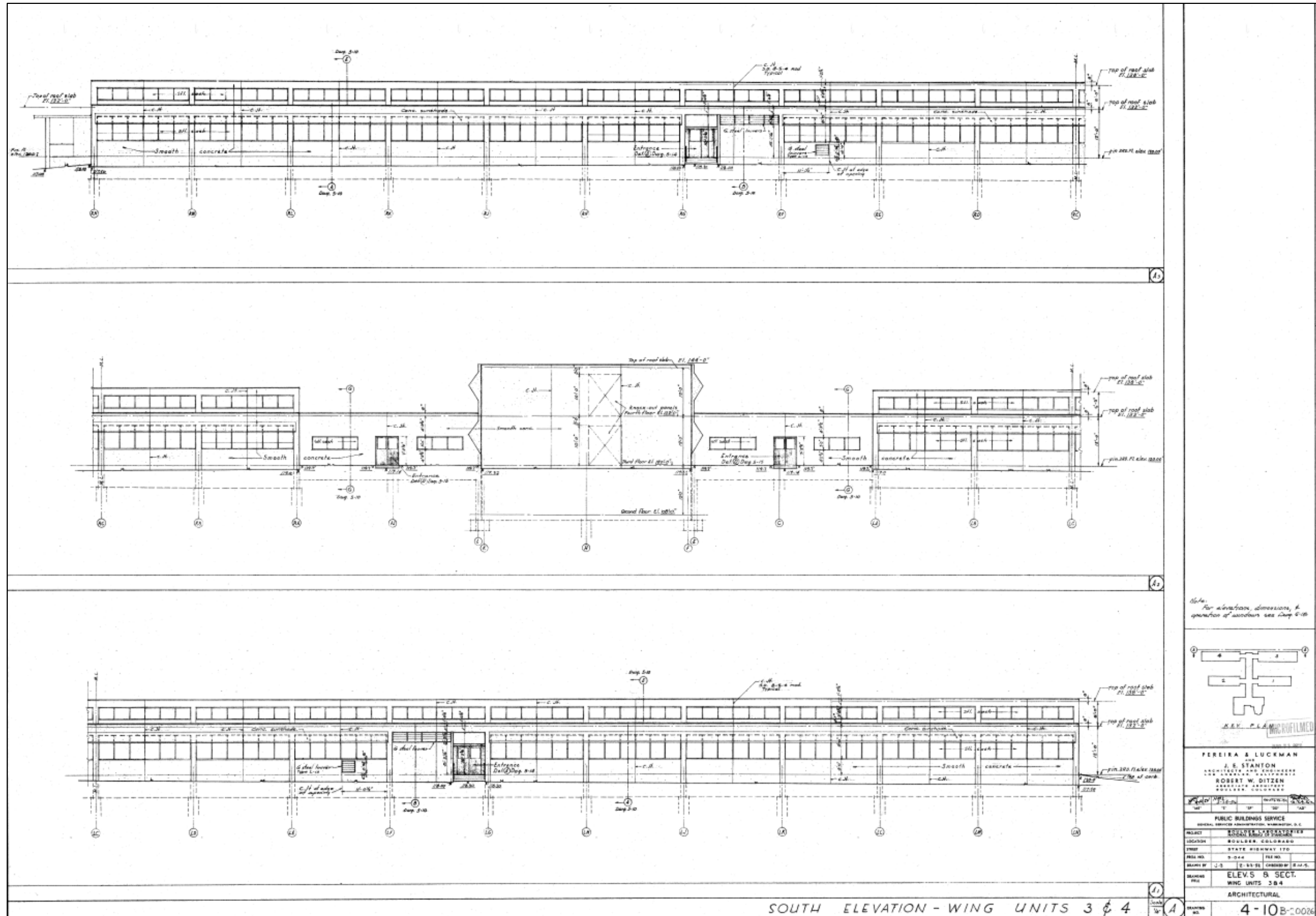


Figure 2-27. South Elevations Wings 3 and 4, Drawing A-4-10, February 22, 1952 Pereira & Luckman, Stanton, and Ditzen 1952)

The bays on the long sides of the wings (north and south) were infilled with smooth concrete and canted windows identical to the tripartite windows on the long sides of the Spine, with a narrow, fixed top light, a larger middle awning window, and a narrower hopper window on the bottom. Because the bays on the wings were twice the width of those on the sides of the Spine, each bay contained six sets of windows.

The north elevations of Wings 1 and 2 were identical, with bays infilled with horizontal bands of windows above concrete aprons for their entire length (**Figure 2-28**; refer to Figure 2-24). The south elevations featured galvanized steel louvered vents below the windows in the fifth bays from the Spine. The sixth bays from the Spine contained galvanized steel louvered vents and entrances with metal double-leaf doors with half lights, hollow metal side panels, and a fixed glass panel transom (**Figure 2-29**; refer to Figure 2-25). The doors were recessed and defined by concrete fin walls installed perpendicular to the building façade that were approximately 7 feet wide, 11 feet tall, and 8 inches thick (refer to Drawing A-5-14 in Appendix B). The doors were accessed by concrete stairs with metal pipe railings. There were no concrete sunshades within the entrance bays.

The vents and entrances on the south elevations of Wings 3 and 4 also were in the fifth and sixth bays from the Spine, respectively, and identical in design to those on the south elevation of Wings 1 and 2 (**Figure 2-30**; refer to Figure 2-27). The north elevations of Wings 3 and 4 did not have vents in the fifth bay from the Spine, but had entrances in the sixth bay that were similar to those on the south elevations but with no adjacent louvered vents (refer to Figure 2-26).

The short ends of all four wings were 73 feet 4 inches wide, comprised of three equal-sized 24-foot-wide bays framed by 8-inch side columns. The central bay was higher to accommodate the high-bay laboratories and monitor clerestories. The wings all possessed the same three-bay configuration but had slightly different door and window openings (**Figures 2-31** and **2-32**).



Figure 2-28. East and North Elevations of Wing 2 under Construction, July 31, 1953 (view west; cropped and enlarged to show detail; annotations added by SDC and AECOM; photograph courtesy of Department of Commerce Boulder Laboratories)

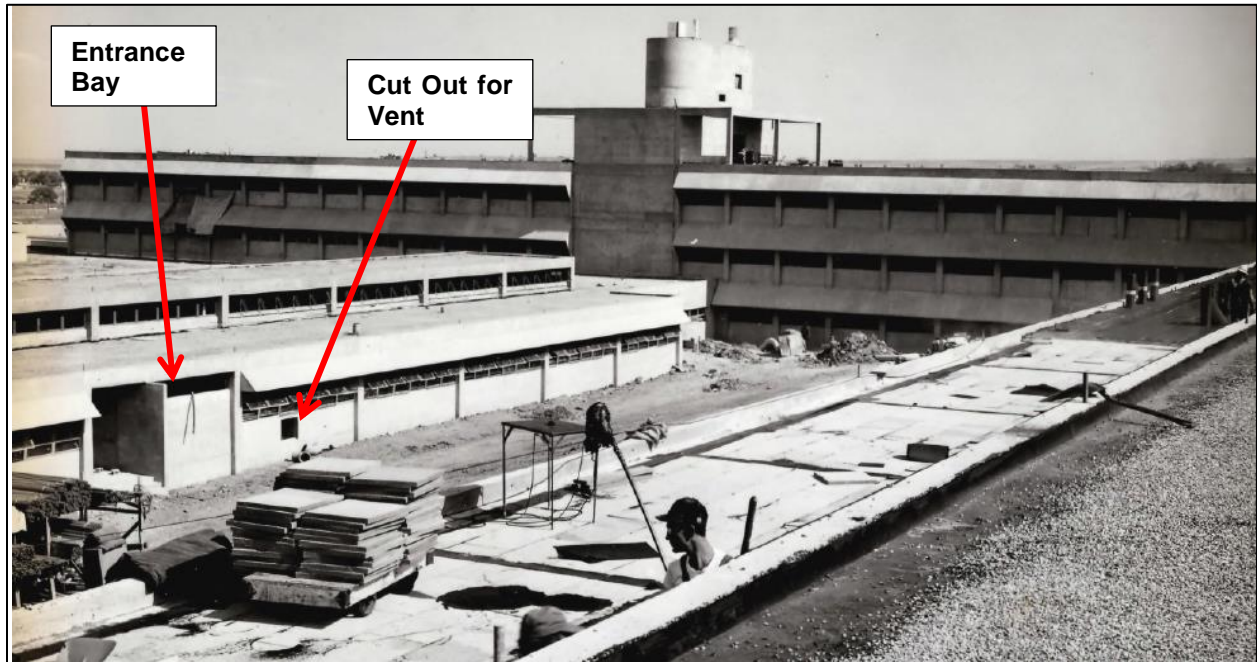


Figure 2-29. South Elevation of Wing 1 under Construction, October 1, 1953 (view east; cropped to show detail; annotations added by sDC and AECOM; photograph courtesy of Department of Commerce Boulder Laboratories)



Figure 2-30. North Elevation of Wing 4, East Elevation of the Spine, and South Elevation of Wing 2, November 1953 (view northwest; photograph courtesy of Department of Commerce Boulder Laboratories)



Figure 2-31. South and East Elevations of Wings 4 and 2, November 2, 1953 (view northwest; cropped to show detail; photograph courtesy of Department of Commerce Boulder Laboratories)

The northern bay and central bay on the west elevation of Wing 1 were infilled with concrete. The south bay had a recessed, double-leaf metal door with half lights, hollow metal side panels, and a fixed glass panel transom (refer to Figure 2-32). The doors were accessed by concrete stairs with metal pipe railings.

The east elevation of Wing 2 was similar to the west elevation of Wing 1, except that the entrance was in the southern bay and the northern bay was infilled with concrete (refer to Figure 2-32).

The west elevation of Wing 3 had two infilled side bays and a loading dock in the central bay. The upper clerestory portion of the central bay was infilled with concrete and the lower portion had an approximately 7-foot-tall overhead rolling steel shutter door and a single-leaf pedestrian door with a half light. The concrete loading dock below the entrances had a wood bumper. Access to the loading dock and the entrances was via a set of concrete stairs with metal pipe railings.

The east elevation of Wing 4 was similar to that of the west elevation of Wing 3, except that the rolling steel door in the central bay was 15 feet tall, which was twice as tall as the rolling door in Wing 3.

2.3.1.4 Wing 6

Construction of Wing 6 began in 1956 and completed in 1958 (**Figure 2-33**; refer to Figures 2-7 and 2-8). Wing 6 was constructed on the east side of the south end of the Spine to the south of Wing 4 and intersected the Spine at Level 4 (refer to Figure 2-7). The wing was connected to the Spine through a one-story hyphen that was constructed at the same time as Wing 6. Like the original wings, Wing 6 also was a one-story rectangular building with a flat roof and a monitor clerestory and featured a cast-in-place post-and-beam concrete structure of 24-foot-wide-bays. Wing 6 was 14 bays or 336 feet long, which was longer than the original wings.

Like the original wings, the clerestory windows in Wing 6 were 1-light awning windows, but on Wing 6 the roof monitor over the last two bays on the east end had a taller roof line than the rest of the monitor and contained no windows. This section of the monitor was ventilated by steel louvers.

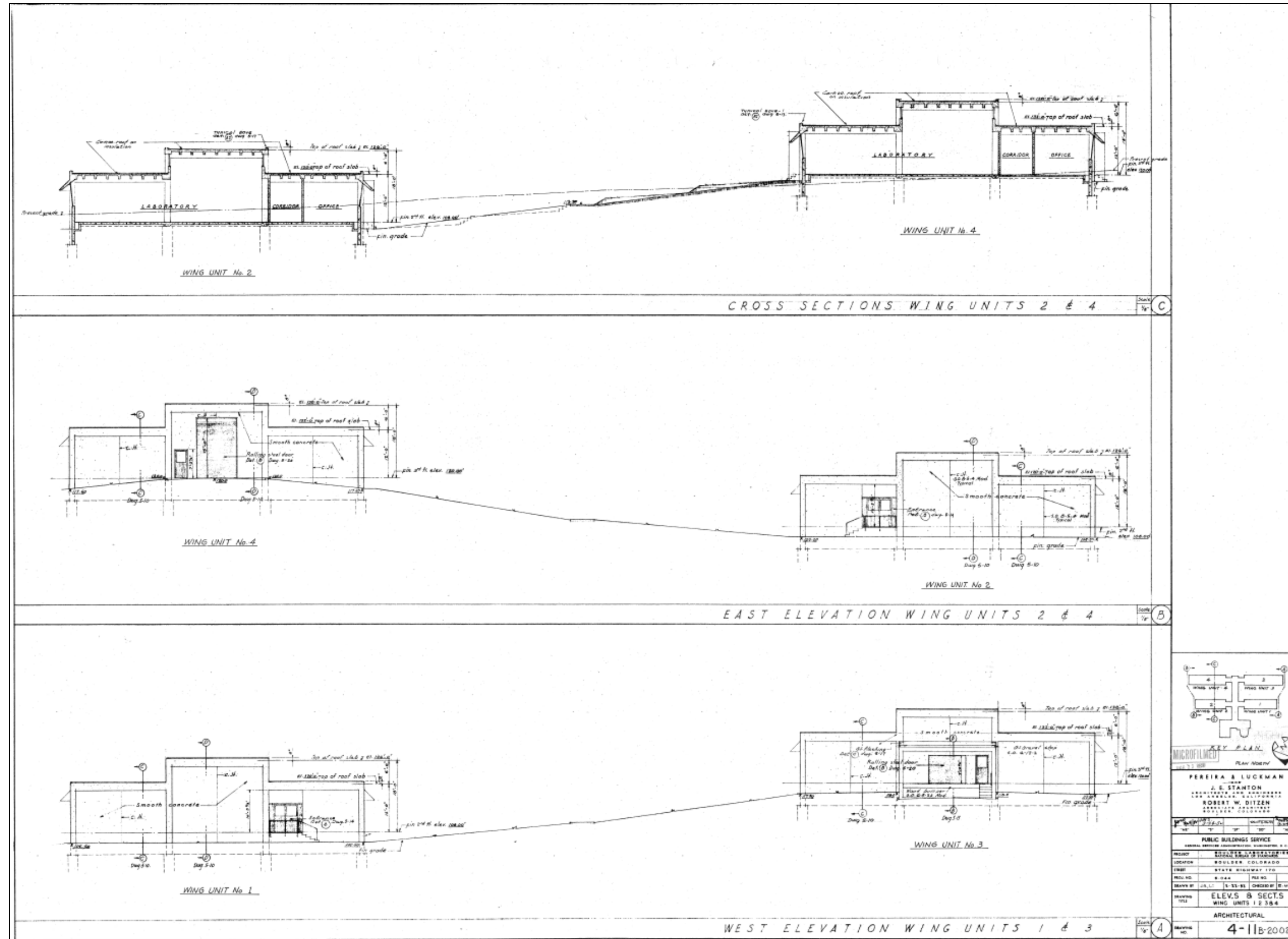


Figure 2-32. West and East Elevations of Wings 1 through 4, Drawing A-4-11, February 22, 1952 Pereira & Luckman, Stanton, and Ditzen 1952)

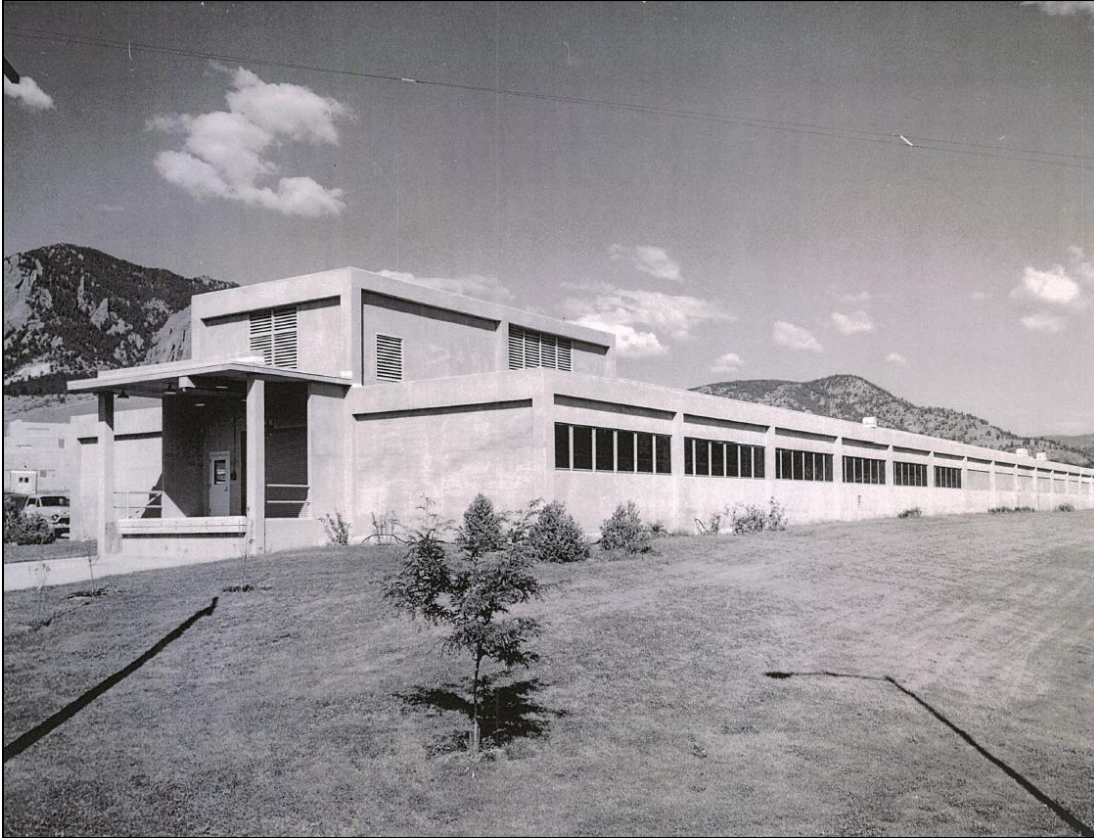


Figure 2-33. East and North Elevations of Wing 6 circa late 1950s (view northwest; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

On the north elevation, the first six bays from the east were infilled with windows and concrete and the remaining eight bays were infilled with smooth concrete only. Each bay included a set of six tripartite steel-framed windows that appear as a combination of fixed, awning, and/or hopper windows. The concrete sunshades that were present on Wings 1 through 4 and the Spine were absent from Wing 6. Instead, a strip of cast-in-place concrete bordered the tops of the windows. The south elevation of Wing 6 had five bays of windows east of the Spine, followed by a bay infilled with concrete. The next bay to the east had a set of three tripartite windows and concrete, followed by two bays infilled with windows, and one bay with a set of five windows and a single-leaf metal door with a half light, concrete stairs, and metal pipe railings. The remaining five bays featured windows.

The short end or east elevation of Wing 6 was similar to Wings 1 through 4 in that it featured three bays with a high central bay. Like Wing 3, Wing 6 had two infilled side bays and a loading dock in the central bay with a rolling steel door, a single-leaf metal person-door with a half light, a wood bumper, and metal pipe railings.

2.3.1.5 Wing 5

Wing 5 or the Computation Facility was constructed in 1962 and was the last wing constructed on Building 1 (**Figure 2-34**; refer to Figure 2-9). It was built on the west side of the south end of the Spine, to the south of Wing 3, and intersected the Spine at Levels 3 and 4 through a two-story hyphen, which was constructed at the same time as Wing 5. Like the other wings, Wing 5 also was a rectangular building with a flat roof and a monitor clerestory and constructed of cast-in-place post-and-beam concrete, which formed 24-foot-wide bays. Although Wing 5 was similar in shape and massing to the other five wings, it had more interior square footage with a partial basement (Level 2 of Building 1) and three stories above or partially above grade.



Figure 2-34. North Elevation of Wing 5 in the 1960s (view southwest; enlarged to show detail; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

On the north elevation, Levels 3, 4, and 5 were above grade and 14 bays long. The windows on all three levels were steel-framed tripartite windows with combination fixed and hopper windows. Each bay included a set of six windows, with the exception of two bays on Level 5 and bays on Level 3 that included doorways. Level 3 was the ground-level story on the north elevation, and had double-leaf metal doors in the hyphen and in the ninth bay west of the Spine. These entrances were recessed double-leaf metal doors with half lights, hollow metal side panels, and plate glass transoms. The wing wall surfaces adjacent to the entrances were exposed aggregate masonry block in stacked bond. A flat, poured-concrete canopy between Levels 3 and 4 shaded the entrance in the ninth bay west of the Spine and the subsequent five bays to the west. Three double-leaf doors were located in three of those bays and one single-leaf door in one bay. A one-story, concrete access portal to a basement staircase was located on the northwest corner. Level 5 mimicked the clerestory levels on the other five wings and was referred to on the 1960 architectural drawings as the monitor level, but it originally included office spaces. On the south elevation, Level 3 was below grade and Level 4 presented as the ground-level story. The windows on the south elevation in both Level 4 and Level 5 were the same as those on the north elevation. A recessed double-leaf door was located in the sixth bay from the west.

The short end or west elevation of Wing 5 was similar to that of the other five wings in that it featured three bays with a high central bay. The northern bay was infilled with concrete and the south bay had a double-leaf metal door. The central bay was infilled with concrete except for the top portion, which had a set of six tripartite windows of the same type as the rest of the building.

2.3.2 Interior Description

2.3.2.1 Front of the House

As indicated in the exterior description, the Front of the House included three divisions – the east, west, and central divisions (**Figure 2-35**). Because it was the original public entrance to the campus and the location of the building's common areas, the architects placed more importance on the architectural details in the Front of the House, while other areas of the building were more utilitarian in design. The Front of the House was connected to the east end of the Spine at what the architectural drawings refer to as the "lobby level," which was midpoint between Levels 1 and 2 of the Spine. The ceilings throughout the Front of the House were concealed spline acoustical tile systems with recessed light fixtures unless otherwise noted.

Central Division

The central division of the interior was the north end of the Spine and was three bays wide and 12 bays long. The floor of the lobby was terrazzo. The north wall of the lobby area consisted of three bays of 0.25-inch-thick plate glass windows divided into six lights by vertical and horizontal steel muntins (**Figure 2-36**). The concrete columns separating the bays were faced with plaster, and the baseboards were steel. The staircases to Levels 1 and 2 of the Spine were centered on

the south wall. The walls east of the staircases were clad with travertine panels (**Figure 2-37**) and the wall west of the staircases was a curved plaster panel. A coat room (Room 116; currently Room 1101A), which was accessed by a door in the reception area in the western division of the Front of the House, was located at the lobby level west of the staircases.

The open staircases to Levels 1 and 2 of the Spine had terrazzo risers and treads, and the handrails were constructed of 1.5-inch steel pipe (**Figure 2-38**). The landing at the top of the staircase and the portion of the Level 2 corridor that was visible from the lobby had terrazzo flooring and baseboards and travertine wall panels. A single-leaf wood door with steel louvers on the east side of the corridor provided access to a dispensary. A double-leaf door on the west side led to stairwell that provided access to the upper levels of the Spine.

The segment of Level 1 of the Spine within the Front of the House included a segment of its double-loaded corridor. There was a public phone alcove and a men's restroom on the west side of the corridor and a gear room, lounge, ladies restroom, telex room, and mail room on the east (refer to Figure 2-35). In the restrooms throughout Building 1, the interior finishes included ceramic tile and plaster. Flooring in the corridor was terrazzo with terrazzo baseboards. The walls surrounding the staircase were clad with travertine panels and the walls in the remainder of the corridor were plaster. The corridor continued south to a set of double-leaf doors that led to the more utilitarian areas of Level 1.

East Division

The east division of the Front of the House was connected to the lobby in the central division by an east/west corridor that terminated in a conference room (refer to Figure 2-35). The walls in the corridor were 8-inch concrete block clad with plaster with steel baseboards and the floors were terrazzo. The south side of the corridor was pierced with four single-leaf wood doors. Two doors provided access to the Personnel Office (Room 123; currently Rooms 1201, 1201A, 1201B, 1203, and 1203A), which measured 32 feet wide and 48 feet long. The other two doors led to the Purchasing Office (Room 124; currently Rooms 1207, 1207A, and 1207B), which measured 48 feet by 48 feet. These offices had concealed spline acoustical ceiling systems, asphalt tile floors and baseboards, and plaster walls.

The library was on the north side of the corridor. It extended the entire width of the north half of the Front of the House's east division and measured 72 feet by 80 feet (refer to Figure 2-35). The main entrance to the library was in the first bay east of the lobby. The entrance consisted of double-leaf birch doors with a birch side panel and baseboard to the west of the door and the plaster wall of the corridor to the east. The flooring in the library was asphalt tile with asphalt tile baseboards and the ceiling was concealed spline acoustical ceiling. Lighting included ten vertical rows of suspension mounted fixtures (**Figure 2-39**). The north and south walls were five bays wide, and the east and west walls were three bays wide. The north wall of the library was exposed structural sandstone, and the south wall was plaster with birch plywood paneling above and to the sides of the library entrance. The east wall included windows that were a combination of fixed and awning windows and furred plaster, and the west wall, which faced the outdoor courtyard, had plate glass window walls in two bays and sandstone in the third (**Figure 2-40**). Baseboard radiators were installed along the north, east, and west walls.

Three interior rooms were constructed on the south wall within the library (Rooms 127, 127A, and 128; currently Rooms 1206, 1202B, and 1202A). The west room was designated as an office and the uses of the central and eastern rooms were initially not assigned. The north exterior wall that faced the stacks area was clad with birch veneer paneling and pierced by two single-leaf doors that provided access to the central and east rooms. The east room also was accessible through a single-leaf door in the exterior corridor, and internal single-leaf doors connected the east room to the central room and the central room to the office. The rooms had

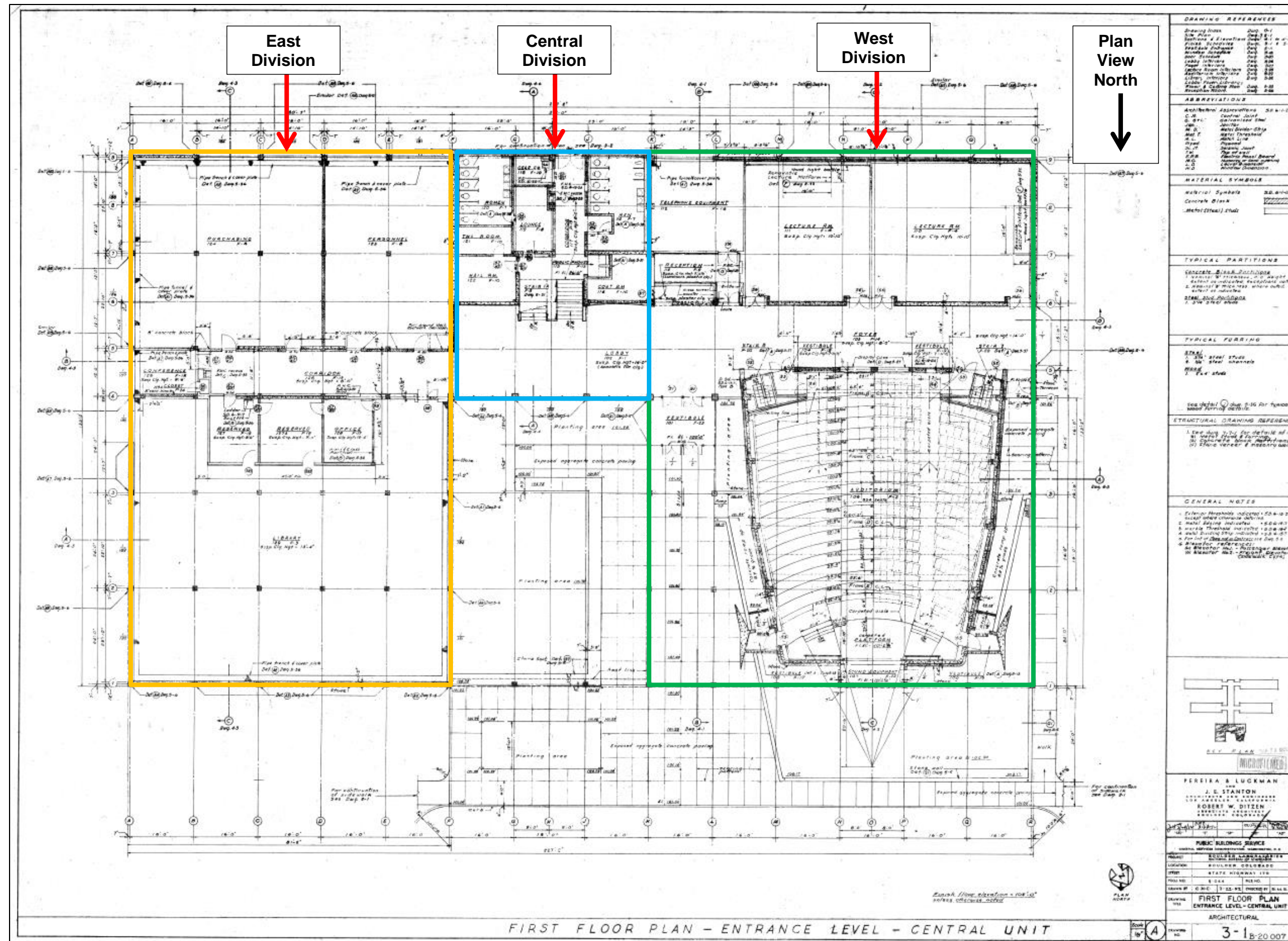


Figure 2-35. Front of the House Floor Plan, Drawing A-3-1, February 22, 1952 (annotations added by SDC and AECOM; Pereira & Luckman, Stanton, and Ditzen 1952)



Figure 2-36. South Wall of the Lobby (*Architectural Forum* 1955, p. 158)



Figure 2-37. Lobby looking east toward the library in May 1954 (photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Museum of Boulder Collection)



Figure 2-38. Staircases to Levels 1 and 2 of the Spine in May 1954 looking southeast toward the Library (photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Museum of Boulder Collection)



Figure 2-39. North Wall of Library in the 1950s (photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Museum of Boulder Collection)

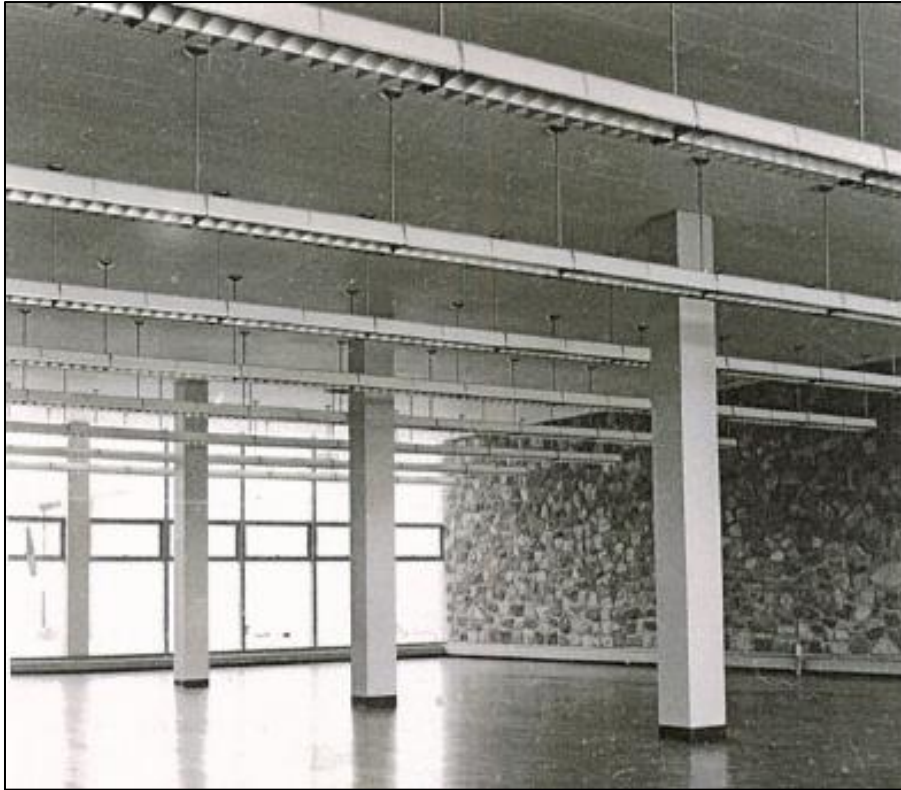


Figure 2-40. West and North Wall of Library in 1954 (photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Museum of Boulder Collection)

concealed spline acoustical ceiling systems, and the floors were clad with asphalt tile and baseboards. The east room had a steel ladder attached to the south wall that provided access to the crawl space above the ceiling. Most interior walls were plaster with the exception of the north wall of the office, which was faced with birch plywood paneling. The west exterior wall of the office also was clad with birch plywood paneling and featured four fixed plate glass windows. The area between the windows and the library ceiling was open.

West Division

The west division of the Front of the House was connected to the lobby by an east/west trending foyer. The auditorium was on the north side of the foyer, and the reception area, a telephone room, and two lecture rooms were on the south side (refer to Figure 2-35). The main entrance to the Front of the House was in this division and encompassed 1.5 bays (refer to Figure 2-22). The entrance included two sets of double-leaf glass doors with sidelights below two fixed plate glass windows with steel frames. The adjacent half bay was infilled with two fixed plate glass windows with steel frames. The exterior doors and window walls served as the north wall of a vestibule. The entrance to the lobby and foyer was opposite the exterior doors on the south wall of the vestibule, which mirrored the window and door configuration of the north wall. The east wall of the vestibule was also glass, and the west wall was an extension of the exterior sandstone wall. The floors of the vestibule were terrazzo with terrazzo baseboards, and there was an interior planting area in the eastern half bay of the vestibule.

The vestibule doors opened onto the intersection of the interior lobby and foyer. Like the lobby, the floors and baseboards in the foyer were terrazzo. The reception area was immediately opposite the vestibule on the south wall (**Figure 2-41**; Room 118; currently Room 1101). The reception area was open to the lobby/foyer, but the reception counter was recessed to allow visitors to step out of the corridor. The wall above the L-shaped reception counter, as well as the

sides and top of the counter, were faced with travertine panels, and the space between the countertop and the ceiling was enclosed with fixed and sliding glass panels. The west, east, and south walls within the reception area were clad with walnut plywood veneer. The east wall also had a single-leaf door to the adjacent coat room, the south wall had a double-leaf door to the telephone equipment room, and the west wall had a section of walnut louvers, a fire house cabinet, and plaster soffits. Employee access to the area behind the reception desk was through a double-leaf, hinged, steel gate. One side of the gate was attached to the west wall of the reception area and other gate was attached to a 12-by-12-inch concrete column clad with plaster on metal lath. The ceiling in the recessed area north of the reception counter was lit by recessed light fixtures; the reception counter and the area behind it had a luminous ceiling.

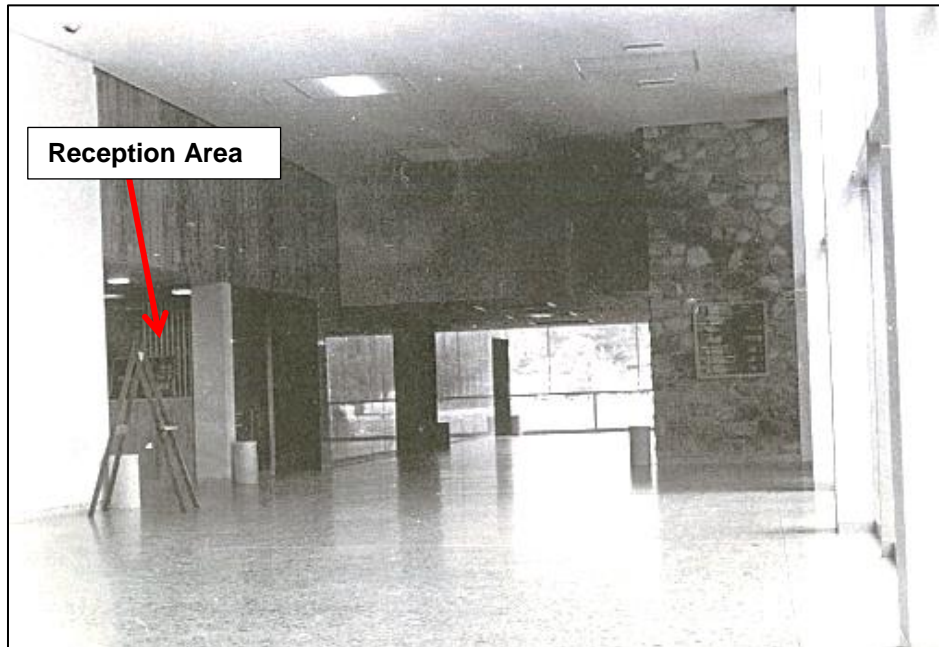


Figure 2-41. Lobby and Foyer looking north toward the Auditorium in May 1954 (annotations added by sDC and AECOM; photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Museum of Boulder Collection)

The foyer continued to the west from the reception area. The south foyer wall was pierced by four sets of double-leaf walnut doors leading to the lecture rooms (Rooms 110 and 111; currently Rooms 1103 and 1107). The walls between and above the doors were faced with travertine panels. The lecture rooms had concealed spline acoustical ceiling systems, asphalt tile floors and baseboards, and plaster walls. One wall of each room featured a removable lecture platform and a chalk board with walnut chalkrails and butterfly-shaped walnut light baffles (refer to Drawing A-5-28 in Appendix B). Anemostats² were installed within the ceilings.

The west wall of the foyer was a bay of plate glass windows divided into five lights by vertical and horizontal steel muntins (refer to Figure 2-41). A small panel south of the windows was faced with travertine and the wall north of the windows was native sandstone. A north-facing exterior double-leaf glass door was installed between the sandstone wall and the short end of the sandstone wall of the west elevation of the auditorium. Segments of both walls partially extended into the interior (**Figure 2-42**). The east end of the north wall of the foyer also was bordered by a segment of sandstone wall, which was the short end of the exterior wall of the east elevation of the auditorium that extended into the interior through the vestibule.

² An anemostat is an anemometer (an instrument used to measure the speed of wind) and a thermostat used to regulate airflow and pressure in a room.

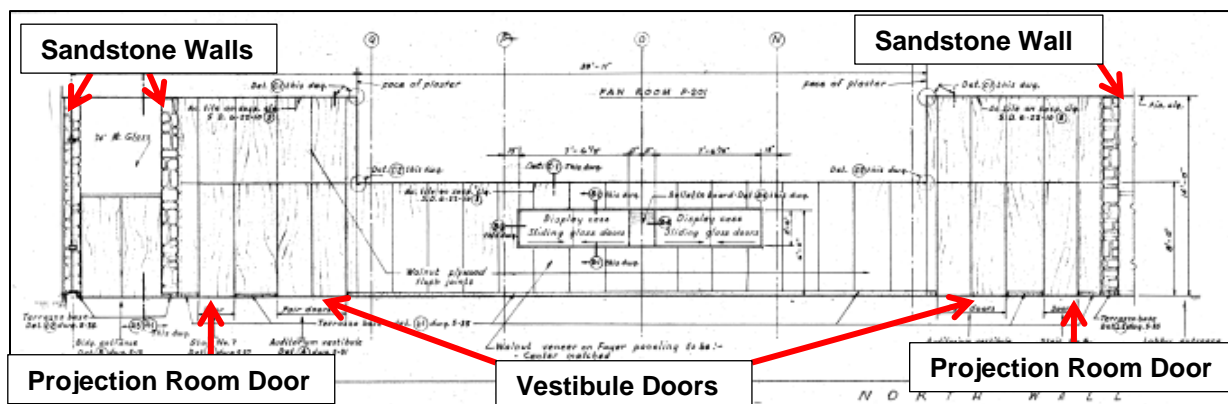


Figure 2-42. North Wall of Foyer, from Drawing A-5-27, February 22, 1952 (annotations added by SDC and AECOM; Pereira & Luckman, Stanton, and Ditzen 1952)

The north wall of the foyer between the sandstone walls was clad with walnut plywood veneer with flush joints and was divided into three sections (refer to Figure 2-42). The central section featured two central horizontal display cases with sliding glass doors inset within the wall. The east and west side sections were angled to match the shape of the auditorium on the opposite side of the wall. Each of the angled walls were pierced by two walnut doors that provided access to the auditorium’s rear vestibules, projection room, and fan room.

The projection and fan rooms were in the upper level at the rear of the auditorium and were accessed by single-leaf wood doors in the north wall of the foyer that opened onto U-shaped steel stairways with concrete treads and iron pipe railings (Figure 2-43). The west staircase terminated in a landing with a single-entry door that accessed the west side of the rectangular-shaped projection room, which had a small restroom in the southwest corner (refer to Figure 2-43). There were nine square openings in the north wall of the projection room that overlooked the auditorium and could be opened and closed using a system of counter weights and chains (Figure 2-44, south wall elevation). Four openings were observation ports, four were projection ports, and one was a spot port. A single-leaf door in the east wall of the projection room accessed an L-shaped fan room that was located on the east and south sides of the projection room (refer to Figure 2-43). The east staircase was similar in design to the west staircase, but its landing entrance opened into the fan room.

The double-leaf east and west vestibule doors were adjacent to the projection room doors on the north wall of the foyer (Figure 2-45; refer to Figure 2-42). These doors led to small carpeted vestibules (Rooms 104 and 105; currently Rooms 1102 and 1108) and an additional set of double-leaf doors to the auditorium. Within the vestibules, the walls surrounding the doors to the auditorium were clad in walnut paneling and the other three walls were clad with perforated cement asbestos panels on one-inch-thick fiberglass and walnut trim (refer to Figure 2-44). The auditorium doors were located within bumped out sections of the south wall of the auditorium to face east and west, and were in alignment with the two aisles that separated the rows of seats.

The Building 1 architects designed the auditorium using the “End Stage” auditorium/theater design, which featured rows of angled seats facing the stage on the north wall (refer to Figure 2-45). The room was trapezoidal in shape, gradually funneling to direct sight lines to the stage and to optimize acoustics. The floor within the auditorium had a gradual downward slope toward the stage, and the rows of 534 coral-colored seats were separated into three columns (left, right, and center) by two aisles that terminated in an arch-shaped perpendicular aisle that spanned the area between the first row of seats and the stage (*The Boulder Camera* 1954d). Floors within the auditorium were carpeted, and the ceiling was suspended plaster to conceal the air ducts above. The plaster ceiling was constructed around six large air diffusers exposed along the north-south centerline of the ceiling.

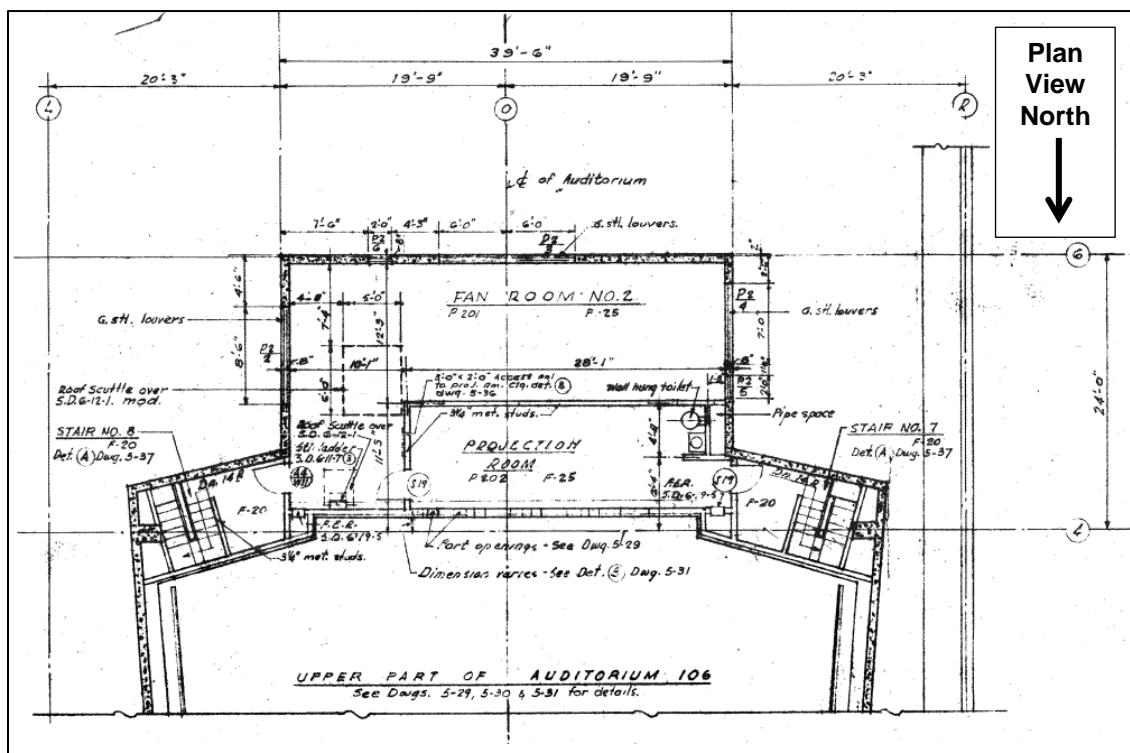


Figure 2-43. Auditorium Projection Room Floor Plan, from Drawing A-3-9, February 22, 1952 (annotations added by SDC and AECOM; Pereira & Luckman, Stanton, and Ditzen 1952)

The arch-shaped stage was accessed by two 8-foot-wide staircases. The wall behind the stage and the two sidewalls were constructed of birch plywood paneling with fiberglass backing. An 8-by-11-foot screen was centered on the stage and bordered on each side by chalkboards with birch chalk rails, molding, and light strips (refer to Figure 2-45, north wall elevation). The stage and the staircases were constructed of concrete and covered with carpeting. Sound equipment was concealed behind the central screen.

On the east and west walls the suspended ceilings were constructed in a slightly jagged, sloping pattern (**Figures 2-46 and 2-47**; refer to elevations on Figure 2-44). The structural columns and plaster walls were visible in the upper portion of the wall. The rest of the wall surface was birch plywood paneling. Bowl-shaped sconces were installed on both walls. Stage doors pierced both the east and west walls adjacent to the stage (**Figure 2-48**; refer to Figures 2-44 and 2-45). These single-leaf birch doors provided access to the east and west stage door vestibules (Rooms 108 and 109; currently Rooms 1102A and 1108A) and the exterior doors and ramps described in Section 2.3.1. The interior walls of the stage door vestibules were exposed concrete slabs, and the ceiling was concealed spline acoustical tile.

The south wall of the auditorium was clad with birch ribs on one- and two-inch-thick fiberglass (refer to Figures 2-44, 2-46, and 2-47). There was an inset fire hose cabinet in the lower wall and observation and projection ports in the upper level for the adjacent projection room.

2.3.2.2 Spine

Level 1

As indicated in Section 2.3.1, the Spine was constructed with four levels. Level 1 was mostly below grade and was approximately 252 feet or 21 bays long. It did not extend the full length of the Spine, terminating about 60 feet west of the intersection of Wings 1 and 2. Primary access to Level 1 of the Spine was by means of a staircase in the Front of the House. The segment of Level 1 within the Front of the House is described in Section 2.3.2.1.

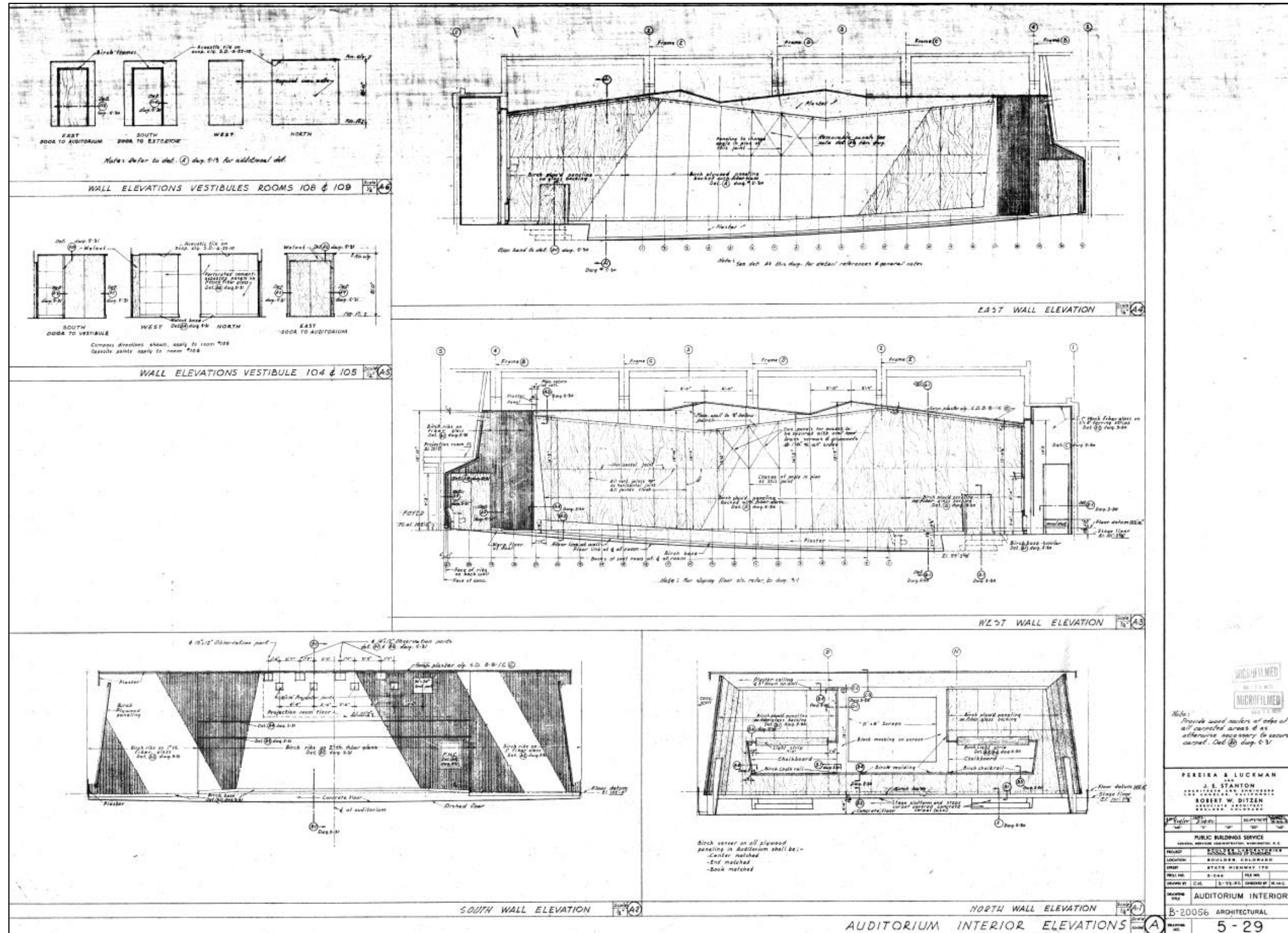


Figure 2-44. Auditorium Interior Elevations, Drawing A-5-29, February 22, 1952 (annotations added by sDC and AECOM; Pereira & Luckman, Stanton, and Ditzen 1952)

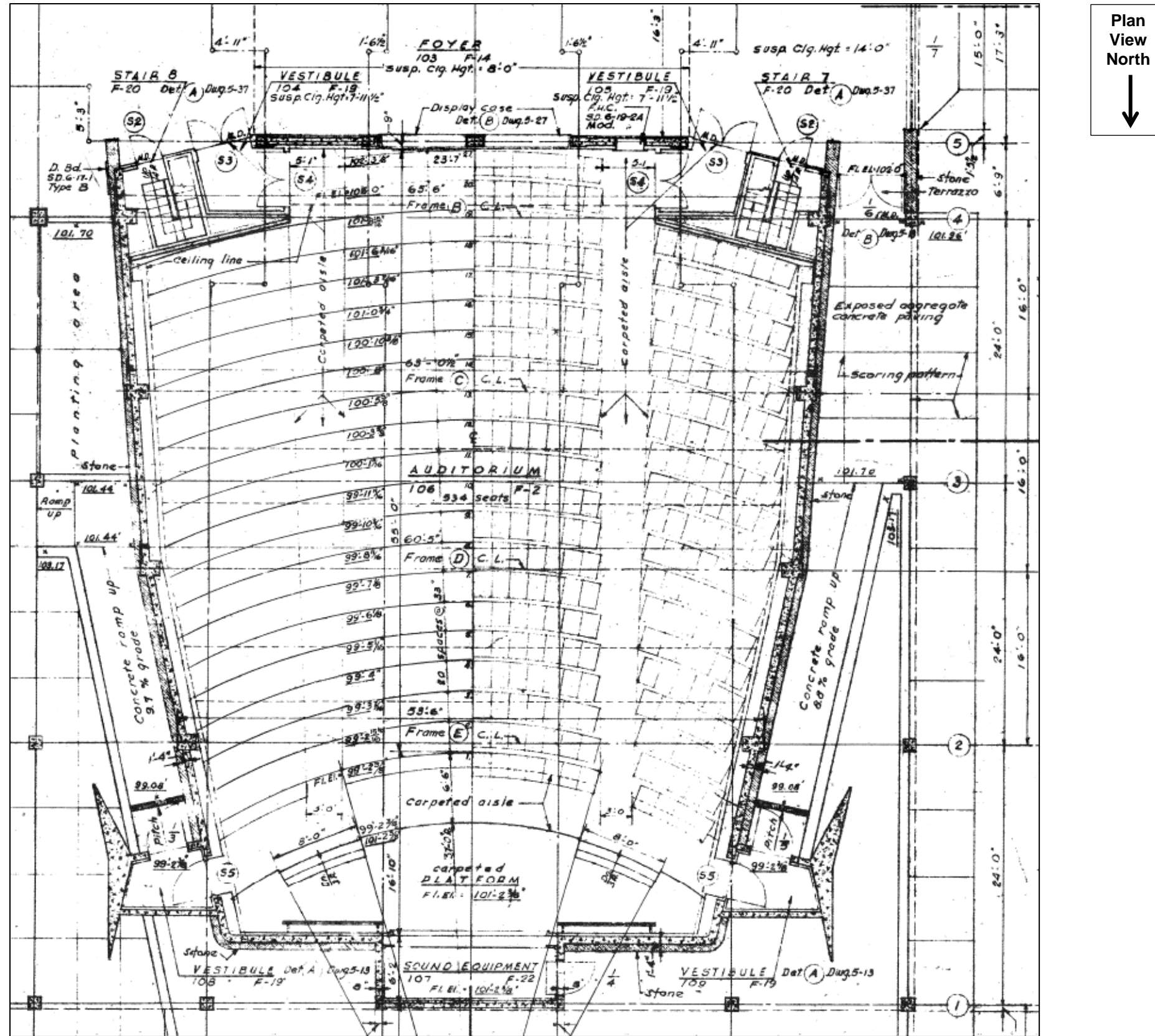


Figure 2-45. Auditorium Floor Plan, Drawing A-3-1, February 22, 1952 (cropped and enlarged to show detail; Pereira & Luckman, Stanton, and Ditzen 1952)



Figure 2-46. South and West Walls of Auditorium under Construction on January 31, 1954 (photograph courtesy of Department of Commerce Boulder Laboratories)

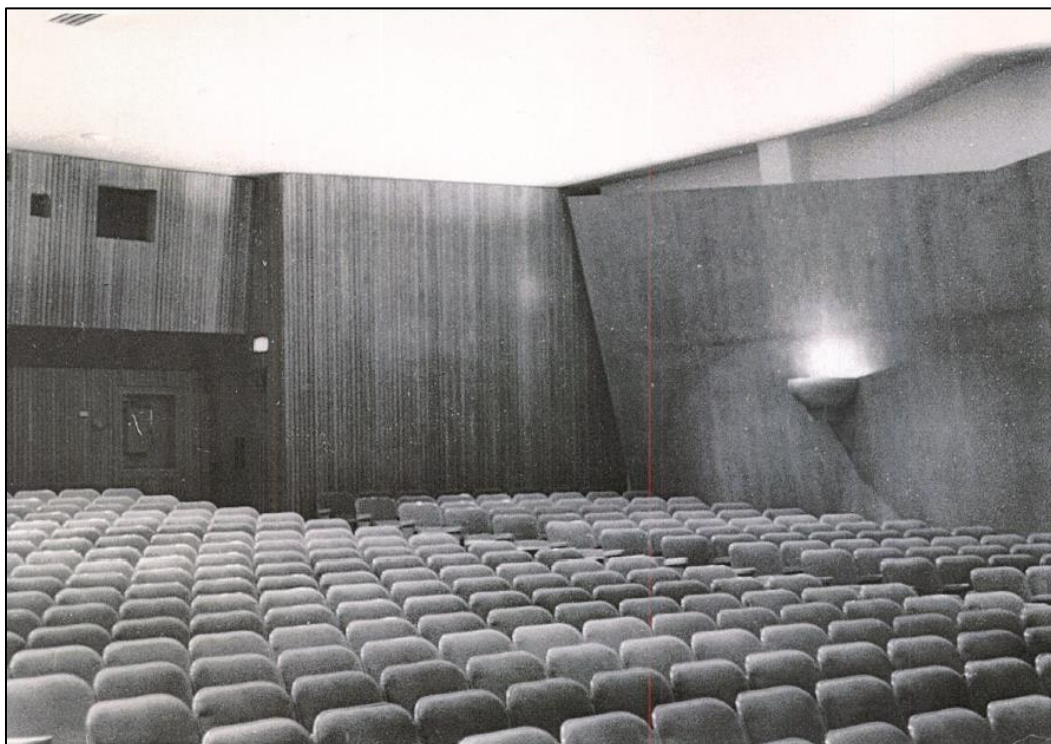


Figure 2-47. South and West Walls of the Auditorium and Auditorium Seats in 1954 (photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Museum of Boulder Collection)



Figure 2-48. Stage and West Stage Door under Construction on March 31, 1954 (photograph courtesy of Department of Commerce Boulder Laboratories)

The more utilitarian areas of Level 1 were through a double-leaf door at the south end of the terrazzo corridor in the Front of the House. Because of the utilitarian nature of Level 1, the floors were likely bare concrete or asphalt tile, and the walls were constructed of concrete masonry units (CMU). Portions of the ceiling may have had suspended plaster or concealed spline acoustical tile and other portions were exposed structural concrete.

A large open area about 8 bays (96 feet) long was south of the double-leaf doors and was reserved for future use as a cafeteria (**Figure 2-49**). The west wall had a sliding door in the fifth bay from the north that provided access to concrete paved outdoor sunken terrace bordered on three sides by concrete planters and walls. Two bays south of the sliding door and three bays to the north contained plate glass windows divided into six lights by vertical and horizontal steel muntins. The east wall of the open area had narrow horizontal bands of windows in seven bays. Each bay included three 1-light awning windows, which were just a few feet above grade level. Adjacent to the eighth bay from the north on the east side, there was a vestibule to an elevator and staircase that provided access to the loading dock on the north side of the Wing 2 hyphen.

The south half of Level 1 was dedicated to the boiler room and other utilitarian proposes. A double-loaded corridor north of the elevator and stair vestibule had trash and incinerator rooms on the east side, and on the west side there was a stairwell and an elevator to the upper levels of the Spine, the boiler stack, and a sewage ejector pit. The south end of the corridor terminated at a descending staircase to the larger boiler room. There was a locker room east of the top of the staircase. At the bottom, there was a work and storage room and the engineer's office. A staircase on the west side of the boiler room provided access to Level 2 and exterior access to the west elevation.

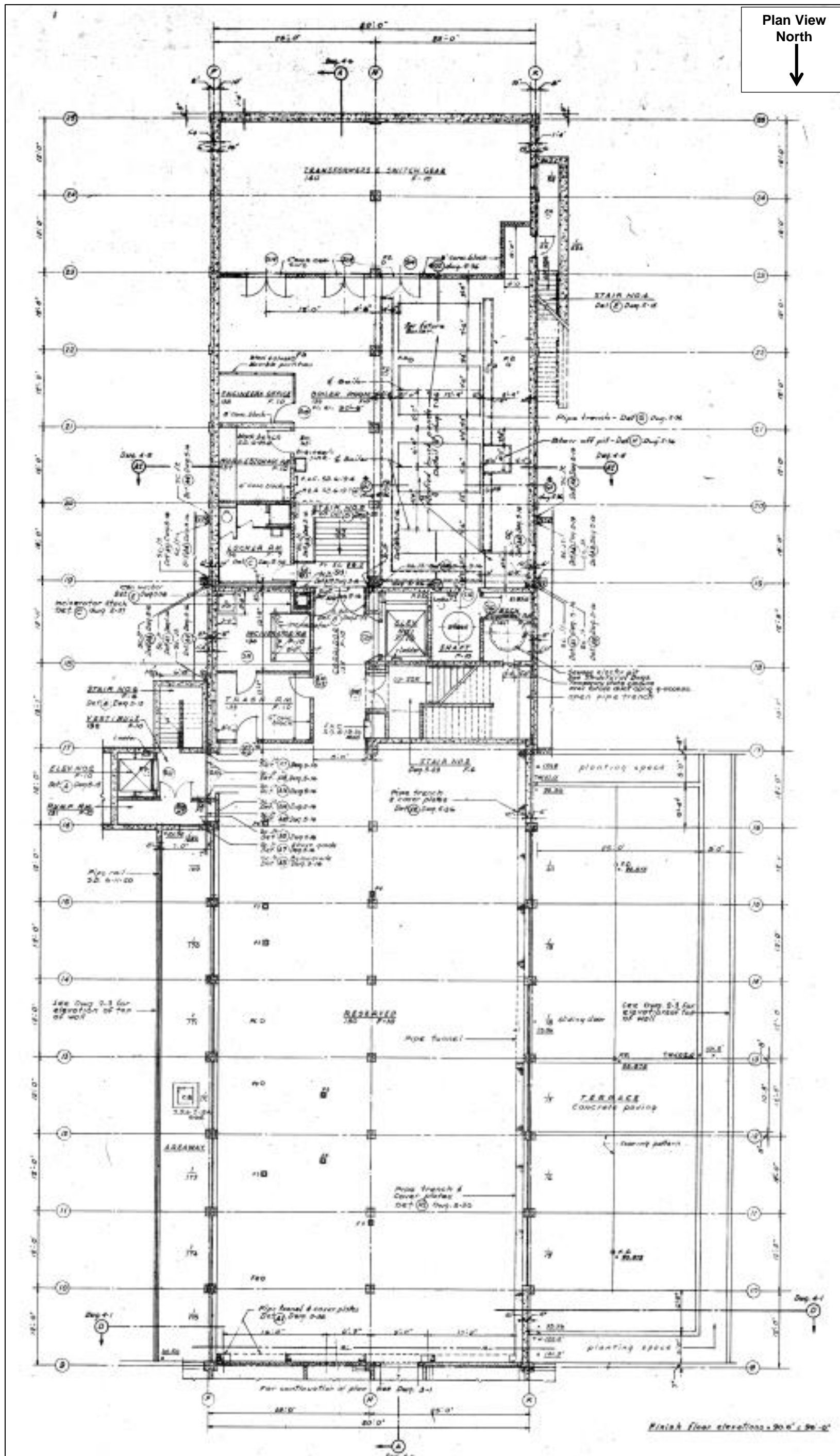


Figure 2-49. Spine Level 1 Floor Plan, from Drawing A-3-2, February 22, 1952 (cropped and enlarged to show detail; annotations added by sDC and AECOM; Pereira & Luckman, Stanton, and Ditzen 1952)

Level 2

Level 2 was about 372 feet or 31 bays long and terminated below grade at the Spine's intersection with Wings 3 and 4. Primary access to Level 2 of the Spine was by means of a staircase in the Front of the House. The segment of Level 2 within the Front of the House is described in Section 2.3.2.1.

Beyond the lobby area, the interior of Level 2 included a 7-foot-wide double-loaded corridor with offices and drafting rooms on the east side that were approximately 16 feet deep, and laboratories on the west side that were about 25 feet deep (**Figure 2-50**). Level 2 originally housed the main administrative offices of the CRPL (Worcester 1954). The non-load bearing interior walls were constructed of 6-inch CMU and the ceilings were suspended plaster or exposed structural concrete (**Figure 2-51**). The flooring was asphalt tile (**Figures 2-52 and 2-53**). Most of the doors to the office, drafting room, and laboratory spaces off of the double-loaded corridor were single-leaf wood doors. The double-leaf doors to the stairwells were wood veneer with incombustible cores, and the restroom and utility room doors were wood with steel louvers.

Within the offices and drafting rooms on the east side of the corridor, the exterior windows were on the east wall, and within the laboratories on the west side of the corridor, the windows were on the west wall. Baseboard radiators were installed below the windows and utilities were concealed within steel raceways attached to the wall surfaces on three walls of rooms below the window level (refer to Figure 2-52). Lighting included rectangular suspension mounted fixtures (refer to Figures 2-51 and 2-56).

Wings 1 and 2 intersected the Spine at Level 2 approximately 144 feet west of the Front of the House (refer to Figure 2-50). At this point, an east-west trending perpendicular corridor intersected the Spine to provide connections to the wings. Within the Spine footprint, this intersection included the 8-foot-wide perpendicular corridor, a women's restroom and lounge on the east side of the Spine's main north-south corridor, and a stairwell, an elevator, and utility rooms containing the boiler stack and electrical equipment on the west. The connecting perpendicular corridors continued to the east and west through one-story hyphens between the Spine and the wings. In addition to the corridor, the east hyphen contained a laboratory and a staircase to Level 1, and the west hyphen included a men's restroom and a laboratory.

Level 2 of the Spine between the intersections of Wings 1 and 2 and Wings 3 and 4 historically housed the offices, drafting rooms, and laboratories associated with the atomic clock (refer to Figure 2-50). To control equipment vibration, Rooms 230, 232, 233, and 235 (currently Rooms 2041, 2047, 2048, and 2052) were constructed with isolated floor slabs and Room 236 (currently Room 2053) with instrument bases. Room 234 (currently Room 2051) was the Frequency Standards Room. Most rooms dedicated to atomic clock research had steel louvers in their single-leaf wood doors. Another stairwell providing access to the other levels of the Spine was located near the south end of Level 2.

Levels 3 and 4

The interiors of Levels 3 and 4 of the Spine were similar in floorplan and design as Level 2. On both levels, the north end of the Spine housed large laboratory spaces above the lobby areas on Levels 1 and 2. The corridors were also 7-foot-wide and double loaded, with the same door types and door patterns, and the same-sized laboratory and office spaces on each side of the corridor. At the junction of Wings 1 and 2 with the Level 2 below, both Levels 3 and 4 housed the continuation of the stairwell, elevator tower, and boiler stack on the west side of the corridor with men's and women's restrooms on the east side.

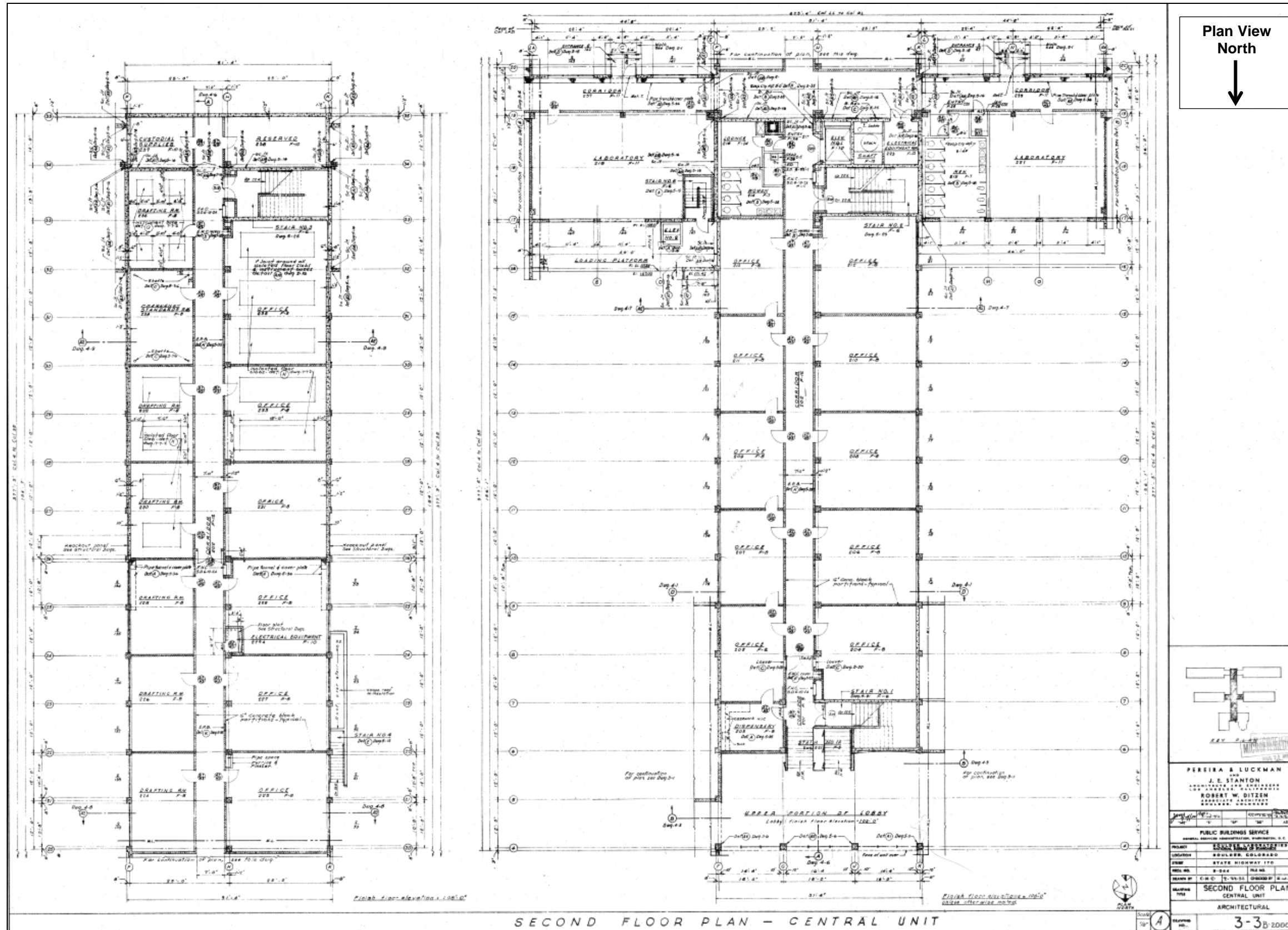


Figure 2-50. Spine Level 2 Floor Plan, from Drawing A-3-3, February 22, 1952 (annotations added by sDC and AECOM; Pereira & Luckman, Stanton, and Ditzen 1952)

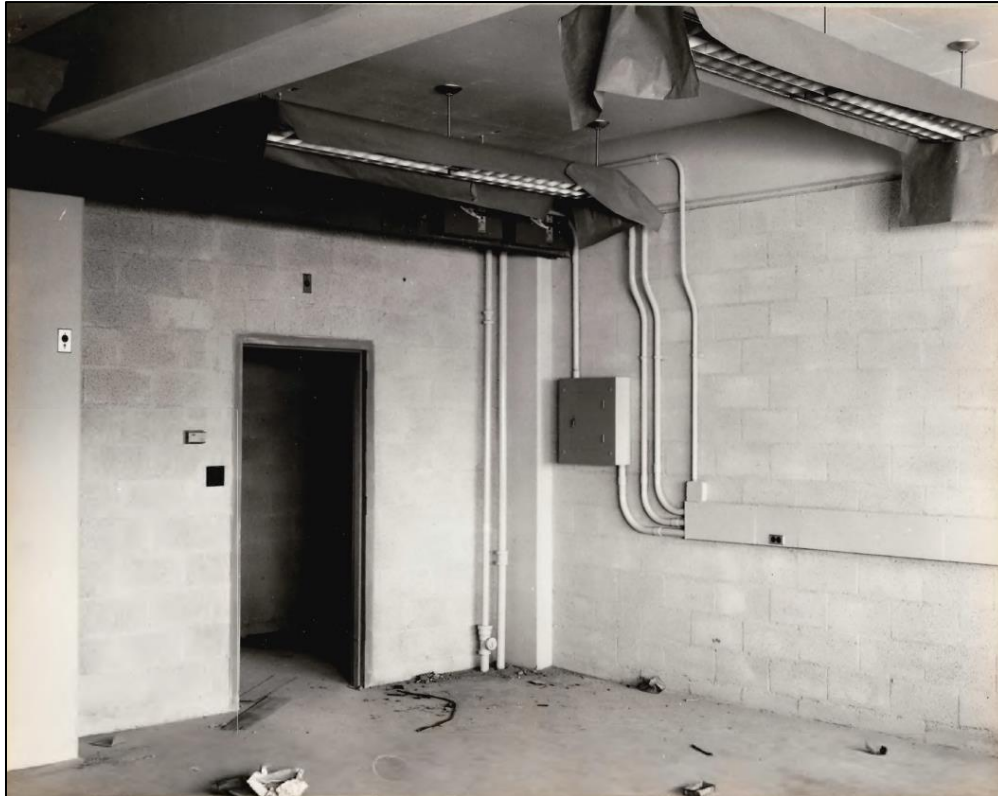


Figure 2-51. Office Room in the Spine under Construction, November 30, 1953 (photograph courtesy of Department of Commerce Boulder Laboratories)

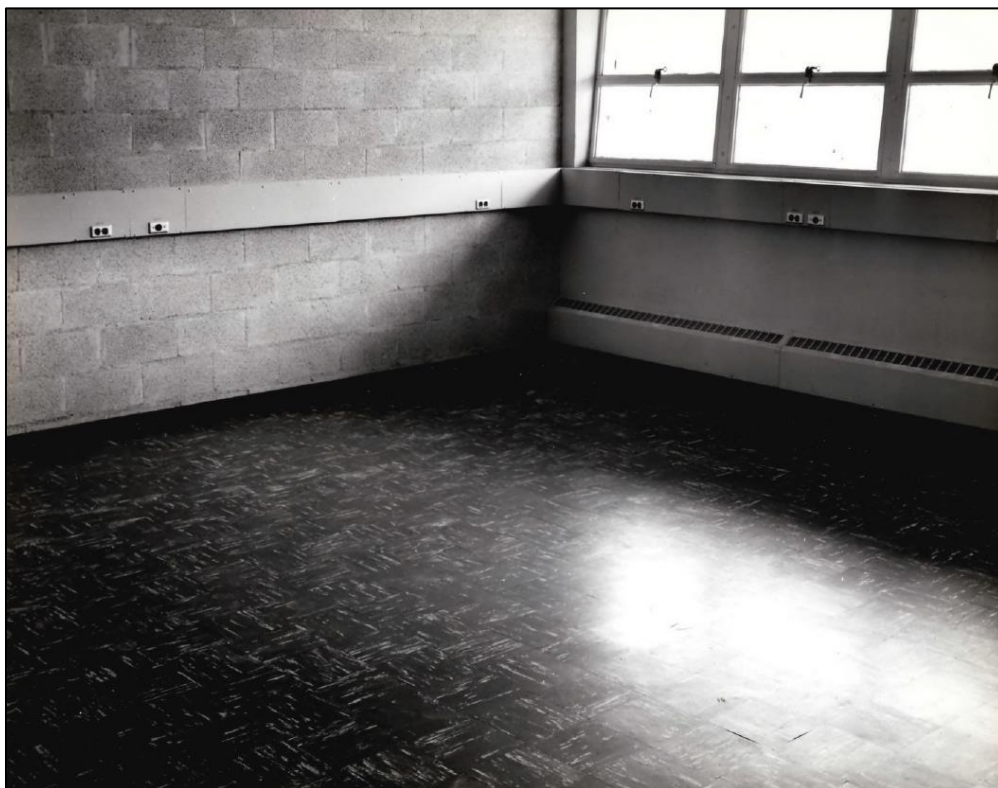


Figure 2-52. Office/Laboratory Room in Building 1, January 31, 1954 (photograph courtesy of Department of Commerce Boulder Laboratories)

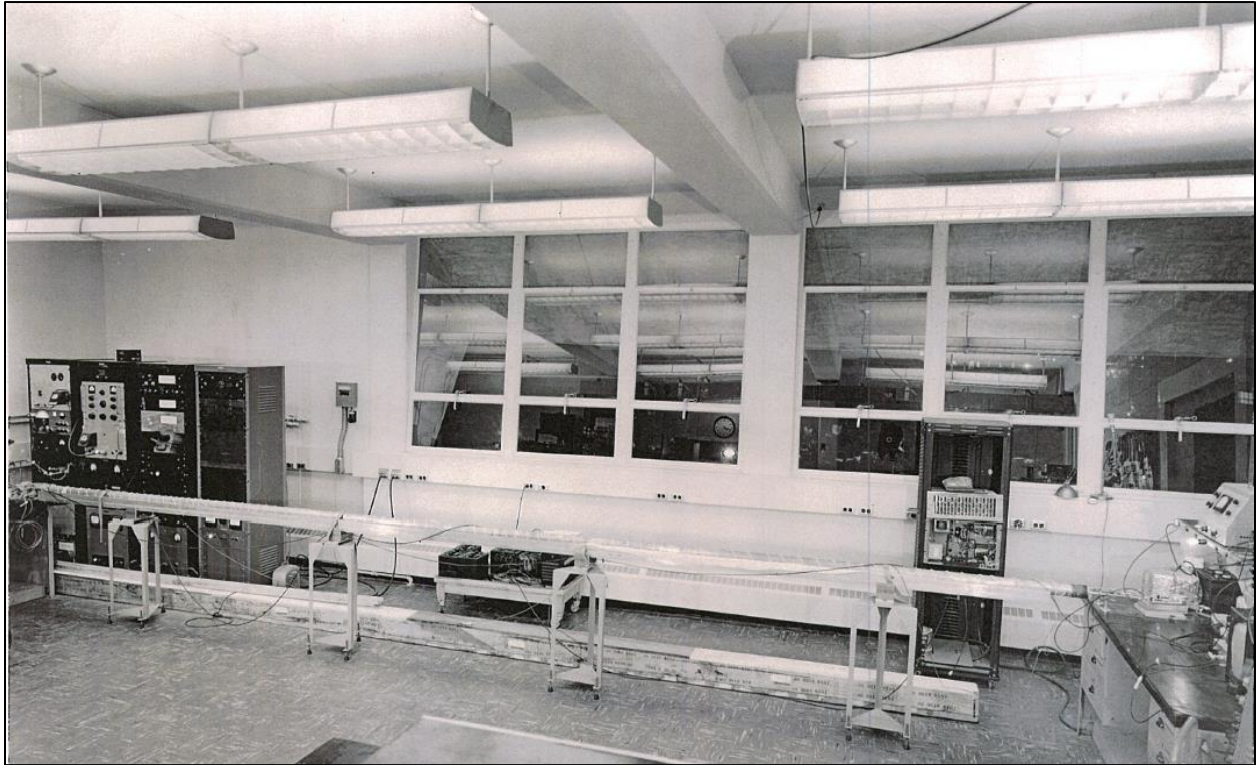


Figure 2-53. Office/Laboratory Room in Building 1 in the 1950s (photograph courtesy of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

Wings 3 and 4 intersected the Spine at Level 3 about 340 feet south of the Front of the House. At this point an east-west trending perpendicular corridor intersected the Spine to provide connections to the wings. Within the Spine footprint, this intersection included the 8-foot-wide corridor, a women's restroom and lounge on the east side of the Spine's main north-south corridor, and an impedance³ room and a stairwell on the west. The connecting perpendicular corridors continued to the east and west through one-story hyphens between the Spine and the wings. In addition to the corridor, the east hyphen contained a laboratory, and the west hyphen included a men's restroom and two locker rooms.

Level 3 continued south of Wings 3 and 4 with its last 40 feet below grade. As originally constructed, Level 4 did not intersect with any of the four wings and remained above grade for its entire length.

2.3.2.3 Wings 1, 2, 3, 4, and 6

Wings 1, 2, 3, 4, and 6 were similar in floorplan design as Levels 2, 3, and 4 of the Spine except the wings were wider, with 8-foot-wide double-loaded corridors, 48-foot wide laboratories on the north sides of the corridors, and approximately 14-foot offices on the south (**Figure 2-54**).

The non-load bearing interior walls were constructed of 6- or 8-inch CMU (**Figure 2-55**). All five wings featured a central monitor clerestory that ran the length of the wings (refer to Section 2.3.1.3). On the interior, the clerestories were within the laboratories on the north side of the corridor and provided high-bay spaces for research. In the laboratories, the ceilings were exposed structural concrete (**Figure 2-56**), utilities were concealed in steel raceways on the north, east, and west walls about four feet above the floor, and radiators were installed both at

³ Impedance is the measure of the opposition of the flow of current through a circuit, which is measured in ohms.

the baseboard and between the main level windows and the clerestory windows on the north walls. The floors were concrete.

Within the offices on the south side of the corridors, the exterior windows were on the south wall. Baseboard radiators were installed below the windows and utilities were concealed within steel raceways attached to the south, east, and west wall surfaces below the window level (refer to Figure 2-52). The flooring was asphalt tile, and lighting was suspension mounted fixtures (see Figures 2-51 and 2-53). Flooring within the corridors also was asphalt tile and the ceilings were either suspended plaster or grid with acoustic tiles or exposed structural concrete. The doors to the offices and laboratories were single- or double-leaf wood doors.

Within the wings, the bays formed by the structural post-and-beam construction were each 24 feet wide. Wings 1 and 2 were 10 bays (240 feet) long and their interior floorplans were virtually the same, with nine offices and a transformer room on the south side of the corridor and five large laboratory spaces on the north (refer to Figure 2-54). The east-west corridors were intersected on the south side by perpendicular corridors that led to exterior entrances to the adjacent courtyards. The entrances were located in the fifth bay from the Spine.

Wings 3 and 4 were 12 bays (288 feet) long and longer than Wings 1 and 2. The laboratory spaces in the northern portion of Wing 3 were initially used as shop areas that provided design and fabrication services for the construction of scientific instruments (**Figure 2-57**). Wing 3 was constructed with a loading dock on its west elevation (**Figure 2-58**). The loading dock opened up on a large interior space that was 2-bays long and encompassed the entire 3-bay width of the wing. This space was connected with the high-bay laboratory areas in the next four bays on the north side of the wing. These spaces were separated from the reserved office spaces on the south side of the building by an east-west trending corridor. A north-south trending corridor perpendicular to the east-west corridor intersected the center of Wing 3. The north and south ends of the corridor contained exterior doors that provided access to the courtyards between the wings. Between the north-south corridor and the Spine, Wing 3 contained a transformer room and three reserved office spaces on the south side of the corridor and a large open space in the laboratory areas north of the corridor.

The floor plan of Wing 4 was similar to that of Wing 3 (**Figure 2-59**). The loading dock was on the east end of the wing, which opened up into a large interior space used as an electronic shop (mobile station shop) and measured three bays wide and two bays long. The double-loaded corridor began west of the electronic shop and continued west for the length of the wing. The south side of the corridor included nine office spaces and a transformer room, and the north side had five high-bay laboratory spaces, one of which was initially designated as the electronic shop and connected to the larger space on the east end of Wing 4. Like Wing 3, Wing 4 also was intersected by a central north-south trending corridor that contained exterior doors to the courtyards between the wings.

Wing 6 was 14 bays (336 feet) long and was the longest of the wings, until Wing 5 was constructed. The interior floorplan of Wing 6 was similar to that of the other four wings, and included a double-loaded corridor with offices and laboratories on either side.

2.3.2.4 Wing 5

Although Wing 5 was similar in footprint to the other five wings, it had more interior square footage with a partial basement and three stories above or partially above grade level. The partial basement was considered Level 2 of Building 1, was limited to the north 192 feet of the building, and was eight bays long (each bay on the long side of all six wings was 24 feet wide). The basement included a large mechanical room with a transformer vault and generator room; a stairwell to the upper levels of the wing; food storage and isolation rooms; restrooms; a decontamination area; and a fallout shelter.

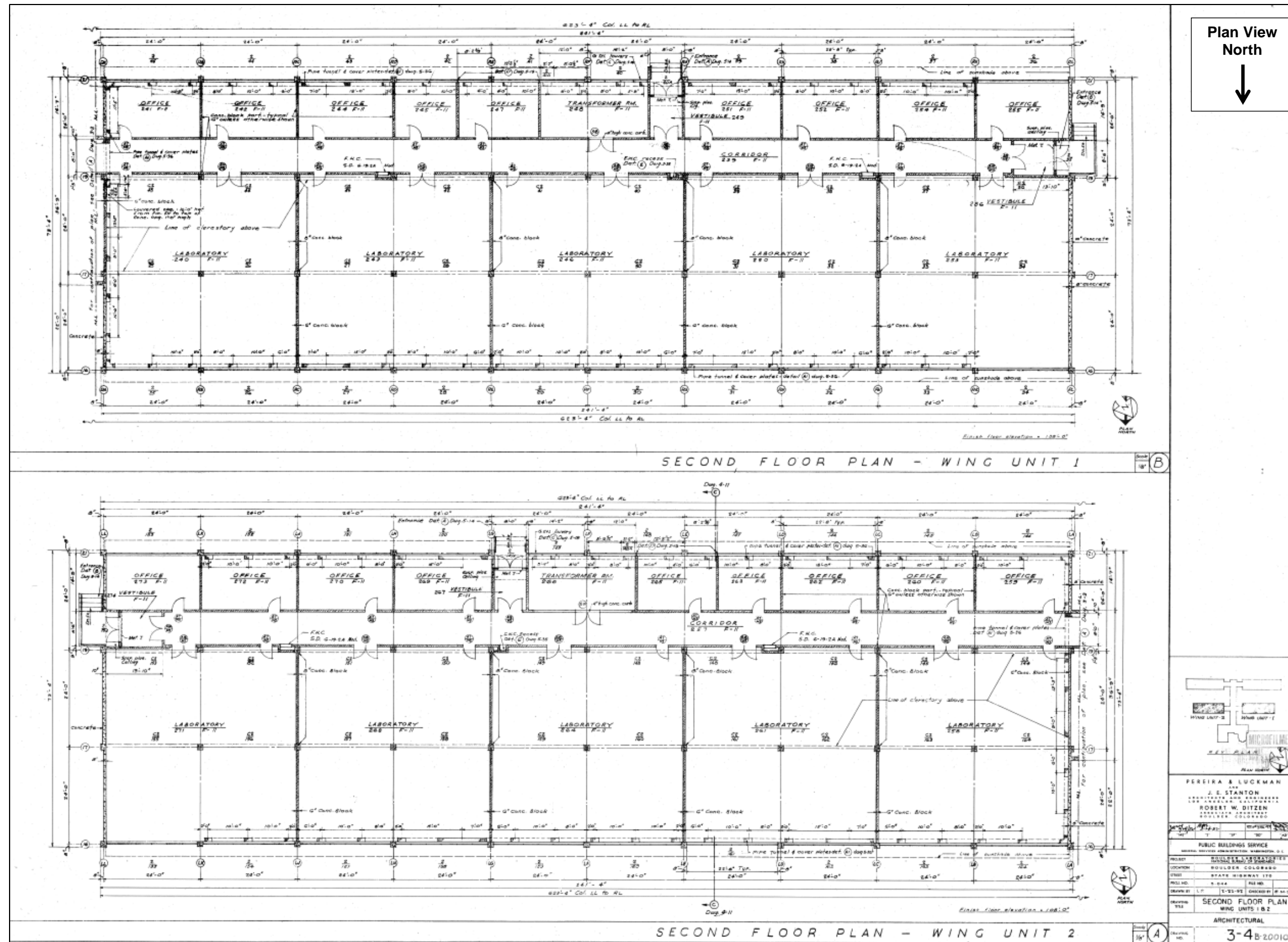


Figure 2-54. Wings 1 and 2 Floor Plans, Drawing A-3-4, February 22, 1952 (annotations added by sDC and AECOM; Pereira & Luckman, Stanton, and Ditzen 1952)

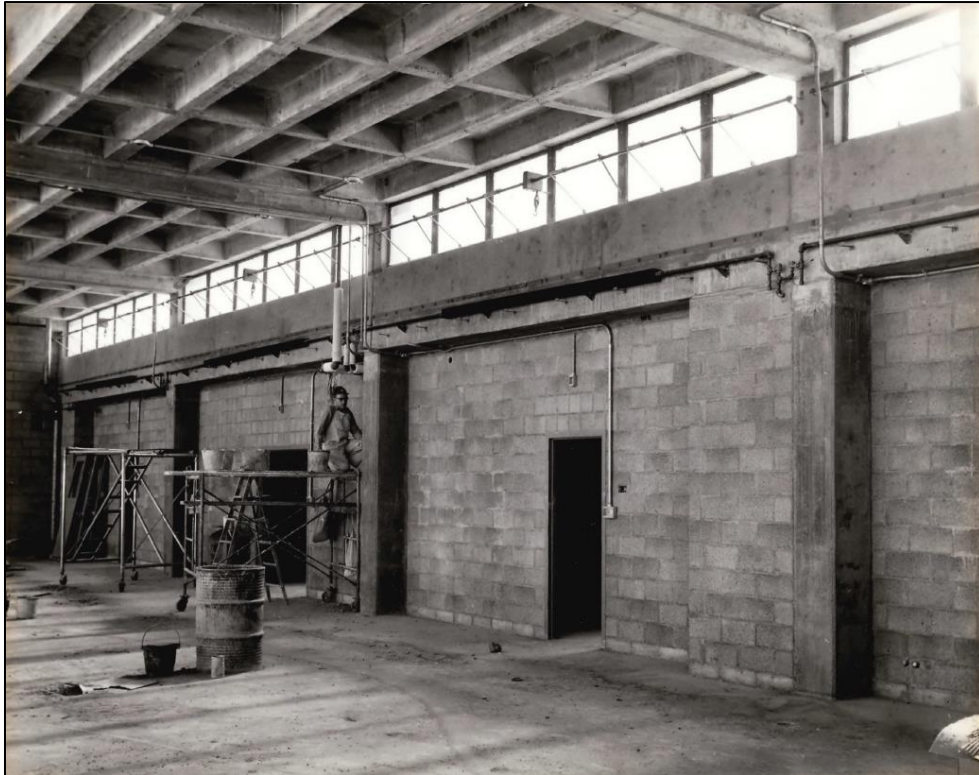


Figure 2-55. Interior CMU Walls, Room 358, Wing 3, under Construction, November 30, 1953 (photograph courtesy of Department of Commerce Boulder Laboratories)



Figure 2-56. Interior of Room 358, Wing 3, under Construction, November 30, 1953 (photograph courtesy of Department of Commerce Boulder Laboratories)



Figure 2-57. Shop Area in Wing 3, date undetermined (photograph courtesy of of Carnegie Library for Local History, Boulder, Colorado, Chamber of Commerce Collection)

When Wing 5 was constructed, the two-story hyphen connecting it to the Spine also was constructed. On Level 3, an existing laboratory on the west side of the Spine's double-loaded corridor was converted into an 8-foot-wide east-west trending corridor that connected to the new hyphen (**Figure 2-60**). The corridor continued west through the hyphen for about 40 feet and then turned north at a right angle to terminate in a north entrance to Wing 5 that provided access to the exterior courtyard. Just south of the entrance, the corridor branched to the west. From this point the corridor was double loaded with offices on the north side and laboratories on the south. The corridor terminated in the ninth bay from the east with an exterior doorway and a stairwell to the south. The remainder of the building included a large open space with divisions for smaller offices and laboratories in the northwest corner.

The Spine connected to Level 4 of Wing 5 by way of a corridor similar to the one described for Level 3 (**Figure 2-61**). Like the other wings of Building 1, Level 4 featured an 8-foot-wide double-loaded corridor. Offices were on the south side of the corridor, and laboratories and restrooms were on the north. The last three bays on the west end on the north side of the corridor had a computer platform over a depressed slab. There was a loading dock in the south bay on the west end of Level 4.

Level 5 was the monitor level and, unlike the other wings, contained a floor and space for future offices and restrooms. The monitor level was one bay (24 feet) wide and was centered on the rooftop of Level 4. When the building was constructed, the area was left as open space with the exception of a 16-by-24-foot mechanical room and a 5-by-16-foot duct shaft that were defined by 8-inch CMU walls.

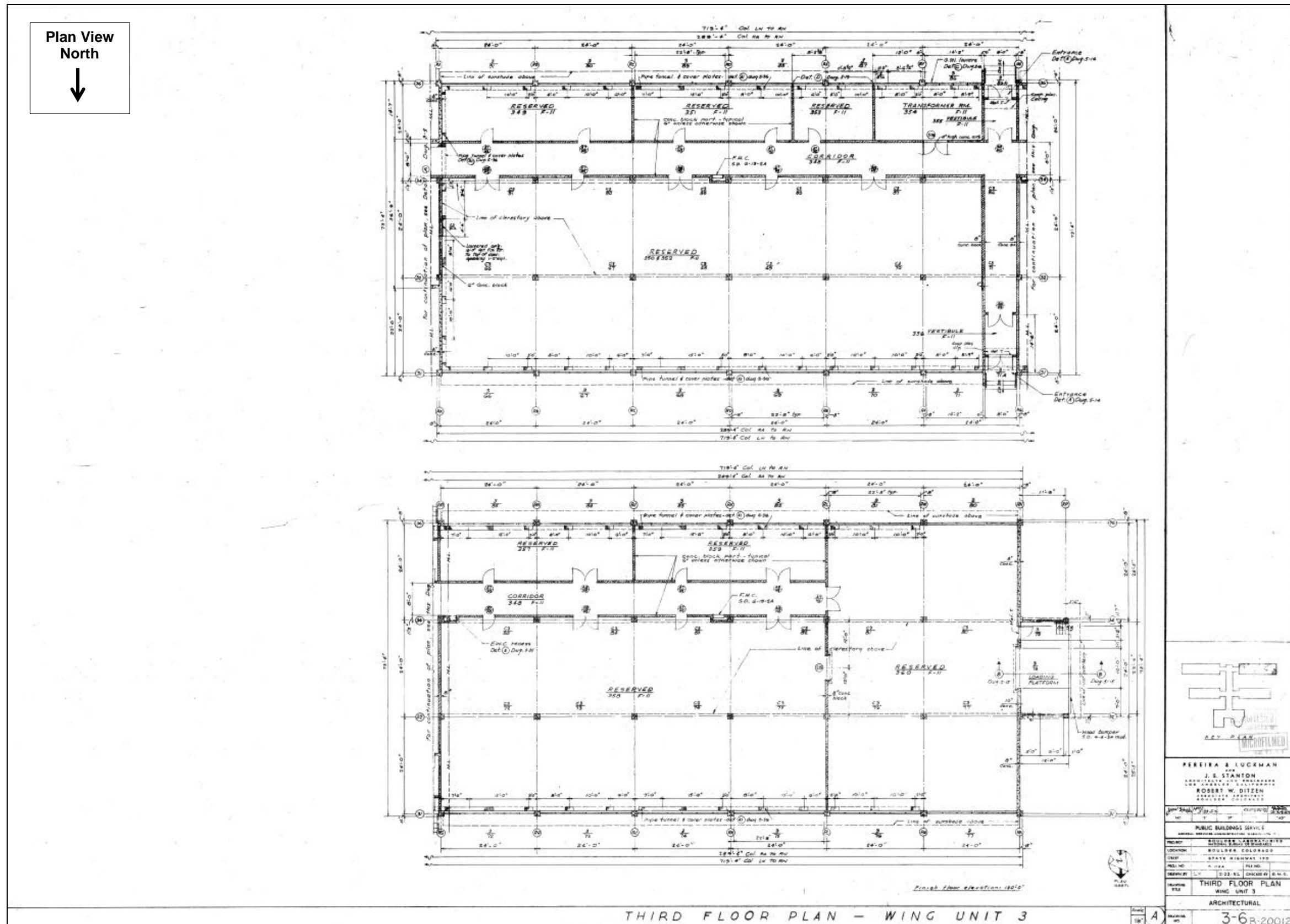


Figure 2-58. Wing 3 Floor Plan, Drawing A-3-6, February 22, 1952 (annotations added by sDC and AECOM; Pereira & Luckman, Stanton, and Ditzen 1952)

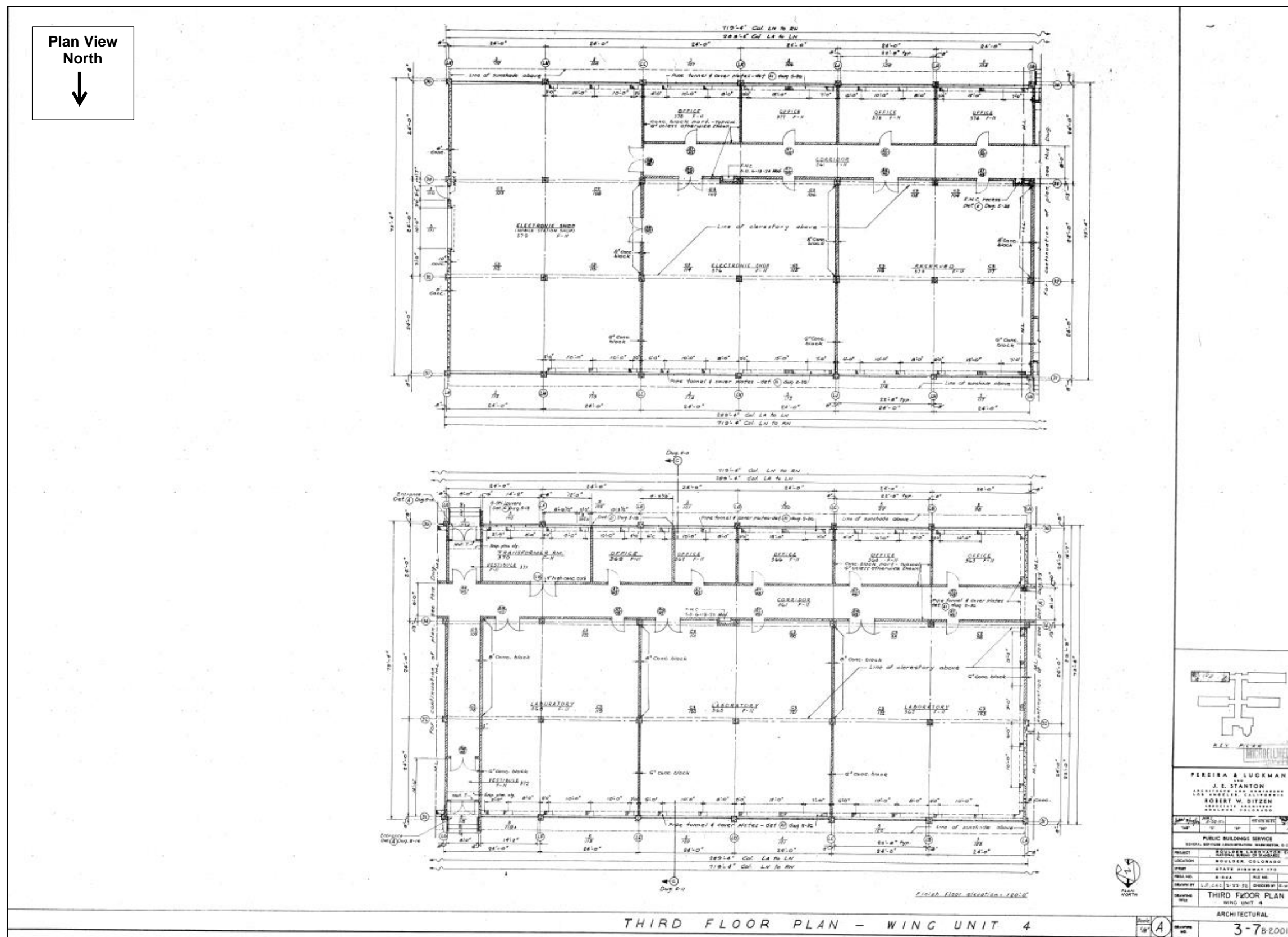


Figure 2-59. Wing 4 Floor Plan, Drawing A-3-7, February 22, 1952 (annotations added by sDC and AECOM; Pereira & Luckman, Stanton, and Ditzen 1952)

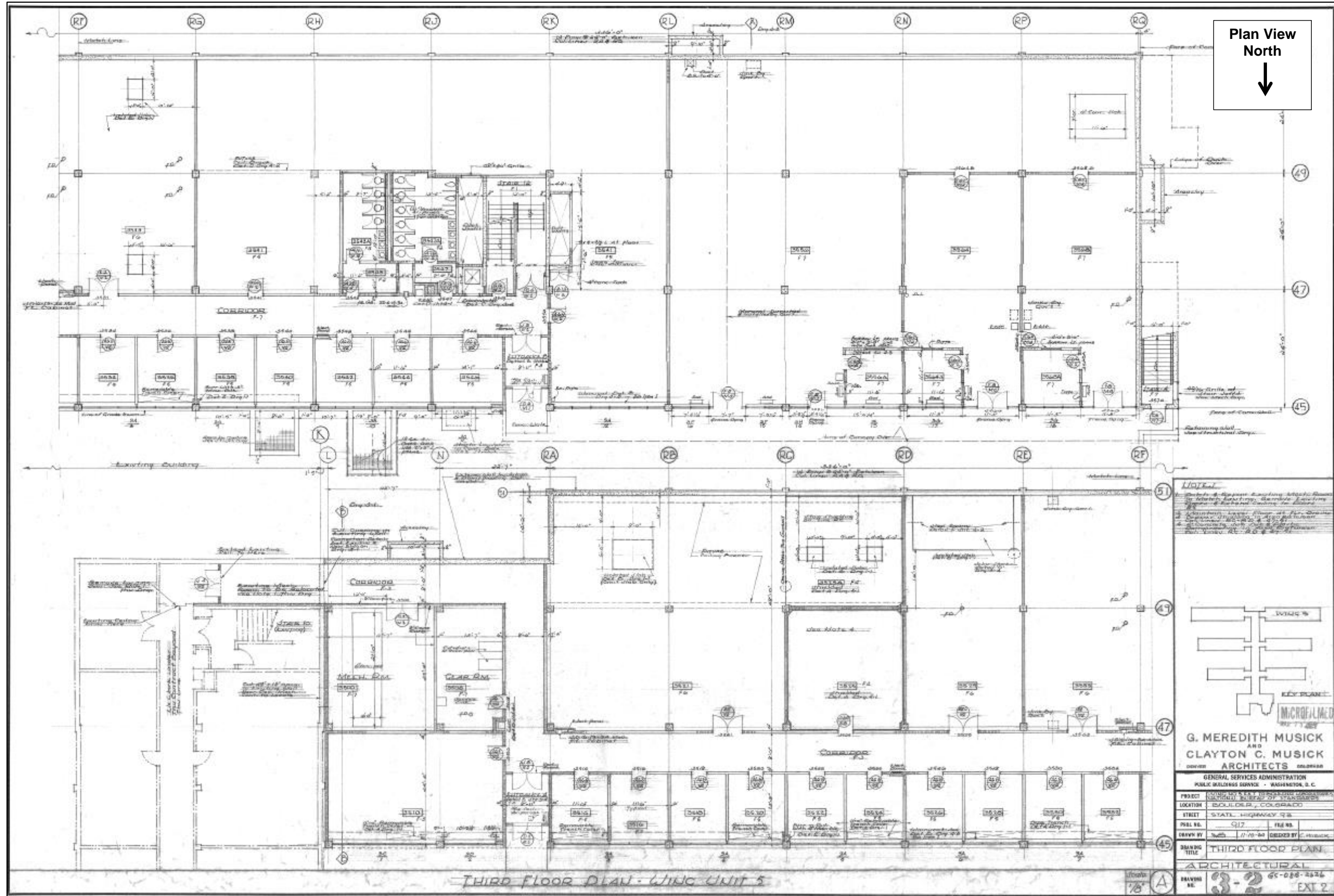


Figure 2-60. Wing 5 Third Floor Plan, Drawing A-3-2, November 10, 1960 (annotations added by sDC and AECOM; Musick and Musick 1960)

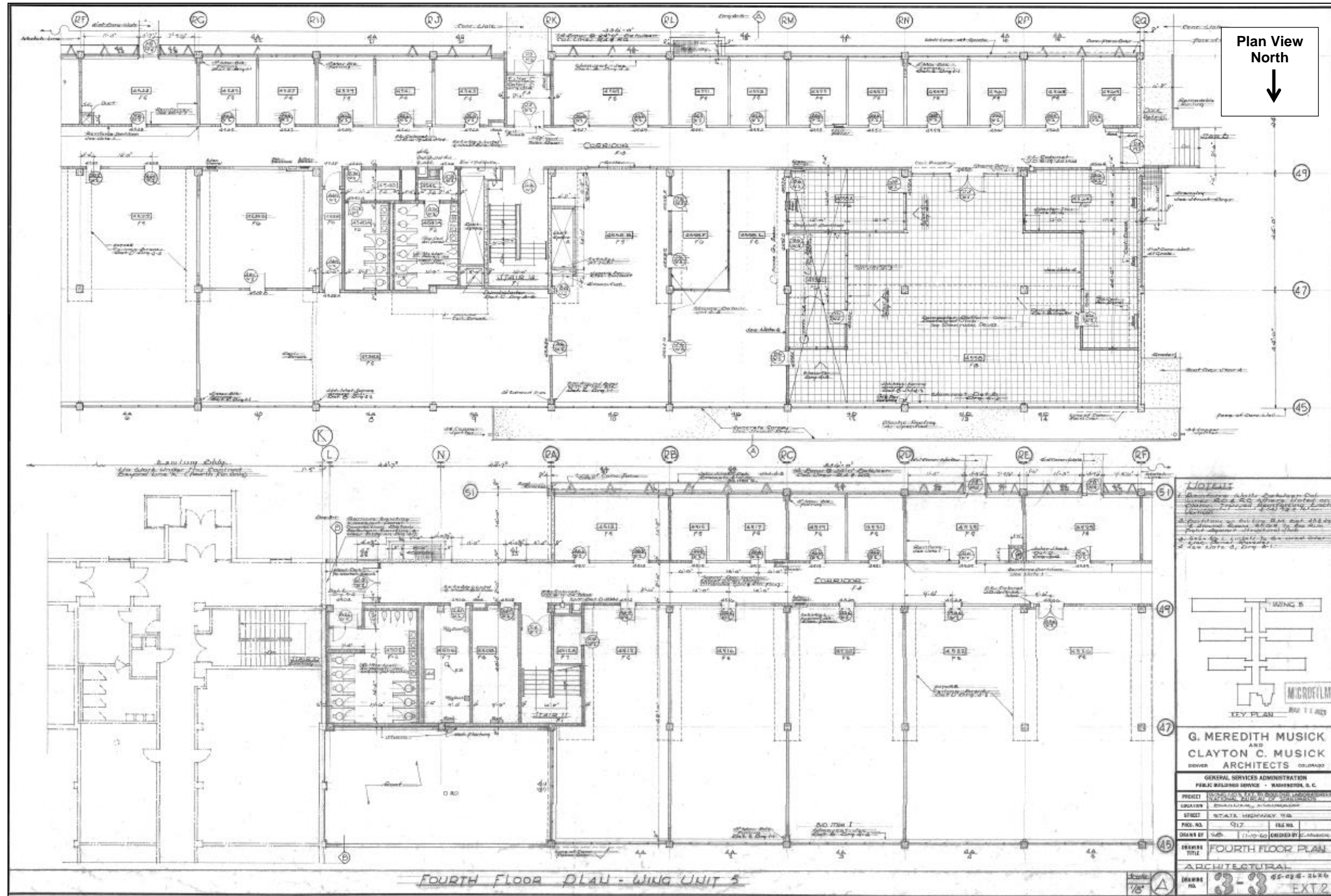


Figure 2-61. Wing 5 Fourth Floor Plan, Drawing A-3-3, November 10, 1960 (annotations added by sDC and AECOM; Musick and Musick 1960)

2.4 Alterations

Because of the scientific mission of the NBS and the CRPL, alterations to the interior of Building 1 began soon after construction was completed in the fall of 1954. In February 1955, the GSA completed plans to renovate Rooms 233 and 235 (currently Rooms 2048 and 2052), which were constructed with isolated floor slabs for atomic clock and frequency standards research. The renovations included shielding the entire room with ARMCO Magnetic Steel and replacement of the door to Room 233 (currently Room 2048). Based upon a review of architectural plans and drawings on file at NIST, these modifications appear to be the first of many interior modifications that occurred within the interior spaces of the offices and laboratories that included the construction of new division walls, the removal and replacement of doors and doorways, and upgrades designed to keep the facilities up-to-date with the most recent technology and scientific standards.

Other early modifications to Building 1 included the gradual installation of air conditioning. The original design did not include a central building cooling system, and air handling units that were installed during construction were provided for heating and ventilation only. The GSA issued invitations to bid on the air conditioning of the building in the spring of 1954 and the first contract for \$104,272 was awarded to Trautman & Shrive of Denver in July (*The Boulder Daily Camera* 1954c, 1954e). Plans and drawings on file at NIST indicate that air conditioning installation began in selected areas of the Spine and the Front of the House in the late 1950s and in the wings in the early 1960s.

Due to the size of Building 1 and the complexity of the scientific research completed within it, the alterations to the utilitarian interior spaces are too numerous to describe in detail in this report. Detailed plans, drawings, and other documentation of these alterations are on file at NIST. The chronology of major alterations that affected the exterior of Building 1 and interior character-defining features is shown in **Table 2-1**. Other alternations to character-defining features that are not documented in architectural drawings or other records are noted in the physical description in the following section.

Table 2-1. Major Exterior Alterations and Selected Interior Modifications

Year	Description
1954	Building 1 (Spine, Wings 1, 2, 3, and 4) completed.
1959	Wing 6 completed.
circa 1960	Mezzanine office spaces added to the clerestory level in Wings 2 and 4.
1960	Open observation deck on the rooftop penthouse enclosed; terrace bays were infilled with sandstone, steel framed fixed windows, single-leaf doors, and concrete.
1962	Wing 5 completed.
1976	Steel roof access stairs with steel pipe handrails added to the exterior of Wings 1, 3, 4, and 5.
1977	Clean room constructed in Wing 1 (Rooms 2132, 2134, and 2136).
1978	Clean Room expanded to include Room 2138 in Wing 1.
1980	Emergency exit window installed within Wing 1 Clean Room (2136); aluminum ladder attached to exterior wall below window.
1981	Glass and aluminum automatic door installed at the rear entrance (west elevation) on Level 4 of the Spine. Glass and aluminum single-leaf automatic door with sidelights installed in the Front of the House north of the auditorium.

Year	Description
1984	Selected fixed sash windows replaced with hopper windows in the penthouse.
1986	Exterior doors replaced on Wings 1, 2, 3, 4, and 6 – double-leaf doors with half lights, a transom, and metal side panels on Wings 1 and 2; single-leaf doors with half lights on Wings 3, 4, and 6.
1988	Replacement of exterior doors on Wings 1, 2, 3, and 4 with security doors.
1989	Lecture rooms in the Front of the House remodeled (Rooms 1103, 1105 and 1107). Existing interior features, including wall treatments, folding partitions, chalk boards, screens, and stages were removed. New wall treatments, dry marker boards, stages, folding partition walls, lights, and carpet installed. Roof replaced on Spine between Wings 1 and 2 and Wings 5 and 6, as well as the south roof of Wing 2 and the Wing 6 mezzanine. Annex C and connecting hyphen constructed on the north elevation of Wing 1.
1990	Roof replaced on north half of Wing 1 (48-by-115-foot area).
1991	Fire door installed within the interior of Wing 1 (within the central corridor between the exit and Rooms 2125 and 2126).
1992	Annex D to Wing 1 constructed.
1999	Construction of new Clean Room in Wing 1 (Rooms 2126 and 2130). Construction included the replacement of the original steel windows with aluminum windows; installation of insulated metal pans in the top sections of the new windows; infill of the clerestory windows with insulated metal panels, and new doors on the east elevation.
2000s	Redwood flower boxes added outside the Front of the House.
2000	Micro-Electromechanical Systems (MEMS) Laboratory remodel within Wing 1 (Room 2126). Remodel included installation of new aluminum windows, electrical conduits on the roof, rooftop equipment, including fan stacks; an exterior entrance and concrete stairs; and exterior equipment housed in new prefabricated metal sheds adjacent to the east elevation (Annexes E and F).
2002	Ions Lab constructed in Wing 1, Room 2106.
2006	Laboratory/office space in the Front of the House remodeled (Rooms 1205 and 1207). Interior partition walls removed; new partition walls added to create large work space and two smaller office spaces; removed room south of Rooms 1205 and 1207 to extend the lobby corridor to the south; removed original steel-framed windows on the south and west elevations and replaced them with aluminum-framed fixed/awning windows.
2008	Elevator in Front of the House lobby replaced.
2011	Roof railing and antenna platform installed on the Spine.
2012	Windows and doors on the Front of the House replaced with blast-proof windows; windows in Wing 2 replaced.
2013	Spine extended to create a connection between Building 1 and Building 81. Auditorium remodeled. Remodel included refinishing wood on the walls, installation of new chairs and flooring; new wall sconces, cleaning of original wood paneling and acoustic tiles cleaned; and removal of asbestos insulation from ceilings. New roofs installed on Spine and Wing 5.

Year	Description
2016	<p>Wing 3, Wing 6, and a portion of the south elevation of the Spine between Wings 4 and 6 renovated as part of NIST’s Building 1 renovation program. The east elevations of Wings 3 and 6 were sheathed with narrow metal horizontal panels, the window openings were enlarged to accommodate larger replacement windows, and the concrete sunshades were removed. The original windows on the west elevations of the wings were replaced with narrow slit windows and a ribbon of single-sash windows along new overhanging eaves and the exterior walls were sheathed with vertical panels. The loading dock areas of both wings also were modified, and the upper roofline of the original clerestory monitor was extended to house mechanical equipment and ductwork. Both wings were widened with additions to accommodate utility corridors. The original sunshades were removed. On the Spine, the concrete sunshades were removed and the windows sheathed in vertical metal rails and the exterior walls were clad with metal panels.</p> <p>Library roof replaced.</p>
2017	<p>Wing 1 roof replaced.</p> <p>Repair of exposed concrete beams and columns in the Front of the House.</p> <p>Penthouse renovations including the installation of an unenclosed egress stairway on the north elevation and a door to access the stairway; removal and replacement of selected windows to facilitate mission critical laser research; installation of a secondary means of egress; removal of suspended ceiling and carpet; installation of vinyl composition tile.</p>

3. Physical Description and Condition Assessment

This chapter provides a physical description and condition assessment of Building 1. The survey of existing conditions was conducted in March 2018 by sDC architects and the AECOM historian/architectural historian, historic architect, and structural, mechanical, and electrical engineers. During the survey, field notes and photographs were taken and subsequently compared to the original architectural drawings and historical documentation to assess the overall integrity of the building.

The physical description and condition assessment includes details about all exterior elements of Building 1, with the exception of Wings 3 and 6, which were recently renovated in 2016 and do not possess any readily visible original features. The interior descriptions focus on the areas that possess the most extant architectural and historical significance, including the Front of the House, which has the most architectural detailing, and the double-loaded corridor on Level 2 of the Spine, which is associated with the development of the atomic clock and frequency standards.

The descriptions and analysis of Levels 1, 3, and 4 of the Spine and Wings 1, 2, 4, and 5 are more streamlined because of the similarity of their utilitarian architecture. The interior of the offices and laboratory spaces in the Spine and the wings were not recorded in detail for this study due to the ongoing scientific activities that occur within those spaces. Because of changing technologies and scientific and research needs, many of the office and laboratory spaces have been reconfigured (in some cases, multiple times) since original construction. In addition, historical research did not identify any significant historical events directly associated with any interior spaces in areas that retained their original configuration and design.

The physical description and condition assessment are divided by discipline beginning with architecture (exterior and interior envelope), followed by engineering (structural, mechanical, and electrical). Conditions were rated as good, fair, and poor, as defined in **Table 3-1**. The photographs referenced in this section are located in Appendix C.

Table 3-1. Condition Definitions

Condition	Definition
Good	Intact, structurally sound, and performing its intended purpose; few or no cosmetic imperfections; or needs no repair and only minor or routine maintenance.
Fair	Early signs of wear, failure, or deterioration, although the feature or element is generally structurally sound and performing its intended purpose; failure of a subcomponent of feature or element; requires replacement of no more than 25 percent of feature or element; or requires replacement of defective subcomponent of feature or element.
Poor	No longer performing its intended purpose; missing; shows signs of imminent failure or breakdown; deterioration or damage affects more than 25 percent of feature or element and cannot be adjusted or repaired; or requires major repair or replacement.

Sources: Department of the Air Force Headquarters/Air Force Civil Engineer Center 2013; Koziol ca. 2007.

3.1 Architecture

3.1 *General Architectural Conditions Assessment Overview*

Building 1 has an exposed concrete structural foundation, frame, and roof with exterior walls of stone, concrete, and glazing. The building envelope, exterior architectural finishes, and weather

protection components, including joints, windows, and roofing systems, are generally in good condition. Exterior walls and other building components that support the exterior finishes are also in overall good condition (**Table 3-2**).

Table 3-2. Architectural Condition Assessment Summary - Exterior

Components	Good	Fair	Poor	No information	Notes
Front of the House					
Concrete structural frame	X				
Concrete walls	X				
Stone walls	X				
Windows	X				
Exterior Doors	X				
Railings	X				
Concrete flat work		X			Signs of heavy wear of top surface on concrete
Roof	X				
Spine					
Concrete structural frame	X				
Concrete walls	X				
Windows	X	X			Original storm windows in fair condition.
Exterior doors	X				
Railings	X				
Concrete stairs and/ or ramps	X				
Roof	X				
Penthouse					
Concrete structural frame	X				
Concrete walls	X				
Siding			X		Siding is missing and in poor condition.
Stone walls	X				
Windows	X				
Exterior Doors	X				
Roof				X	Roof condition unknown
Wings 1, 2, 4, and 5					
Concrete structural frame	X				
Concrete walls	X				Heavy noticeable orange stain on concrete
Windows	X	X			Original windows in fair condition.
Exterior doors	X		X		A few doors and hardware in poor condition.
Railings	X				
Concrete stairs and/ or ramps	X				
Roof	X	X		X	Wings 2 and 4 (poor), Wing 5 (good); Wing 1 (unknown)

A few features have been observed to be in fair or poor condition, specifically:

- The roofs of Wings 2 and 4 are in poor condition.
- Original windows with single glass panes and painted metal are in fair condition.
- Some of the building's exterior doors and hardware are in poor condition.
- The siding on the south side of the penthouse is damaged and/or missing and in poor condition.
- The front entry concrete finishes were damaged due to application of de-icing materials and are in fair condition.

Corrective actions and maintenance to some of the building components were observed during the survey. In general, the work conducted was effective in correcting the issues, but alterations resulted in finishes that are not consistent with the building's historic character and original finishes. Depending on the recommended historic preservation treatment approach (i.e. preservation, rehabilitation, etc.), these items would need to be addressed, so that the final appearance is consistent with the treatment goals.

Like the building envelope, the interior architectural finishes, including the floors, doors, and ceilings, are generally in good condition, with some signs of wear in a few locations, primarily within the Spine. The detailed assessment of Building 1's interior is limited to the Front of the House and the double-loaded corridors in the Spine and Wings 1, 2, 4, and 5. The finishes and conditions of the Spine and wing corridors are similar throughout the facility. Wings 3 and 6 have been recently renovated on both the interior and exterior, and are not included in this assessment.

3.1.2 Exterior and Building Envelope Observations

3.1.2.1 Front of the House

The Front of the House is at the north end of the Spine and faces northeast toward Broadway Street. It was the original public entrance to the campus and features and retains the most exterior architectural detail. The front façade features three vertical divisions that include the auditorium (west division), the library (east division), and an open courtyard that leads to the entrance and lobby (central division) (**Photo C-1**; refer to Figures 2-17 and 2-18).

Auditorium (West Division)

The overall exterior condition of the auditorium is good. The exterior walls consist of exposed poured concrete and concrete post-and-beam structural frame infilled with medium-sized native sandstone with exposed mortar joints. The exposed concrete walls on the west elevation are in good condition and characterized by the visual expression of 4-by-8-foot plywood form boards, exposed control joints, and a natural concrete color with no finishes (**Photo C-2**). Minor signs of biological growth and concrete spalling are present (**Photo C-3**).

The main character-defining feature of the auditorium exterior is the exposed red/pink sandstone wall with large (2- to 3-inch) mortar joints (**Photos C-4 through C-11**). The stone and mortar joints are in good condition. The exposed structural frame also is a notable Modernist expression of the façade in conjunction with the exposed walls on either side of the auditorium at the exit doors (refer to Photo C-7). The concrete frame shows signs of spalling and water infiltration, in addition to surface damage at the base of the column, likely due to exposure to de-icing materials over the decades.

The roof of the auditorium is a white thermoplastic polyolefin (TPO)-type roof membrane that was installed within the past five years and is in good condition (**Photo C-12**). The auditorium roof projects higher than the surrounding roofs. The roof transitions and edges have transition and cap flashings. Roof drains are present and appear to be functioning properly (**Photo C-13**).

The high auditorium roof drains to the adjacent lower roof through a sidewall of the auditorium roof projection. The roof also supports a mechanical room penthouse and heating, ventilation, and air conditioning (HVAC) roof-mounted equipment.

Library (East Division)

The overall exterior condition of the library is good. The exterior walls consist of concrete post-and-beam structural frame bays infilled with medium-sized native sandstone with exposed mortar joints on the north elevation and windows on the south, east, and west elevations (**Photos C-14 through C-19**). The east and south elevations are characterized by stone sills and aprons under windows.

Similar to the auditorium, the main character-defining feature of the library exterior is expressed by the exposed red/pink sandstone wall, made of local stone and with large mortar joints, which are in good condition (refer to Photos C-14 and C-15). Roof scuppers without downspouts release storm water onto the concrete columns, which results in faster deterioration of the concrete in these locations (refer to Photo C-15). The south, east, and west elevations have large replacement window systems with double pane insulated glazing and framing with a natural aluminum finish that were installed in 2012 and are in good condition (refer to Photos C-16 through C-19). Some original steel-framed windows remain extant on the south elevation adjacent to the Spine that are generally in fair condition (refer to Photos C-18 and C-19). A non-original aluminum-framed storefront door system with a sandstone retaining wall was installed on the east elevation at an undetermined time (refer to Photo C-17).

The roof of the library is a white TPO-type roof membrane installed in 2016 that is in good condition. Flashing and termination bars are present and appear to be performing properly. The roof also supports a mechanical room penthouse and HVAC roof-mounted equipment. Non-original steel pipe railings have been installed for safety on the rooftop, and a non-original exterior staircase has been installed on the south elevation to provide exterior access to the roof (refer to Photo C-18).

Entrance and Lobby (Central Division)

The overall exterior condition of the entrance and lobby are good. Levels 3 and 4 of the Spine extend above this section of the Front of the House and serve as the backdrop for the Building 1's identifying signage. The exterior walls are smooth cast-in-place concrete scored with a rectangular pattern (**Photo C-20**). The original 15-inch-tall bronze letters spelling "National Bureau of Standards" were removed and replaced with letters spelling "U.S. Department of Commerce / Boulder Laboratories" after the ESSA was established in 1965 (Snyder and Bragaw 1986). The "325 Broadway" was added at a later, undetermined date. At some point, a utility tray was extended across the face of the building to connect utilities between the auditorium and library roofs.

The exterior walls in the rest of the entrance and lobby area consist of exposed cast-in-place concrete and concrete post-and-beam structural frame infilled with glazing systems (**Photo C-21**; refer to Photo C-20). The windows were replaced in 2012 with double pane insulated glazing and framing with a natural aluminum finish. The courtyard is defined by a concrete post-and-beam structural frame with no infill (**Photo C-22**). Minor signs of biological growth are present on the concrete columns and beams. NIST repaired segments of these columns and beams in 2017 but the repairs do not visually match the historic concrete finish (**Photo C-23**).

3.1.2.2 Spine

The overall exterior condition of the Spine is good. The exterior walls of the Spine are constructed of cast-in-place concrete with horizontal bands of windows set within the concrete structural frame at each floor. The concrete walls are structurally sound, however, the exterior

exposed concrete wall finishes are stained and therefore are considered in fair condition. The horizontal bands of windows are shaded by original continuous concrete sunshades, which are also present on the adjacent Wings 1, 2, and 4 (**Photos C-24, C-25 and C-26**). The sunshades have been recently coated with a sealant and are in good condition. Most windows within the Spine are original painted single-pane steel-framed windows with an aluminum storm system mounted on the exterior or interior side of the windows (**Photo C-27**). The aluminum storm windows are in fair to poor condition and the original window system is in fair condition. Newer full height storefront system windows have been installed on the west elevation adjacent to the sunken terrace on Level 1 (**Photo C-28**). The roof of the Spine is a white TPO-type roof membrane installed in 2013 that is in good condition (**Photo C-29**).

Like the rest of the Spine, the exterior walls of the penthouse on the roof of the Spine also are constructed of concrete post-and-beam structural frame infilled with medium-sized native sandstone with exposed mortar joints, which are all in good condition (**Photos C-30 and C-31**). The sandstone infill was added to the penthouse in 1960 and is not an original feature of the building, but does date to the building's period of significance (1954 to 1965). The upper portion of the penthouse is constructed of cast-in-place concrete walls that also are in good condition. Non-original siding applied to the south side of the penthouse is missing and in poor condition. The windows are a system of aluminum-framed windows and the doors are metal with metal frames and hardware. Both the windows and doors are in good condition. In 2017, renovations were completed on the penthouse including the installation of an unenclosed egress stairway on the north elevation and a door to access the stairway; removal and replacement of selected windows to facilitate mission critical laser research, and the installation of a secondary means of egress (**Photo C-32**).

On the east elevation of the Spine between Wings 4 and 6, the exterior of the Spine was substantially altered with between 2012 and 2016 (**Photo C-33**). The original concrete sunshades were removed and the windows were sheathed with vertical metal rails. The original concrete exterior walls were removed and replaced with metal panels. This area of the Spine is in good condition.

3.1.2.3 Wing 1

The overall exterior condition of Wing 1 is fair. The exterior walls of Wing 1 are made of exposed cast-in-place concrete with horizontal bands of canted windows set within a concrete structural frame (refer to Drawings A-4-7 and A-4-8 in Appendix B). The walls are characterized by a noticeable pour line approximately three feet above grade with a vertical control joint halfway between the columns and the horizontal band of windows shaded by continuous concrete sunshades (**Photo C-34**). The concrete walls show signs of orange staining, but the origin of that staining was not determined. The concrete walls are structurally sound, however, the exterior exposed concrete wall finishes are stained and therefore are considered in fair condition.

Sections of the windows on the first floor (considered Level 2 of Building 1) are newer aluminum-framed windows that were installed circa 2000 and are in good condition (**Photos C-35, C-36, and C-37**; see Photo C-34). Other sections are original painted steel-framed windows in fair condition (**Photo C-38**). The original windows are canted, tripartite windows with a narrow, fixed, top light, a larger middle awning window, and a narrower hopper window on the bottom. Windows in the upper clerestory are original painted steel-framed windows in fair condition. The exterior doors are generally painted metal doors with metal frames accessed by systems of concrete steps and landings, some of which have metal pipe railings. All the metal door frames and the non-original replacement doors are in good condition, but the original doors are in poor condition (**Photos C-39 and C-40**; refer to Photos C-36 and C-37). The roof surface of Wing 1 was not observed, but newer roof flashing and downspouts hanging over the concrete

sunshades on the north and south elevations were noted (**Photo C-41**). These downspouts terminate just below the sunshades and do not have a downspout to direct water to grade and avoid water splashing against the building. The downspout system is in good condition, albeit incomplete.

Annex C and a connecting hyphen were constructed on the west elevation of Wing 1 in 1989 (**Photo C-42**) and Annex D was constructed with the courtyard between Wings 1 and 3 in 1992 (**Photo C-43**). Both annexes were constructed to provide additional laboratory and office space. Alterations to the window and door openings on the north elevation of Wing 1 are associated with construction and modifications of the Clean Room on the interior of the building in 1977, 1978, 1980, and 1999; the remodel of the MEMS Laboratory in 2000, and the construction of the Ions Laboratory in 2002. As part of the Clean Room construction in 1999, a section of replacement windows were installed, some original windows were altered with the installation of metal pans in the top sections of the tripartite windows, and new doors were installed. More original windows were replaced in 2000 with construction of the MEMS Laboratory, which also included the installation of electrical conduits and other equipment on the roof, a new exterior door and access stairs, and prefabricated metal equipment sheds east of the north elevation, which were designated Annexes E and F (**Photos C-44, C-45, and C-46**).

3.1.2.4 Wing 2

The overall condition of Wing 2 is fair (**Photo C-47**). The exterior walls are made of exposed cast-in-place concrete with horizontal bands of canted windows set in a concrete structural frame (**Photo C-48**). The walls are characterized by the noticeable pour line approximately three feet above grade with a vertical control joint halfway between the columns and the horizontal band of windows shaded by continuous concrete sunshades. The concrete walls show signs of orange staining, but the origin of that staining was not determined. The concrete walls are structurally sound however, the exterior exposed concrete wall finishes are stained and therefore are considered in fair condition (**Photo C-49**).

The windows on the first floor (considered Level 2 of Building 1) are replacement aluminum-framed windows that were installed in 2012 and are in good condition (**Photo C-50**). The windows in the upper clerestory are original painted steel-framed windows in fair condition (**Photo C-51**). The exterior doors are generally painted metal doors with metal frames accessed by systems of concrete steps and landings, some of which have metal pipe railings (**Photos C-52, C-53, and C-54**). All the metal door frames and the non-original replacement doors are in good condition, but the original doors are in poor condition.

The roof of Wing 2, as observed from the roof of the Spine, shows significant water ponding and insufficient slopes for proper water drainage (**Photo C-55**). The roof drains through newer roof side scuppers rather than interior roof drains. The downspouts of the scuppers only clear the concrete sunshades and do not conduct the storm water to grade in a controlled way. The roof appears to be in poor condition.

Other major alterations to the exterior of Wing 2 include the addition of a cantilevered shade structure and new metal pipe railings on the east elevation (refer to Photo C-54) and the addition of rooftop equipment (refer to Photo C-55). None of these changes are architecturally significant or character defining.

3.1.2.5 Wing 3

The overall condition of Wing 3 is good. Between 2012 and 2016, Wing 3 was substantially altered by a major renovation that included new exterior envelope systems and all new interior finishes (**Photos C-56 and C-57**). The north elevation was sheathed in narrow metal horizontal panels, the window openings were enlarged to accommodate larger windows, and the concrete sunshades were removed. The original windows on the south elevation were replaced with

narrow slit windows and a ribbon of single-sash aluminum-framed windows along the new overhanging eaves. The original concrete exterior walls were removed and replaced with metal panels. The loading dock area on the west elevation also was modified, and the upper roofline of the original clerestory monitor was extended to house mechanical equipment and ductwork and the wing was widened to accommodate a utility corridor. All the original concrete sunshades were removed (Gatewood and others 2016). Because of this recent renovation and the absence of any visible original features, Wing 3 was not described in detail as part of this historic structure report.

3.1.2.6 Wing 4

The overall condition of Wing 4 is fair. Similar to Wings 1 and 2, the exterior walls of Wing 4 are made of exposed cast-in-place concrete with horizontal bands of canted windows set in a concrete structural frame (**Photo C-58**). The walls are characterized by the noticeable pour line approximately three feet above grade with a vertical control joint halfway between the columns and the horizontal band of windows shaded by continuous concrete sunshades (**Photo C-59**). The concrete walls show signs of orange staining, but the origin of that staining was not determined. The concrete walls are structurally sound however the exterior exposed concrete wall finishes are stained and therefore are considered in fair condition.

The windows in the first floor (considered Level 3 of Building 1) and in the upper clerestory are original single-pane, steel-framed windows that are in fair condition (**Photo C-60**; refer to Photos C-59). The exterior doors are generally painted metal doors with metal frames accessed by systems of concrete steps and landings, some of which have metal pipe railings. All the metal door frames and the non-original replacement doors are in good condition, but the original doors are in poor condition (**Photos C-61 and C-62**).

One bay on the south elevation has been previously altered by the removal of one window and installation of a single-leaf door with a concrete landing and stair with a metal pipe railing (refer to Photo C-61). Historic photographs and plans indicate that three historic windows also have been removed on the easternmost bay on the north elevation (**Photo C-63**) and a concrete accessibility ramp has been added to the secondary entrance on the north elevation (refer to Photo C-62). The east elevation retains its historic three-bay configuration with an overhead door and single-leaf personnel door in the central bay (**Photo C-64**). The north and south bays are infilled with cast-in-place concrete. A concrete loading dock and stairway are not original to this elevation, but the date of installation was not determined.

The roof of Wing 4 was observed from the roof of the Spine and shows significant water ponding and insufficient slopes for proper water drainage. The roof drains through newer roof side scuppers rather than interior roof drains. The downspouts of the scuppers only clear the concrete sunshades and do not conduct the storm water to grade in a controlled way. The roof appears to be in poor condition.

3.1.2.7 Wing 5

The overall condition of Wing 5 is fair. Similar to Wings 1, 2, and 4, the exterior walls of Wing 5 are made of exposed cast-in-place concrete with horizontal bands of windows set in a concrete structural frame. However, Wing 5 was constructed about eight years after the other wings were constructed, and its windows are of a different type, concrete sunshades were never part of this wing, and the concrete exterior walls within the structural frame are not the same (**Photos C-65 and C-66**). Like the other wings, the steel-framed windows on Wing 5 are tripartite, but unlike the other wings, all three lights are the same size and are plumb, recessed, and parallel to the structural frame rather than canted. The windows are single-pane painted steel-frame windows that are original to the building and generally in poor condition. The exterior concrete walls are smooth and do not exhibit the pour and joint lines that the other wings do. Similar to the other

wings however, the exterior concrete walls show signs of orange staining of unknown origin. The concrete walls are structurally sound, however the exterior exposed concrete wall finishes are stained and therefore are considered in fair condition.

The exterior doors are painted metal doors. The metal frames are in fair condition, but the original metal doors and associated hardware are in poor condition. In the first story on the south elevation (Level 4 of Building 1), three non-original single-leaf doors have been inserted in original window spaces in the ninth, tenth, and eleventh bays from the west and are in good condition (refer to Photo C-66). Steel-framed metal awnings have been attached to the wing on the first story on the north side (Level 3 of Building 1) to replace and supplement a failed concrete canopy that was original to the building (**Photos C-67 and C-68**). The canopy has been partially cut off and the rebar is exposed and in poor condition. The original concrete and openings in the second and third bay from the west also have been removed and infilled with concrete block. Some windows on the west end of the north elevation also have been replaced (refer to Photo C-67).

The west elevation retains its historic three-bay configuration with a double-leaf door in the south bay (**Photo C-69**). The central bay includes clerestory windows in Level 5 and concrete infill on Level 4. The north bay is infilled with concrete. Existing mechanical ductwork attached to the side of the building and a temporary aluminum ramp are not original features of Wing 5.

The roof of Wing 5 was observed to be in good condition and surfaced with a newer, TPO-type roof membrane. Some signs of water ponding are noticeable. However the roof is flashed and has operational roof drains.

3.1.2.8 Wing 6

The overall condition of Wing 6 is good. Between 2012 and 2016, Wing 6 was substantially altered by a major renovation that included new exterior envelope systems and all new interior finishes (**Photos C-70 and C-71**). The north elevation was sheathed in narrow metal horizontal panels, the window openings were enlarged to accommodate larger windows, and the concrete sunshades were removed. The original windows on the south elevation were replaced with narrow slit windows and a ribbon of single-sash windows along the new overhanging eaves. The exterior walls were sheathed with vertical panels. The loading dock area on the west elevation also was modified, and the upper roofline of the originally clerestory monitor was extended to house mechanical equipment and ductwork and the wing was widened to accommodate a utility corridor (Gatewood and others 2016). Because of this recent renovation and the absence of any visible original features, Wing 6 was not described in detail as part of this historic structure report.

3.1.3 Interior Observations

3.1.3.1 Front of the House

The interior finishes in the Front of the House are overall in good condition. Comparison of the existing room materials to the original drawings and historical photos indicate some finishes are original to Building 1. Those materials that are believed to be original features are indicated with an asterisk (*).

West Division

Auditorium

The overall interior condition of the auditorium is good (**Photos C-72 through C-76**). New materials have been introduced including oak on the stage and an acoustical ceiling system, which replaced the original plaster ceiling. In 2013, the auditorium underwent a remodel, which included refinishing the original wood walls; installation of new chairs, flooring, and wall

sconces; cleaning of the original wood paneling and non-original acoustic tiles; and removal of asbestos insulation from ceilings. Possibly as part of the same renovation, the original observation and projection ports on the north wall were removed and replaced with one larger rectangular port. Despite the past renovations, the auditorium has retained its original character.

- Carpet – tan carpet throughout room; good condition.
- Base – black vinyl base at stage and north wall, one-by-one-inch wood base at side walls*; good condition.
- Walls – north, east, and west: natural wood paneling* over painted walls; south wall: vertical natural color wood slats* over sound absorbing material; all in good condition.
- Ceiling – white two-by-four-foot acoustical ceiling; good condition.
- Seating – tan fold-up chairs with vinyl finishes; good condition

Projection Room

The overall interior condition of the Projection Room is good (**Photos C-77** and **C-78**). It is finished with carpet and wood flooring with a vinyl base and painted walls and ceilings, which are all in good condition. The doors are painted single-leaf wood doors with wood frames*. A small restroom* with one toilet and one sink, is in the southwest corner of the room but has been remodeled with updated fixtures, vinyl composition tile (VCT) flooring, and painted walls.

Lecture Rooms 1105 and 1107

Lecture Rooms 1105 and 1107 were originally numbered 110 and 111 and are located on the south side of the foyer in the Front of the House. The overall condition of these rooms is good, but they have both been remodeled and the only historic materials remaining are the wood doors and frames (**Photos C-79** and **C-80**). A common audio and visual room and a storage room (Rooms 1107A and 1107B, respectively) have been constructed between the rooms.

- Carpet – gray tiled carpet throughout rooms; good condition.
- Base – black vinyl base; good condition.
- Walls – plaster painted off-white; good condition.
- Ceiling – white two-by-four-foot acoustical ceiling with two-by-two-foot light fixtures; good condition.

East Division

Offices and Laboratories – Rooms 1201, 1201A, 1203, and 1203A

The offices and laboratories are located on the south side of the corridor in the east division of the Front of the House and historically housed the purchasing and personnel offices (**Photos C-81**, **C-82**, and **C-83**). The office suite has a main work area accessed by the corridor and smaller offices that are accessible from the larger work area. All these rooms have been modernized with VCT flooring with a vinyl base, painted plaster walls, and acoustical ceilings. All finishes are in good condition. Nothing, including the original floor plan, is original.

Library

The overall condition of the library is good. Like the auditorium, the library has retained much of its original finish materials and furniture. It is characterized by high ceilings, large windows, wood paneling, and native sandstone walls (**Photos C-84**, **C-85**, **C-86**, **C-87**, **C-88**, and **C-89**).

- Floor – tan carpet; good condition.
- Base – continuous base heater; good condition.
- Walls – painted plaster*, wood paneling*, and sandstone*; good condition.
- Windows – aluminum insulated double paned; good condition.

- Ceiling – suspended ceiling with acoustic tiles; good condition.

East, West, and Central Divisions – Corridor, Foyer, and Lobby

The overall condition of the corridor, foyer, and lobby is good. The main lobby is an open area connected to the corridor in the east division of the Front of the House and the foyer in the west division. The lobby and foyer areas are characterized by high ceilings; the use of reddish travertine stone, wood paneling, and native sandstone as wall finishes; and a multi-colored terrazzo floor finish (**Photos C-90** through **C-100**). The corridor in the west division that separates the library and office/laboratory spaces has painted plaster walls, suspended ceilings with acoustical tiles, and multi-colored terrazzo floors (**Photo C-101** through **C-104**). Levels 1 and 2 of the Spine that are visible from the lobby also have terrazzo floors and a mixture of travertine and plaster wall surfaces (**Photos C-105** and **C-106**). These areas retain the original character of the building despite the introduction of some new architectural elements such as a wood replacement railing and an Americans with Disabilities Act (ADA) access lift on the stairways to Levels 1 and 2 of the Spine (refer to Photos C-98 and C-99) and a new brushed metal finish and wood wall panel system around the door of a replacement elevator (refer to Photo C-97).

- Floor – multi-colored terrazzo*; good condition.
- Base – black vinyl and multi-colored terrazzo*; good condition.
- Walls – wood paneling*, wood wall panel system, travertine stone*, painted plaster, and sandstone*; good condition.
- Windows – aluminum insulated double paned; good condition.
- Ceiling – suspended two-by-four-foot ceiling with acoustic tiles; good condition.

The restrooms on Level 1 of the Spine have been fully modernized with new tile flooring and wainscot, painted walls, and a painted gypsum board ceiling, which are all in good condition (**Photos C-107** and **C-108**).

Reception Area – Room 1101

The reception area is located on the south side of the foyer and immediately west of the lobby. Its overall condition is good and it retains many of its original features and materials (**Photos C-109**, **C-110**, and **C-111**).

- Floor – Multi-colored terrazzo*; good condition.
- Base – black vinyl base; good condition.
- Walls – painted off-white plaster and wood paneling*; good condition.
- Ceiling – white two-by-four-foot acoustical ceiling with two-by-two-foot light fixtures; good condition
- Counter – speckled green plastic laminate top with red colored travertine*; good condition
- Counter Door – wood double-swing gate with a bronze hardware; good condition (this door replaced an earlier metal door of the same type)

Support Rooms – Room 1101A, 1101B, 1101C, and 1101E

The support rooms historically housed the telephone equipment room. Room 1101A is accessed off of the east wall of reception and was not accessible at the time of the assessment. Room 1101B (network; **Photo C-112**), Room 1101C (office; **Photo C-113**), and 1101E (safe) are south of reception and have been modernized. None of the finishes in these rooms are original but all are in good condition.

Room 1101B

- Floor – VCT; good condition.
- Base – black vinyl base; good condition.

- Walls – painted off-white plaster; good condition.
- Ceiling – none; open to structure.

Room 1101C

- Floor – carpet; good condition.
- Base – black vinyl base; good condition.
- Walls – sound absorbing wall panels; good condition.
- Ceiling – white two-by-four-foot acoustical ceiling with two-by-two-foot light fixtures; good condition.

Room 1101E

- Floor – VCT; good condition.
- Base – black vinyl base; good condition.
- Walls – painted off-white plaster; good condition.
- Ceiling – painted plaster; good condition

Public Displays

The foyer and lobby feature several display cases and free-standing displays that describe the history of NBS, NIST, and Boulder Laboratories. There are three display cases on the south side of the foyer and built-in display cases on the north side of the foyer (refer to photos C-97 and C-98). To the west of the main entrance, there is a grouping of displays, including a chunk of quartz and information about the quartz crystal oscillator, and the Emmy Award NIST received for the development of closed captioning for television (**Photo C-114**; refer to Photo C-92). In the corridor in the east division of the Front of the House, there is a wall plaque that lists the contributors to the Chamber of Commerce fund raiser for the purchase of the Boulder Laboratory site and another display case featuring several awards received by NIST (**Photos C-115 and C-116**). The dedication and cornerstone monuments are located on the exterior wall north of the main entrance vestibule (**Photos C-117 and C-118**). The displays all appear to be in good condition but could benefit from some updating.

3.1.3.2 Spine

The overall condition of the Spine interiors was evaluated as fair. Levels 1 and 2 are discussed in more detail. Levels 3 and 4 are similar and are discussed together in one section.

Level 1

Level 1 of the Spine south of the lobby area was originally constructed as an open space for a future cafeteria and a boiler room. The open space was eventually converted to a cafeteria at an undetermined date and was closed about ten years ago (**Photo C-119**). Most of this area was modernized with VCT flooring with a vinyl base, painted plaster walls, and acoustical ceilings. The windows and doors on the west wall that look out on the sunken terrace are newer full-height storefront system windows. There is a new metal staircase in the terrace that provides access to grade level (**Photo C-120**). All finishes are in good condition.

The corridor between the former cafeteria area and the boiler room has similar finishes to the former cafeteria (**Photo C-121**). The more utilitarian boiler room area has concrete floors, open ceilings, and plaster walls, which are in good condition (**Photo C-122**).

Level 2

Beyond the lobby area, the interior of Level 2 includes a 7-foot-wide double-loaded corridor with offices on the east side that are approximately 16 feet deep and laboratories on the west side that are approximately 25 feet deep (**Photo C-123**). The more utilitarian areas of Level 2 are accessed from the lobby area by a set of double-leaf metal doors with a metal frame and

hardware and two narrow rectangular lights (refer to Photo C-105). These doors do not appear to be part of the original construction, but may have been added to address building fire separation requirements. South of the double doors, the non-load bearing interior walls are constructed of 6-inch CMU with a gray vinyl base. The ceilings are suspended grid. The acoustical tiles were not installed at the time of the assessment and utilities routed through the ceiling were exposed. Other utilities are concealed within a painted steel raceway on the east wall. The floors are light colored 12-by-12-inch VCT tiles that replaced the original asphalt tiles. The interior doors are mostly natural wood doors within metal frames painted light gray (**Photo C-124**). The door frames are mostly original and many of the doors are either original to the building or were installed as part of interior renovation projects that occurred within the period of significance. Hardware on some of the older doors has been updated and a few newer doors are present (**Photo C-125**). The elevators also have been upgraded (**Photo C-126**).

- Floor – Light colored VCT; fair condition.
- Expansion Joints – metal covers; poor condition.
- Base – gray vinyl base; fair condition.
- Walls – painted off-white CMU*; good condition.
- Doors – natural colored wood doors*; fair condition
- Ceiling – suspended ceiling without tiles; poor condition

The offices and laboratories on Level 2 of the Spine are historically significant for the atomic clock and frequency standard research conducted in these spaces. The offices and laboratories themselves have been modified and upgraded over time, and due to the sensitivity of the work conducted within those rooms, they were not accessible at the time of the building survey nor are they typically accessible to tour groups. According to NIST Outreach Director James Burrus, the Level 2 corridor of the Spine, in particular the segment south of the intersections of Wings 1 and 2, is included in private tours of the facility due to its historical associations (**Photo C-127**). In the late 1970s or 1980s, when access to the building was less restricted, a series of public displays were installed on the corridor walls outside of the laboratories and offices where the work occurred. Visitors were guided to the displays by blue and red horizontal painted lines on the walls of the corridor, which terminated at a painting at the end of the corridor (**Photos C-128** through **C-134**). One display was a window that allowed visitors to view the atomic clock and the scientists at work (refer to Photo C-133). Although public access to the building is now restricted, these exhibits remain within the corridor for the education of NIST employees, as well as private, escorted tour groups. Most exhibits are in fair condition and in need of upgrade. The viewing window for the atomic clock was boarded up at an undetermined time at the request of the scientists but could be reopened.

Levels 3 and 4

The interiors of Levels 3 and 4 are very similar in type, materials, dimensions, and finishes (**Photos C-135** through **C-138**). The double-loaded corridors are characterized by white low acoustic ceiling, white painted CMU block walls with a black vinyl base, and light colored 12-by-12-inch VCT floor tiles. The interior doors are mostly natural wood doors within a metal frames painted dark brown or black. The door frames are mostly original, and many of the wood doors are from the original building construction or renovations that occurred during the period of significance. Some of the original door hardware has been updated and some doors have been replaced with newer doors or additional door openings have been added. The elevators have been upgraded. The Level 4 corridor also has two curtained viewing windows into laboratory spaces (**Photo C-139**).

- Floor – Light colored VCT; fair condition.
- Expansion Joints – metal covers; poor condition.
- Base –black vinyl base; fair condition.

- Walls – painted off-white CMU*; good condition.
- Doors – natural colored wood doors*; fair condition
- Ceiling – suspended ceiling with missing acoustic tiles; poor condition

3.1.3.3 Wings 1, 2, 4, and 5

The overall condition of the wing interiors was evaluated as fair. The interiors of Wings 1, 2, 4, and 5 are similar to Levels 2, 3, and 4 of the Spine in type, materials, dimensions, and finishes. The double-loaded corridors are characterized by exposed ceilings or white low acoustic ceiling, white painted CMU or gypsum board walls with black vinyl bases, and light colored 12-by-12-inch VCT floor tiles. The interior doors are mostly natural wood doors within a metal frames painted dark brown or black. The door frames are mostly original, and many of the wood doors are from the original building construction or renovations that occurred during the period of significance. Some of the hardware has been updated and some doors have been replaced with newer doors or additional door openings have been added. The elevators have been upgraded.

- Floor – Light colored VCT; fair condition / carpet; good condition.
- Expansion Joints – metal covers; poor condition.
- Base –black vinyl base; fair condition.
- Walls – painted off-white CMU* and gypsum board; good condition.
- Doors – natural colored wood doors*; fair condition
- Ceiling – suspended ceiling with missing acoustic tiles or exposed ceilings; poor condition

Portions of the corridor and laboratory spaces on the interior of Wing 1 are currently under renovation and Wing 1 appears to be the most altered of the wings (other than Wings 3 and 6). Wing 1 has exposed ceilings and many of the original wood doors have been replaced (**Photo C-140**), although some original doors remain extant (**Photo C-141**).

The ceiling of Wing 2 has its acoustic ceiling tiles in place. The corridor appears to be less altered than Wing 1 and more of its original doors remain intact (**Photos C-142** and **C-143**). Circa 1960, office spaces were added in portions of Wing 2's monitor clerestory spaces (**Photo C-144**).

Wing 4 also has an open ceiling (**Photo C-145**). It also has more original doors than in Wing 1, and also features a segment of original asphalt tile floor in the entry vestibule (**Photo C-146**). Like Wing 2, portions of Wing 4's monitor clerestory spaces were converted to offices circa 1960. However both wings retain some interior high-bay laboratory spaces (**Photo C-147**).

Wing 5 is larger than Wings 1, 2, and 4, and features a basement, two full stories, and a monitor level. The interior finishes in the basement are similar to those in the other wings and the upper levels of Wing 5 (**Photo C-148**). Some restrooms in the basement retain their original finishes and fixtures (**Photo C-149**). On Level 3, some of the utilities are routed through soffits mounted to the walls and others are visible due to the exposed ceiling (**Photo C-150**). Level 4 features newer suspended grid ceiling with acoustic tiles and a segment of the corridor has been carpeted. Level 5 is the monitor level of the wing, which is narrower than the other levels due to its location in the roof monitor (**Photo C-151**).

3.1.3.4 Wings 3 and 6

Wings 3 and 6 were recently completely renovated on the interior and those interiors were not documented or evaluated as part of this study. No original interior features remain visible within the buildings (**Photos C-152** and **C-153**).

3.2 Engineering

During the field survey and site assessment, engineering staff documented observations about the building's condition and gathered information to complete a detailed evaluation and

assessment of the building's architectural elements, including the historic time period, condition, and code violations or deficiencies for each element. The following elements were evaluated:

- Structural: interior and exterior envelope, safety and load-bearing limits and other structural elements as appropriate.
- Mechanical
 - HVAC: heating and cooling equipment and piping network; ventilation air handlers, fans, and duct work; and other HVAC elements, as appropriate.
 - Plumbing: water piping network and equipment, hot water heaters, water fixtures, wastewater piping network, fuel type/storage, and other plumbing elements, as appropriate.
- Electrical: incoming service transformer; incoming service line, ground, main distribution panel, access, and marking; power and length of panel service cap, access, and marking; conductors and raceways; lighting; and other electrical elements, as appropriate.

Research involved an assessment of historic drawings and existing documentation of the building with guidance from the NIST staff.

3.2.1 *Structural*

3.2.1.1 Original Structural Systems

Original 1952 drawings of Building 1 by Pereira & Luckman and J.E. Stanton were reviewed to determine the original structural systems, which are described in the following sections.

Foundations

Due to the geology of the site, the foundation system for Building 1 utilized reinforced concrete beams supported by deeply drilled caissons with belled ends. The wings typically were constructed with grade beams measuring 8 inches wide and 5 feet, 6 inches deep, and 30-inch diameter caissons with 60-inch diameter bottom bells. Caissons were generally located directly below reinforced columns on the structural grid. These deep foundations were designed based on an allowable soil bearing pressure of 8,000 pounds per square foot (psf) for total dead loads plus live loads with a dead load balance of 4,950 psf. None of the drawings provide seismic design criteria or related seismic soil properties.

Floor Framing

The wings and the Front of the House are all one-story structures with floors that are typically 6-inch-thick reinforced concrete slabs on grade with integral 12-by-12-inch tie beams running between caissons.

Wing 5 is a multi-story wing that has three separate areas with similar 6-inch-thick slab on grade and tie beam construction. A segment of the third floor consists of a 10.5-inch-thick reinforced concrete two-way slab with defined column and middle strips in each direction supported by 16-inch-thick perimeter grade beams (below-grade foundation walls), interior 24-by-24-inch reinforced concrete columns, and 8-by-8-foot square drop panel capitals that are 8 inches thick. Level 4 of Wing 5 has a 3-inch-thick reinforced concrete slab supported by a one-way pan joist system with 6-by-12-inch joists spaced at 2 feet, 2 inches on center, spanning between reinforced concrete girders 20 inches wide and 30 inches deep that are supported by 16-by-16-inch columns.

The Spine is also multi-story and, because of its stepped construction along the slope of the site, it steps from a four-story building at the north end to a one-story building at the south end (at Wings 5 and 6). As the spine steps downward, its floor construction changes with the transition of the exterior grade. The slab construction consists of a 6-inch-thick reinforced

concrete slab on grade with integral 12-by-12-inch tie beams running between caissons on the 12-by-25-foot structural grid. The elevated floors of the spine typically consists of a monolithic 6-inch-thick reinforced concrete slab supported by transverse reinforced concrete one-way beams that are 16 inches wide and 18 inches deep, and spaced at 12 inches on center. The beams are supported by 14-inch-square interior and 12-by-16-inch exterior reinforced concrete columns on the structural grid.

Roof Framing

The majority of the roof framing of Building 1 consists of a one-way reinforced concrete pan joist or ribbed slab system. On the wings and the Front of the House, the 2.5-inch-thick roof slab is cast integrally with joists 5.5 inches wide and 10 inches deep that are spaced at 3 feet on center. The Spine's roof is a monolithic 5-inch-thick reinforced concrete slab supported by transverse reinforced concrete one-way beams 16-inches wide and 15-inches deep, spaced at 12 feet on center, and supported by exterior reinforced concrete columns on the structural grid that measure 12 inches on the interior and 12-by-16-inches on the exterior.

Wall Framing

The structural wall framing predominantly consists of reinforced concrete walls. Below-grade basement walls vary from 10- to 12-inches thick, while partial and full height above-grade walls vary between 8- to 10-inches thick. Non-load bearing interior walls may consist of lightly reinforced 8- to 10-inch-thick block masonry and exterior stone faced walls. Some locations have masonry, stone, or reinforced concrete backup.

Miscellaneous

Concrete compressive strength is listed to be 3,000 pounds per square inch (psi). In 1952, the reinforcing steel was designated to be intermediate grade with an allowable stress of 20,000 psi, which is believed to be today's equivalent to American Society for Testing and Materials (ASTM) A15 material with a yield strength of 40,000 psi.

Original Design Loads

Based on the original drawings, current floor and roof live loads are rated as follows:

- Roof Live Load 30 psf
- Floor Live Load (Wing) 150 psf
- Floor Live Load (Spine, Level 1) 150 psf
- Floor Live Load (Spine, Levels 2, 3, and 4) 100 psf
- Wind Load 20 psf

Current Structural Systems

The original construction of Building 1 remains largely intact and untouched with the exception of the relatively recent major renovations to Wings 3 and 6, which built new structural additions on and around the existing structural frames. Spot-checks confirmed that floor heights, exterior building dimensions, and wall and column locations consistently match the existing reference drawings. Observations were limited to exposed surfaces without destructive demolition and removal of finishes.

The structural system was observed to be in generally good condition, with some minor concrete spalling, staining, cracks, and exposed corroding reinforcing bars on the exterior of the building (**Photos C-154 through C-164**). These are consistent with regional climatic exposure and the building's age and represent the worst of the conditions observed. There are no signs of structural distress that would pose a life-safety hazard.

The interior face of exterior concrete walls and superstructure could not be viewed directly due to access limited by furring and gypsum board finishes, which is typical. Floor and wall finishes and ceilings also limited views of interior slabs, beams, columns, and walls in many places. However, where interior concrete was visible, it was in generally good condition though some minor hairline cracking was observed.

The exterior of the structure is in good to fair condition though it needs some minor repairs. Limited visibility of interior slabs, beams, and columns revealed the interior concrete structural elements to be in good condition. Based on limited observation, it is doubtful that the existing spalls, cracks, and corroded rebar have resulted in any significant reduction in the gravity or lateral load-carrying capacity of the structure. Regardless, repairs are necessary to arrest deterioration, including removing loose concrete, exposing and cleaning corroded rebar, and patching spalls.

Based on the construction details depicted in the original 1952 drawings, it is apparent that the existing structure does not meet seismic standards for current building codes. Seismic design criteria would have been minimal to non-existent at this location at the time of the original design and construction in the 1950s.

3.2.2 Mechanical / HVAC and Plumbing

With more than 60 years of service life, any original building systems, including distribution systems such as piping and ductwork, are beyond their prescribed useful service life. Many elements have been replaced as the building's tenants moved, space usage modified, and mechanical codes evolved to require additional HVAC support systems for compliance. In general, what exists today is a wide mix of varying systems that have been cobbled together over time to meet the needs of the individual spaces, de-centralizing the original HVAC systems' design intent.

3.2.2.1 Original Mechanical Systems

Original drawings by Pereira & Luckman and J.E. Stanton indicate an original steam boiler plant in Level 1 of the Spine between Wings 1 and 2. The steam plant housed as many as four dual-fuel steam boilers that fired off natural gas or diesel fuel oil (**Figure 3-1**). Three boilers were part of the original installation, supporting Wings 1 through 4, with space allocated for a fourth boiler to support Wings 5 and 6. They provided steam to the various terminal heating equipment, air handling unit heating coils, and hot water generators.

There was no design for a central building cooling system because the facility was only equipped to provide heating throughout the majority of spaces (**Figure 3-2**). Laboratories, offices, and drafting rooms all had perimeter steam radiation units and relied on operable windows both for ventilation and cooling (when practical). Baseboard radiation units were installed at floors and wall-mounted radiation equipment at the clerestory windows. Distinctive trenches at the perimeter walls were created to allow for the routing of steam condensate (vacuum) return lines back to the central boiler room. Even the auditorium, library, and other densely occupied areas which were equipped with air handling units were only provided with heating and ventilation. The lack of a central building cooling system is typical of 1950's design.

Piping distribution throughout for steam and condensate return is steel piping, originally insulated with asbestos-containing materials. Much of the renovated piping has been remediated, but many areas in Wings 1, 2, 4 and 5 still contain asbestos-covered piping directly above occupied spaces. Undisturbed or coated, the piping has been systematically abated and removed with each renovation project.

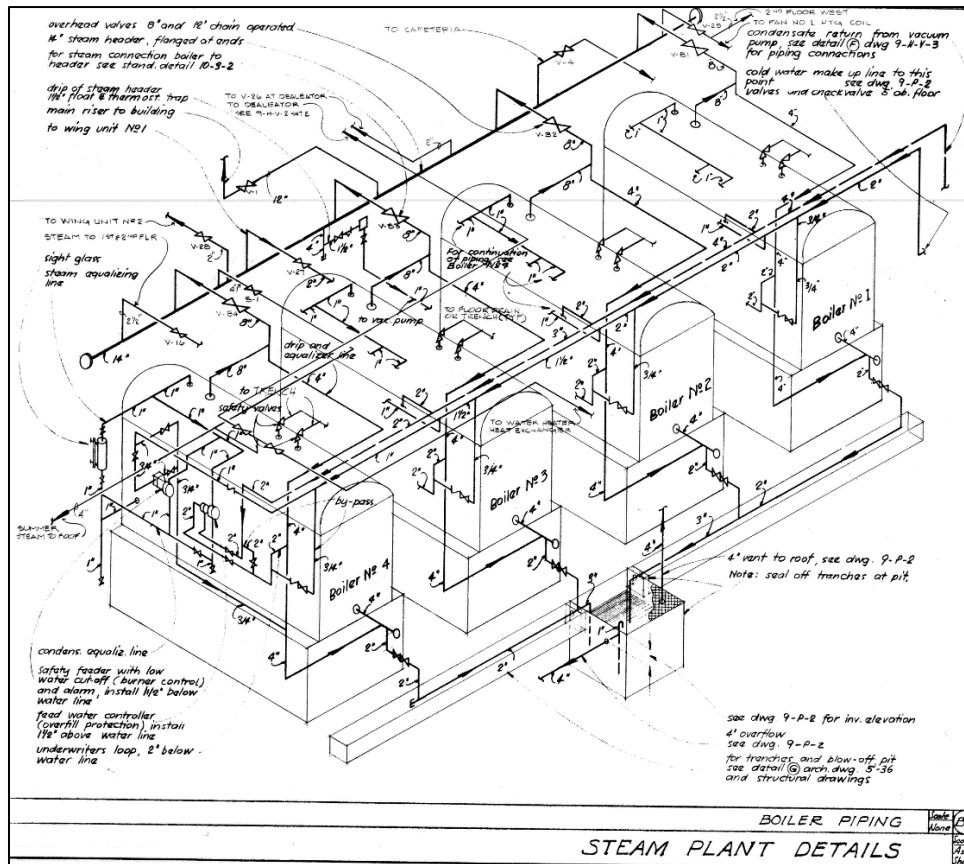


Figure 3-1. Building 1 Steam Plant Design (Pereira & Luckman, Stanton, and Ditzen 1952)

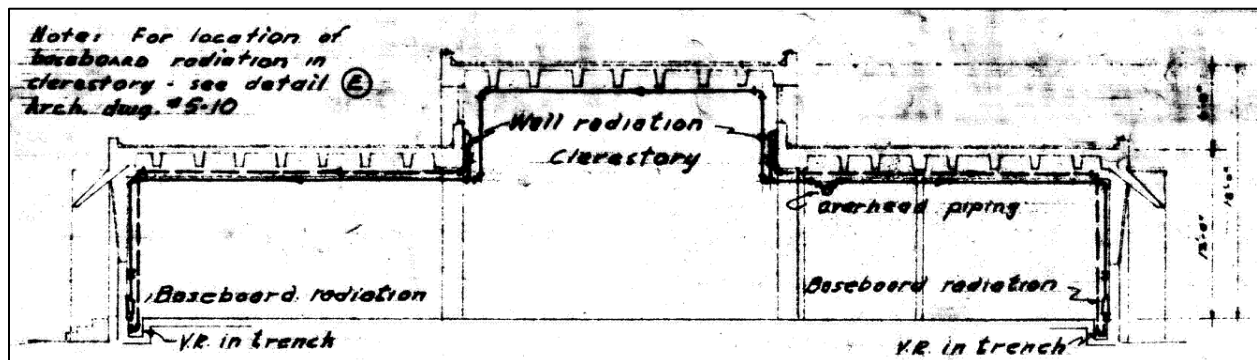


Figure 3-2. Building 1 Perimeter Heating Design (Pereira & Luckman, Stanton, and Ditzen 1952)

HVAC equipment throughout the building was generally arranged as concealed component systems and structures. The equipment utilized penthouse spaces, mezzanines, or dedicated interior rooms for concealment. There was very little roof-mounted equipment or equipment on grade adjacent to the building wings. The exceptions are penetrations for ventilation intakes and exhaust fans serving the laboratories. The previous figures in this report show clean lines of the facility, unobstructed by mechanical equipment. The systems present today represent a significant departure from the original design intent, mostly driven by the change to mechanical codes and updated requirements of the laboratory users and building occupants.

Based on review of original design documentation and visual assessment of the exterior envelope, the exterior walls of the facility lack adequate insulation to meet the code-required minimums of the International Energy Conservation Code (IECC) and the American Society of

Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard 90.1-2013. The original thermal envelope (walls, floors, roof and doors) was designed as an uninsulated concrete mass structure, with single pane, operable windows and no evidence of insulation above the roof deck.

3.2.2.2 Current Mechanical Systems

There have been numerous renovations to nearly all the facility spaces, which have adjusted space usage and occupancy, brought areas up to code (at the time of the renovation), and impacted the performance of the mechanical systems of the building significantly. The major renovations impacting mechanical systems significantly include:

- The addition of recirculating fan-coil units throughout Wings 1 through 4.
- The construction of a campus Central Utility Plant (CUP).
- The additions of Wings 5 and 6.
- The renovations of Wings 3 and 6.
- The addition of cooling to nearly all occupied spaces.

Within a decade after initial construction was complete, many spaces were outfitted with recirculating fan coil units, and connection to central multi-zone air handling units was abandoned. This was presumably the beginning of greater thermal control for each of the spaces, either to meet new requirements of the occupants or to address inadequate performance of original systems. Where fan coil units could not fit within the laboratories, small outdoor units were installed at grade adjacent to the laboratories. While code-compliant, this led to significant amounts of visible mechanical equipment being added the exterior of the building (**Figures 3-3 and 3-4**).

The Building 1 heating plant no longer services much of the facility. A CUP was constructed providing high-pressure steam, chilled water, and compressed air to the campus. An underground utility service tunnel system provides a conduit for these services to this building and others on the Boulder campus.

The existing steam boilers in Building 1 have been replaced with heating water boilers and now only serve Wings 1 and 2. Recent renovations to Wing 3 and 6, as well as planned renovations to Wings 4 and 5, will have new CUP utilities routed independently to each of the wings. Use of steam within the building, outside of the mechanical room, is in violation of Public Buildings Service (PBS)-P100.

The existing Building 1 boilers are no longer dual-fuel. The fuel oil piping and oil tanks were abandoned in 1990. It is not clear whether the tanks were removed or sealed and abandoned in place.

The renovations of Wings 3 and 6 between 2012 and 2016 significantly shifted the mechanical systems approach, starting with the thermal envelope upgrades. Both wings were demolished down to their concrete structures, with all existing mechanical and above-grade plumbing components abated and removed in their entirety. The existing thermal envelope was completely enshrouded with a new, code-compliant super structure. The new walls were insulated, new windows provided, and the building footprints expanded to the south to accommodate mechanical service corridors. To meet current code requirements for HVAC, and requirements for laboratory indoor air quality, thermal and humidity control, and vibration control, the new mechanical corridor provides interior space to house the mechanical equipment within the buildings. The roof-mounted and grade-mounted mechanical equipment was removed. Chilled and heating services water lines were brought from the CUP to provide cooling and heating to all occupied spaces. Existing steam radiators were removed and a shift to heating water was established. Laboratories were each outfitted with independent air

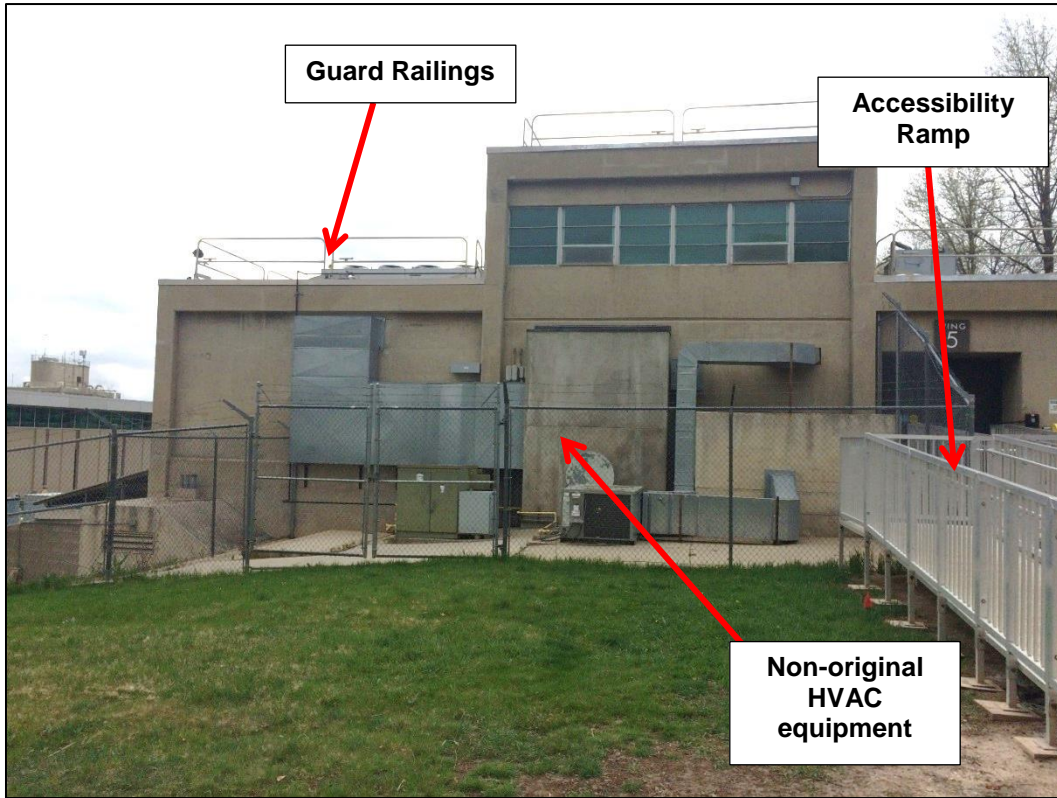


Figure 3-3. Wing 5, Looking Southwest – Mechanical Systems Additions

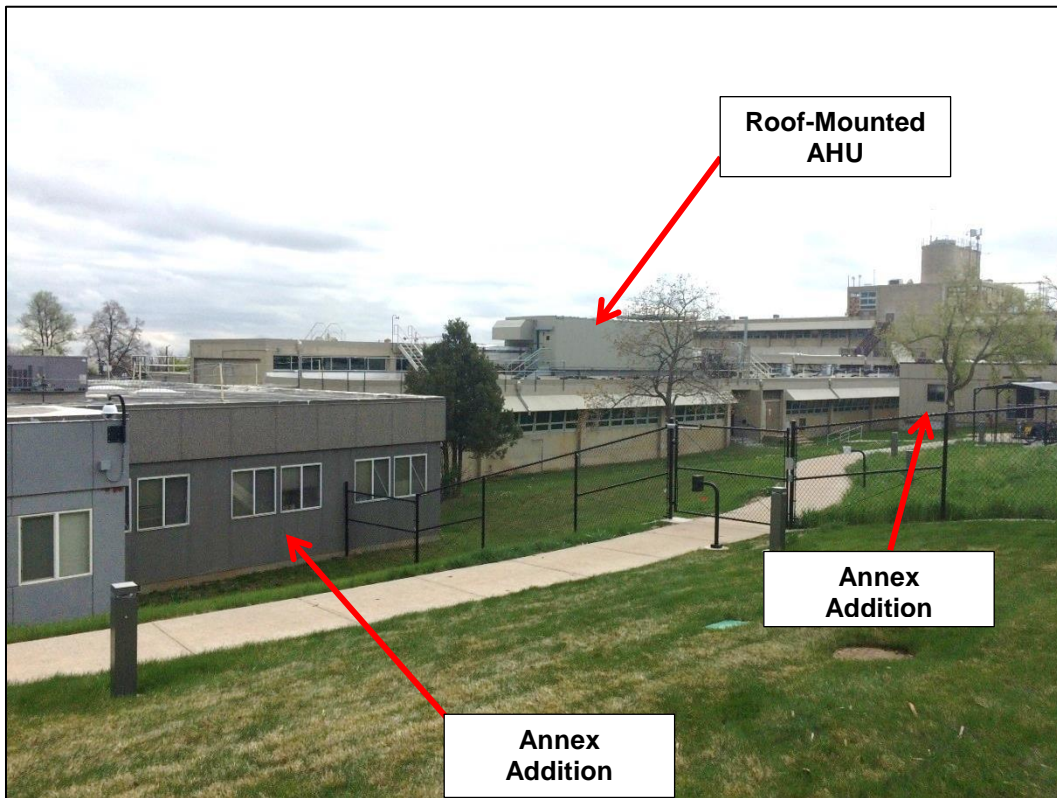


Figure 3-4. Wing 1, Looking Southeast – Mechanical Systems Additions

handling systems, monitoring controls, piping, and ductwork systems. The renovated wings incorporated all the modern equipment and systems that would be present in a new construction. The only remaining evidence of the existing wing is the concrete structure, which can be seen from unfinished/exposed areas within the building.

The remainder of the facility, exclusive of Wings 3 and 6, represents a mix of original and newer construction. Although many windows have been replaced, many original windows are extant. Most original windows have broken window seals, leaking window panes, and single window panes, and many are well past the recommended 30-year service life. Occupants have documented uncontrollable laboratory conditions (temperature, humidity) affecting both experimental procedures and integrity of results. Uninsulated mass walls and roofs also negatively impact the thermal envelope. ASHRAE standard 90.1-2013 and the IECC-2015 require (at a minimum) thermal construction characteristics described in **Table 3-3**.

Throughout the years, changes to code requirements have demanded additional cooling to be provided for nearly all of the occupied spaces. This is a result of change to code-required temperatures that must be maintained, an increase in heat-generating process loads and equipment, an increase in lighting levels and heat output, and an overall thermal comfort improvement demand. To accommodate the cooling demand, chillers and cooling towers have been installed in available spaces. There are multiple cooling towers installed on the roof structures of the wings and Spine (**Figure 3-5**). Distribution piping has been routed throughout the facility to provide chilled water to fan coils, air handling units, and process equipment.

The operable windows are no longer relied upon for ventilation. Nearly all occupied spaces have been equipped with air systems that provide ventilation air to occupants. This has led to an increased number of air handling units being installed on the roofs of the wings and Spine. No code compliance of existing ventilation supply rates was assessed. Each permitted renovation will require an update to its ventilation rates to meet code-compliant minimums. The code requirements have become more stringent, and it is expected most spaces that have not been renovated in the past 15 years will be found deficient.

With the addition of roof-mounted equipment, guard railings were added to the perimeters of the buildings at or near the parapets for Occupational Safety and Health Administration (OSHA) fall protection (refer to Figure 3-5), but the railings are fully demountable. Building 1's original pneumatic controls have been replaced through each renovation to a direct digital control system. Any remaining pneumatic controls would be in violation of PBS-P100.

In general, existing HVAC equipment is well maintained and within normal service life for equipment servicing occupied spaces. However, several exhaust fans have been abandoned in place, or serve laboratories with severely degraded equipment or damaged or leaking ductwork.

3.2.2.3 Plumbing

The cold water piping for the building enters the basement in the northwest corner. A new water meter was installed, but the piping was capped, and all domestic water piping within the building has been evacuated and abandoned. All domestic hot and cold water piping within the building is original galvanized iron pipe in need of replacement to prevent the iron from leaching from the piping into the water. The building currently does not have a hot water recirculation system installed, which is in violation of the current plumbing code.

The 40-gallon electric water heater in the basement appears to have been installed in 2006 and is in good condition, but, may be oversized for the building based on plumbing demand.

Table 3-3. IECC 2015 Building Envelope Requirements for Climate Zone 5 (A, B, C)

TABLE C402.1.3 OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD ^a																	
CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8		
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	
Roofs																	
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci	
Metal buildings ^{a,b}	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-49	
Walls, above grade																	
Mass	R-5.7ci ^c	R-5.7ci ^c	R-5.7ci ^c	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci	
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13+ R-19.5ci	R-13+ R-19.5ci	
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13+ R-17.5ci	
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-15.6ci or R-20 + R-10ci	R-13 + R-15.6ci or R-20 + R-10ci
Walls, below grade																	
Below-grade wall ^d	NR	NR	NR	NR	NR	NR	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-10ci	R-10ci	R-10ci	R-12.5ci
Floors																	
Mass ^e	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	R-10ci	R-10.4ci	R-10ci	R-12.5ci	R-12.5ci	R-12.5ci	R-15ci	R-16.7ci	R-15ci	R-16.7ci	
Joist/framing	NR	NR	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30 ^f	R-30 ^f	R-30 ^f	R-30 ^f	
Slab-on-grade floors																	
Unheated slabs	NR	NR	NR	NR	NR	NR	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 24" below	R-20 for 24" below
Heated slabs ^f	R-7.5 for 12" below	R-7.5 for 12" below	R-7.5 for 12" below	R-7.5 for 12" below	R-10 for 24" below	R-10 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 36" below	R-15 for 36" below	R-15 for 36" below	R-15 for 36" below	R-20 for 48" below	R-20 for 24" below	R-20 for 48" below	R-20 for 48" below	R-20 for 48" below
Opaque doors																	
Nonswinging	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	

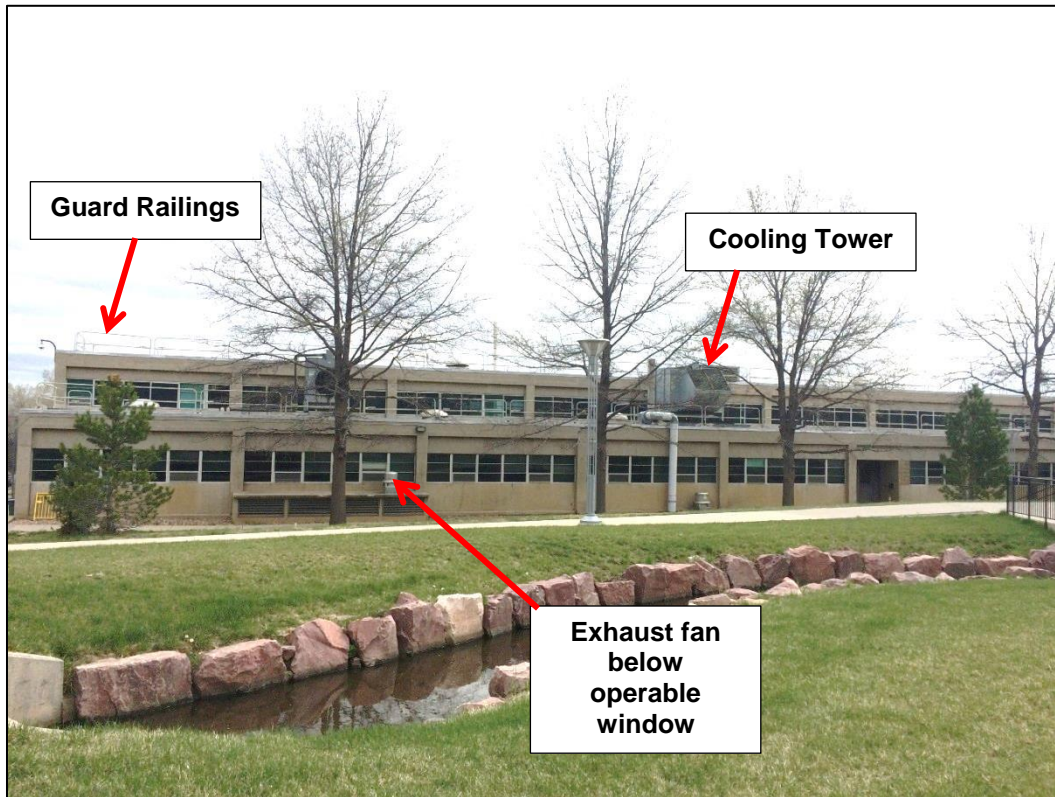


Figure 3-5. Wing 5, Looking East – Mechanical Systems Additions

All vitreous china plumbing fixtures in the building are original. There are no visible defects or damage to any of the fixtures. The fixtures appear to be in good condition and are recommended to remain. With the water being shut off from the building and no visible signs of glycol being put into fixtures to maintain trap seals, the piping associated with the plumbing fixtures has probably rusted or collected debris, thus reducing the effective capacity and deteriorating the condition of the piping.

3.2.3 *Electrical*

The evaluation of the building's electrical systems included electrical service and distribution, lighting, lightning protection, fire alarm, telecommunication, and security. The electrical systems were assessed for condition, and code compliance and deficiencies.

3.2.3.1 Original and Current Electrical Systems

Electrical Service and Distribution

With the exception of Wings 3 and 6 and minor tenant improvement alterations, the electrical distribution gear and branch circuit panelboards are original to the building. The overcurrent protection devices are molded case circuit breakers. The Building 1 internal power distribution is 208Y/120V in Wings 1, 2, 4, and 5, and the Spine. Building 1's medium-voltage service enters the building on Level 2 of the Spine from MH #11, which is located in the courtyard between Wings 2 and 4. This service connects to the Spine's 208Y/120V service transformers and connects to Wings 1 and 2 service transformers. Wing 4 is radially fed from Wing 2 transformers. The MV conductors then connect the Spine, Ions Lab, and Wing 5 to the southwest through numerous splices.

Lighting

Exterior building mounted lighting is high intensity discharge (HID)-type luminaires that illuminate the exterior doors. Area lighting around the building is limited to light-emitting diode (LED) luminaires mounted on 30-foot standards. It is anticipated the original lighting in Building 1 was incandescent and T-12 linear fluorescent. Over the life of the building these may have been replaced and upgraded to the current T-8 linear fluorescents, compact fluorescent downlights, and HID luminaires. The corridors of the Spine are illuminated by recessed linear fluorescents mounted in egg crate style dropped grid ceilings. Office lighting primarily consists of recessed troffers mounted in acoustic grid and laboratories are configured with pendant mounted linear fluorescents. Egress lighting consists of unit battery backup ballasts in luminaires and emergency units.

Lightning Protection

Building 1 had lightning protection added as part of the renovations of Wing 3 and Wing 6, but the remainder of Building 1 is not protected from a lightning protection system.

Fire Alarm System

The fire alarm system is an analog system. Pull stations at exit doors and smoke detectors (in required areas not covered by fire protection system) provide the system initiation. Combination horn/strobes provide alarm annunciation. The existing topology is level-based throughout the wings and the Spine. As the renovation to the building progresses, the topology follows the renovations to divide the building into zones by wing and the Spine.

Telecommunication System

Voice System

CenturyLink is the local carrier and enters Building 1 from the Broadway Street side into Room 2001. A 600 pair copper telephone cable runs up both levels of the Spine from Room 2001. The voice riser lands in the Voice and Station cabling rack in the Telecommunication Room (TR). From there, Category 6 cable is routed to each station jack throughout the wing. Telephone cable is in conduit, which is factory-painted white.

Data System

Data system jacks are located throughout the wings in offices, conference rooms, break rooms, and laboratories. Category 6 cable in conduit connects the outlets to the racks in the TR. Data cabling is in conduit that is factory-painted blue. Conduit is provided from the back box to the cable tray in the corridor. The cable tray transitions to conduit to “waterfall” into the tray in the TR. A rack in the TR utilizes adequate 48 port patch panels with wire managers.

Optical Fiber

Optical fiber connects the existing NIST fiber-optic system into the wings. Room 2001 is the entry facility room with a backbone fiber-optic cabling to Room 3036. As the fiber-optic hub, cabling is routed to wing TRs. Each TR is provided with 24 strands multimode fiber-optic cable.

Security System

The Boulder campus is accessed through a vehicular gate near Broadway Street. Vehicles are screened and visitors are badged in the Visitor’s Center just outside the gate. Several pedestrian trails pass through the site for walking, jogging, or biking. Campus security is at the building level utilizing intrusion detection, access control, and a Closed-Circuit Television (CCTV) system.

4. Evaluation of Significance

4.1 Statement of Significance

The historic assessment of the Department of Commerce Boulder Laboratories completed in 2016, in conjunction with the development of a Master Plan and an associated Environmental Assessment, recommended that Building 1 be considered eligible for listing in the National Register of Historic Places (NRHP) under Criteria A and C (Gatewood et al. 2016; Metropolitan Architects and Planners 2017a, 2017b). In February 2016, the Colorado State Historic Preservation Officer (SHPO) concurred that Building 1 is eligible under Criterion A and possibly eligible under Criterion C (Turner 2016).

The building's period of significance was defined as 1954, when much of Building 1 was constructed, to 1965, when the CRPL was dissolved and the building was no longer used for its original purpose. Building 1 is individually significant under NRHP Criterion A for its associations with the broad patterns of the history of the NBS. The building is associated with the growth and expanding research activities of the NBS and the CRPL in the post-World War II era, when agency activities began to play a key role in Cold War technology and research. When Building 1 was completed, it was considered the flagship building of the Boulder site. With its prominent and visible location along Broadway Street and its cutting-edge International-style architecture, Building 1 conveyed the NBS's image as a progressive and modern agency.

Prior evaluations of the building in the 1990s suggested that Building 1 could also be significant under NRHP Criterion A for the important technological research and development that occurred within the building during the Cold War and Space Age periods, but the 2016 historical assessment concluded that the building no longer retained sufficient historical integrity to reflect this historic theme and the defined period of significance (Gatewood and others 2016). The assessment determined that the use of the building and the interiors of its laboratories had been altered since the CRPL was dissolved in 1965, and although the building did house several atomic clocks, the building was not specifically designed for that purpose and the areas used to research and store the clocks had been altered.

Building 1 also is individually significant under NRHP Criterion C. The building design is representative of Modernist architecture with design elements of the International style, which was considered cutting edge in the early 1950s. Those elements include cast-in-place concrete and concrete block construction, a horizontal orientation, a flat roof, horizontal bands of windows, and minimal exterior ornamentation. The building also possesses elements of Functionalism, a variation of the International style based on the theory that building design should emphasize functional efficiency. The building was designed to accommodate the entire laboratory, support, and administrative functions of the CRPL in one building with architectural detailing focused on the public and common areas in the Front of the House and more utilitarian design in the Spine and wings to be used as laboratory and office spaces. The building's architects also appear to have been influenced by Organic Architecture, an American response to European Modernist architecture initiated by Frank Lloyd Wright. This influence is reflected in the architects' use of the existing terrain in the design of the building, the use of native stone details in the Front of the House, and the low profile of the building designed to preserve views of the Flatirons beyond (City of Phoenix Historic Preservation Office and Ryden Architects 2010).

Although the building has been altered since its original construction, it is a good example of the International style and of the post-World War II research campus model. It also was designed by the noted Los Angeles architectural and engineering firm of Pereira & Luckman, which was well-known and celebrated for its modern architectural designs. Pereira & Luckman, along with

Jesse Earl Stanton and associate architect Robert William Ditzen, were awarded the AIA Award of Merit for the building design in 1954. Pereira identified Building 1 as one of his top ten notable designs in 1957 (Gatewood and others 2016).

4.2 Historic Character-Defining Features

All extant original exterior elements of Building 1 contribute to its character and its eligibility for listing in the NRHP. On the interior, character-defining features are concentrated in the Front of the House, which, as the original public entrance to the campus and the location of the building's common areas, possesses all the building's architectural ornamentation while the rest of the building is more utilitarian in design. To support the scientific mission of the NBS and the CRPL, alterations to the interior of Building 1 began soon after the building was constructed and has continued throughout the building's history. The historic integrity of the laboratory and office spaces in the Spine and wings has been compromised by these alterations, and the only character-defining features that remain intact on the interior of the Spine and wings are the configuration of the double-loaded corridors. Major character-defining features are described in detail in the following sections.

4.2.1 Site

- The spatial relationship of the Building 1 footprint, the lawns and landscaped exterior courtyard at the Front of the House, and the outdoor spaces between the wings.
- The setting of the building within the topography of the site, including the Spine's position within the existing slope and the ascending intersections of the wings.
- The axial siting of the building toward Broadway Street.

4.2.2 Exterior

- Modernist architecture with design elements of the International Style, Organic architecture, and Functionalism.
- Overall configuration, massing, and scale as a singular large resource with common areas with expansive office and laboratory wings.
- Exterior wall finishes, including native sandstone and cast-in-place concrete.
- Low, horizontal orientation emphasized by flat roofs, horizontal bands of windows, bays formed by exposed concrete structural beams and columns, rooftop monitor clerestories in the wings, and contrasting vertical divisions in the Front of the House.
- Extant concrete sunshades above the windows on the Spine and Wings 1, 2, and 4.

4.2.3 Interior

- The north, south, and central division floor plan in the Front of the House and the north end of the Spine including the auditorium, library, and lobby/entrance space.
- Extant original Interior finishes in the Front of the House including:
 - terrazzo flooring and baseboards;
 - travertine wall panels;
 - original single- and double-leaf wood doors;
 - exposed native sandstone walls;
 - birch and walnut plywood paneling;
 - built-in display cases in the foyer; and
 - jagged/sloping pattern of east and west auditorium walls.
- Configuration of double-loaded corridors (central corridors with offices and laboratory spaces on either side) in the Spine and the wings.

4.3 Assessment of Integrity

Besides meeting one of the NRHP criteria, a property must also retain a significant amount of its historic integrity to be considered eligible for listing in the NRHP. Historic integrity is made up of seven aspects: location, design, setting, materials, workmanship, feeling, and association.

Location is the place where the historic property was constructed or the place where the historic event took place. The location of Building 1 has remained the same, and it has not been moved since its construction. The integrity of the property's location remains intact.

Design is the combination of elements that create the form, plan, space, and style of a property. Although the major alterations discussed in the architectural description, especially the renovations of Wings 3 and 6, have compromised the building's integrity of design, the Front of the House and Wings 1, 2, 4, and 5 have not been substantially altered, and the building overall retains its configuration, massing, and scale.

Setting is the physical environment of a historic property. The setting of Building 1 has not changed significantly since it was constructed in 1954. The integrity of the property's setting remains intact.

Materials are the physical elements that were combined or deposited during a particular period of time and in a particular pattern of configuration to form a historic property. The building's integrity of materials has been compromised by the recent renovations to a portion of its spine and Wings 3 and 6. However, the Front of the House remains mostly unaltered, and Wings 1, 2, 4, and 5 retain many of their original materials.

Workmanship is the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory. Building 1 is a good example of Modernist architecture, and the building materials and design are indicative of the skills of the contractors and their knowledge of contemporary trends of the 1950s. The building retains integrity of workmanship.

Feeling is a property's expression of the aesthetic or historic sense of a particular period of time. Despite the recent renovations, Building 1 continues to convey the character of a government research campus constructed in 1954. The building retains integrity of feeling.

Association is the direct link between an important historic event or person and a historic property. The property is a good example of Modernist architecture and representative of a government research campus designed using the post-World War II research campus model. It continues to function as a government research campus and has maintained the same associations since it was established. The building retains integrity of association.

Between 2012 and 2016, Wings 3 and 6 of Building 1 were substantially modified. The sheathing of the original exterior concrete wall surfaces with metal panels, the changes to the shape of the roofline, the removal of the concrete sunshades, changes to the size of the window openings, and window replacement severely compromised the historic integrity of Wings 3 and 6. A portion of the façade of the spine between Wings 4 and 6 also has been sheathed with metal panels. In addition, the construction of Annexes C, D, E, and F, as well as the installation of rooftop equipment, has compromised views of the original features of Wing 1.

Although these modifications and others previously described have compromised the building's historic integrity, Building 1 retains sufficient integrity to convey its historical significance.

PART 2: TREATMENT AND RECOMMENDATIONS

5. Historic Preservation Objectives

5.1 Introduction

In 1991, the Advisory Council on Historic Preservation (ACHP) published a report titled *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities* (ACHP 1991) in response to a joint request from the House Committee on Interior and Insular Affairs, the Subcommittee on National Parks and Public Lands, and the House Committee on Science, Space, and Technology. The purpose of the report was to analyze preservation issues concerning federal support of highly scientific and technical facilities, and to consider the appropriate role of historic preservation in decision-making about the operation and management of these facilities. Although some highly technical and scientific facilities in the United States are historically significant for the role they played in the advancement of scientific and engineering knowledge and warrant preservation, many of these facilities continue to be in use and need to be frequently upgraded and modified to stay on the cutting edge of technology. The study concluded that a trade-off between traditional historic preservation and scientific facilities is appropriate. Although the upgrade of scientific facilities could compromise the historic integrity of the property, the upgrades themselves would allow the facility to continue to be used, so that the facilities are not deemed obsolete and abandoned (ACHP 1991).

Building 1 is the original core research building at the Boulder campus and is valued for its spatial and structural characteristics, including its high-bay laboratory spaces and the single-story at-grade construction in the wings. However, the building's systems are outdated and obsolete, and in order to meet performance levels required by NIST's evolving scientific research, as well as federal requirements for energy reduction, seismic strengthening, and physical security, the building needs to be renovated and upgraded to ensure continued use of the building (Metropolitan Architects and Planners 2017a).

Since the Boulder campus was constructed, the NBS and NIST have been an important part of the local community, beginning with the Chamber of Commerce fund-raising effort to purchase the land for the campus, followed by the grand dedication by President Eisenhower, and subsequent scientific and educational programs offered to local students and residents through science fairs, conferences, and tours. In the past, the Front of the House was open to the public, but current security policies require Department of Commerce employee sponsorship, badging, and screening, which has reduced the number of on-campus conferences and public forums. One of NIST's 2017 Master Plan goals is to re-open the Front of the House to the public, which, if achieved, would provide opportunities for the interpretation and education of the history of NBS, NIST, and the Boulder campus to visitors.

The Secretary of the Interior's Standards for the Treatment of Historic Properties (Standards) identify four treatment approaches for historically significant resources such as Building 1 – Preservation, Rehabilitation, Restoration, and Reconstruction. Given the goals of NIST, the most appropriate treatment approach for Building 1 would be Rehabilitation, which would preserve materials and features that convey the building's historical and architectural values, while allowing for the necessary repairs and upgrades.

5.2 Secretary of the Interior's Standards

5.2.1 Preservation

Preservation is the appropriate treatment when the objective is to retain the building as it currently exists, including the original materials as well as the later changes and additions (National Park Service [NPS] 2017: 29). The NPS defines **preservation** as "the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an

historic property” (NPS 2017: 2). Work, including preliminary measures to protect and stabilize the property, generally focuses on the ongoing maintenance and repair of historic materials and features, rather than extensive replacement and new construction. New exterior additions are not within the scope of this treatment; the limited, sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties more functional is appropriate for a preservation project. Under this treatment standard, the goal is to retain the building’s existing form, features, and materials through protection, maintenance, and repair with minimal replacement (NPS 2017). **Preservation is not recommended as a feasible treatment for Building 1 because it would limit NIST’s ability to meet its goal of continued scientific use, which would require repairs and upgrades to meet current scientific performance levels and federal code requirements.**

5.2.2 *Rehabilitation*

Rehabilitation is the recommended treatment for Building 1. Under this treatment, historic building materials and character-defining features are protected and maintained as they are under Preservation, but greater flexibility is given to replace extensively deteriorated, damaged, or missing features using the same or compatible substitute materials. The NPS defines rehabilitation as “the act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values. The Rehabilitation Standards acknowledge the need to alter or add to a historic building to meet continuing or new uses while retaining the building’s historic character” (NPS 2017: 2). NPS identifies 10 standards for rehabilitation (**Table 5-1**).

5.2.3 *Restoration*

The NPS defines **restoration** as “the act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time by means of the removal of features from other periods in its history and reconstruction of missing features from the restoration period” (NPS 2017:3). Restoration would involve the retention of historic elements from the defined period of significance and the removal of features from other time periods (NPS 2017). **This treatment is not recommended** as a feasible treatment for Building 1 because it is not compatible with NIST’s goal of continued scientific use of the building and restoration to the period of significance of 1954 to 1965 would not allow for the upgrades required for continued use. In addition, alterations to the interior spaces of Building 1 began almost immediately after construction was completed, and the building incorporated a “use module design” to accommodate future growth and changes in research programs.

5.2.4 *Reconstruction*

The NPS defines **reconstruction** as “the act or process of depicting, by means of new construction, the form, features, and detailing of a non-surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time and in its historic location” (NPS 2017:3). The **reconstruction** treatment method **does not apply** to Building 1 because it remains standing and does not require reconstruction.

5.3 **Application of Standards and Treatment to Building 1**

To guide future improvements to Building 1, a series of Preservation Zoning Plans were developed based upon the findings of this document and the goals and scientific program needs of NIST. All areas of the exterior and interior of Building 1 were assigned a treatment zone – Zone 1: Preservation Treatment Zone; Zone 2: Rehabilitation Treatment Zone; and Zone 3: Renovation Treatment Zone. The treatment zones are defined in the following section. The Preservation Zoning Plans are attached in **Appendix D**.

Table 5-1. Secretary of the Interior’s Standards for Rehabilitation

Rehabilitation
1. A property will be used as it was historically or be given a new use that requires minimal change to its distinctive materials, features, spaces, and spatial relationships
2. The historic character of a property will be retained and preserved. The removal of distinctive materials or alteration of features, spaces, and spatial relationships that characterize the property will be avoided.
3. Each property will be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or elements from other historic properties, will not be undertaken.
4. Changes to property that have acquired historic significance in their own right will be retained and preserved.
5. Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.
6. Deteriorated historic features will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and where possible, materials. Replacement of missing features will be substantiated by documentary and physical evidence.
7. Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.
8. Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.
9. New additions, exterior alternations, or related new construction will not destroy historic materials, features, and spatial relationships that characterize the property. The new work will be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the property and its environment.
10. New additions and adjacent or related new construction will be undertaken in such a manner that, if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.

Source: NPS 2017

5.3.1 Zone 1 – Preservation Treatment Zone

Zone 1 or the Preservation Treatment Zone includes primary spaces considered to be the most historically significant in terms of retention of original materials, features, and functions. The primary spaces are architecturally unique, may be important circulation features of the original plan, contain original materials, and possess a high level of architectural integrity. Spaces designated as Zone 1 also would be subject to the Standards for Rehabilitation, as discussed in Section 5.1. The following areas of Building 1 were designated as Zone 1:

Level 1

- Interior of the north end of the Spine in the Front of the House.

Lobby Level

- Interior and exterior of the Front of the House.

Level 2

- Interior of the north end of the Spine in the Front of the House.
- Double-loaded corridor in Level 2 of the Spine.

Level 3

- Exterior of equipment rooms on the roofs of the library and auditorium.

Roof Form (i.e. flat roof)

- Front of the House, including the north end of the Spine.

The Front of the House contains most of the building's architectural ornamentation, which retains a high degree of historic integrity, and the preservation of this area will retain many of Building 1's character-defining features.

Level 2 of the Spine is historically significant as the primary location of the development of the atomic clock and frequency standards during the period of significance. However, the interiors of the offices and laboratories do not retain integrity from the period of significance and continue to be used for scientific purposes. Therefore, only the double-loaded corridor with its existing interpretive displays was designated as a Preservation Treatment Zone. The preservation of this segment of the corridor, along with the Front of the House, would both convey the feeling of the 1950 and 1960s campus and facilitate interpretation of the history of NBS, NIST, and the Boulder campus.

5.3.2 Zone 2 – Rehabilitation Treatment Zone

Zone 2 or the Rehabilitation Treatment Zone are secondary spaces that also are important to the overall historic integrity of the building, possess many original features and materials, but with an understanding that some changes may be needed for future rehabilitation and support of scientific mission. Rehabilitation offers more flexibility for possible alternate uses, for repair of historic materials, and for installation of new equipment. Spaces designated as Zone 2 also would be subject to the Standards for Rehabilitation, as discussed in Section 5.1. The following areas of Building 1 were designated as Zone 2:

Level 1

- Exterior of the above-ground portions of the Spine.

Level 2

- Exterior of the above-ground portions of the Spine.
- Exterior of Wings 1 and 2.
- Interior configuration of double-loaded corridors in Wings 1 and 2.

Level 3

- Exterior monitor clerestories of Wings 1 and 2.
- Exterior of the above-ground portions of the exterior of the Spine, including the entire west side and the east side between the Front of the House and Wing 4.
- Exterior of Wings 4 and 5.
- Interior configuration of double-loaded corridors of the Spine, Wing 4, and Wing 5.

Level 4

- Exterior monitor clerestory of Wing 4.
- Exterior of Wing 5.
- Exterior above-ground portion of the Spine, including the entire west side and the east side between the Front of the House and Wing 4.
- Interior configuration of double-loaded corridors of the Spine and Wing 5.

Levels 5 and 6

- Exterior of rooftop penthouse on the Spine.
- Exterior of Wing 5 monitor level.

Roof Form (i.e. flat roof, monitor clerestories)

- Spine south of the Front of the House, Wings 1, 2, 4, and 5.

Designation of these areas as rehabilitation zones allows for the renovations and updates to the research areas of the buildings required by NIST to fulfill its goal of continued use of the building, while still retaining historic character-defining features and the historic materials, scale, and massing. The only character-defining features in the interior of the building recommended for rehabilitation are the double-loaded corridors in Levels 3 and 4 of the Spine and in Wings 1, 2, 4, and 5. These corridors, including the doors and openings within the corridors, may need to be redesigned or replaced for future improvement and renovation projects, but the overall configuration of the double-loaded corridor should be retained.

5.3.3 Zone 3 – Renovation Zone

Zone 3 or the Renovation Zones are tertiary spaces identified throughout the building that are more utilitarian or may have had some modifications of varying degrees to their original layout or finishes. These spaces include scientific laboratories, private offices, service areas, mechanical spaces, restrooms, locker rooms, storage areas, and other areas. The following areas of Building 1 were designated as Zone 3:

Level 1

- Interior of the Spine.

Level 2

- Offices and laboratories in the Spine and Wings 1 and 2.
- Interior of Wing 5.

Level 3

- Offices and laboratories in the Spine and Wings 4 and 5.
- Interiors of rooftop equipment areas on the Front of the House.
- Interiors of the monitor clerestories on Wings 1 and 2.
- Wings 3 and 6.

Level 4

- Offices and Laboratories in the Spine and Wing 5.
- Mezzanine offices in Wing 4.
- Wings 3 and 6.

Levels 5 and 6

- Interior of rooftop penthouse on the Spine.
- Interior of monitor level of Wing 5.
- Wing 6

Roof Form

- Wings 3 and 6.

Areas of Building 1 that are designated as the renovation zone are not subject to the Standards and can be renovated as needed, unless those renovations impact areas of the building that are designated as Zone 1 or 2.

6. Requirements for Work and Work Recommendations

6.1 Requirements for Work

The preservation treatment recommended for Building 1 follows the Standards for Rehabilitation, which acknowledges and allows for sensitive upgrading of mechanical, electrical, and plumbing systems, and other code-required work including accessibility and life-safety requirements. These requirements include building and fire codes, accessibility, hazardous materials assessments, and energy efficient considerations.

Building, Fire, and Electrical Codes

- 2015 International Building Code (IBC)
- 2015 International Existing Building Code
- 2015 International Fire Code
- 2015 International Fuel and Gas Code
- 2015 International Mechanical Code
- 2015 International Plumbing Code
- 2015 National Fire Protection Association (NFPA) Safety Code
- 2015 National Electric Code
- 2015 NFPA 45 Standard on Fire Protection for Laboratories Using Chemicals

Americans with Disabilities Act Considerations

- 2017 International Code Council/American National Standards Institute 117.1 Accessible and Usable Buildings and Facilities
- ADA Standards for Accessible Design by the Department of Justice
- Architectural Barriers Act (for federally funded facilities)

Energy Efficiency

- 2015 IECC
- ASHRAE Standard 90.1-2013
- US Green Building Council Leadership in Energy and Environmental Design (LEED) Requirements: LEED v4 for New Construction

Hazardous Materials Abatement

Building 1, including the Front of the House, Spine, and Wings 1, 2, and 4 were constructed in 1954, and Wing 5 was constructed in 1962. Because of the age of the building, lead-based paint (LBP) and presumed asbestos-containing materials (PACM) are likely present. Testing for lead and asbestos would be completed prior to any improvement project where the potential for these materials exists, and would be systematically abated and removed with each project.

6.2 Work Recommendations

As part of its 2017 Master Plan (Metropolitan Architects and Planners 2017a), NIST initiated a phased renovation and upgrade program for Building 1 to replace outdated systems and meet the performance level required for NIST's research. The renovations of Wings 3 and 6 were previously completed. Future projects to renovate the remaining sections of the building, including the Front of the House, the Spine, and Wings 1, 2, 4, and 5, should be designed and executed in accordance with the appropriate recommended NPS standards and guidelines for Rehabilitation (NPS 2017). Future designs should be analyzed on a case-by-case basis by professionals meeting the Secretary of the Interior's Professional Qualification Standards for History and Architectural History, as well as Historic Architecture, if warranted, to determine if those projects meet the appropriate recommended Standards.

The following sections include specific work recommendations for the structural, mechanical and plumbing, and electrical aspects of Building 1. Relevant Preservation Briefs published by the NPS are included in Appendix D.

6.2.1 *Structural*

Building 1's exterior concrete walls have a number of locations where moisture has penetrated and corroded rebar, causing concrete to crack and spall. Water stains on interior partition walls and ceilings provide evidence of past leaks in the roof or building exterior. Measures should be taken to halt the progress of this water intrusion and deterioration. The following are recommendations for the building's structural elements in regards to rehabilitation treatment options.

Rehabilitating Building 1 through repair, alterations, additions, and/or change of use has a number of structural considerations. Repairs of cracked and spalled concrete and corroded rebar should be made to the exterior concrete walls of the building, and a weathertight envelope restored to the building, including the roof.

If alterations, additions, or change of use are considered for rehabilitation of the building, the following rules in the current code (see Appendix 11B of ASCE 7-10 referenced by the 2015 IBC) should be considered to prevent triggering a mandatory seismic retrofit of the entire structure to be compliant with the current code:

- Alterations/additions must not increase the seismic force in any existing structural element by more than 10 percent nor decrease the design strength of any existing structural element.
- Change of use must not result in a structure being reclassified to a higher occupancy/risk category as defined in Table 1.5-1 of ASCE 7-10.

A voluntary seismic retrofit would selectively address some significant seismic deficiencies and improve the building's expected performance during an earthquake. Therefore, early in the rehabilitation process, a seismic evaluation of the building (utilizing *ASCE 41 Seismic Evaluation and Retrofit of Existing Buildings* [ASCE 2014]), in conjunction with guidance from the NPS's Preservation Brief 41: *The Seismic Rehabilitation of Historic Buildings* [Aguilar 2016]), would identify seismic deficiencies and rank them based on their potential threat to life and safety. Retrofit concepts would be developed to address the identified deficiencies.

As part of the evaluation, a seismic performance objective (e.g., collapse prevention, life safety, immediate occupancy, or operational) should be chosen. Some retrofit concepts may be applied on the interior with minimal-to-no impact on exterior historic appearance, such as thickening the interior face of concrete shear walls, or adding strengthening to the underside of floor members hidden by ceilings or in the basement. The ASCE 41 document provides a wide range of evaluation options that range from a brief Tier 1 screening procedure (using checklists and basic rough-order-of-magnitude calculations to identify probable seismic deficiencies warranting additional investigation) to a Tier 3 systematic evaluation (using nonlinear computer models for retrofit).

Regardless of whether a voluntary seismic retrofit is pursued for the structure, it is recommended that any existing suspended ceilings, piping, or conduits be seismically braced and mechanical units anchored. Any newly installed suspended ceilings, piping, conduits, or equipment would be installed with seismic bracing per current code.

Occupancy/use of the building requires consideration of the live load limits for which each of the floor levels have been designed. Current floor and roof live load and wind load limits derived from the 1952 original drawings were referenced in the previous "Original Design Loads" section.

Occupancies/uses that exceed these live load limits will require the following:

- Strengthening of the concrete slabs and beam framing.
- Verification that the columns, walls, and foundations can support the increased loads.
- Verification that such strengthening does not add such weight that would unduly increase seismic loads and trigger mandatory seismic upgrades as noted in preceding paragraphs.

6.2.2 *Mechanical and Plumbing*

The following are specific mechanical recommendations for the HVAC and plumbing systems necessary to correct deficiencies to effectively rehabilitate the existing building.

Preservation work, including preliminary measures to protect and stabilize the property, generally focuses on the ongoing maintenance and repair of historic materials and features, rather than extensive replacement and new construction. Since most of the building's mechanical and plumbing elements are in poor condition, are beyond repair and in need of replacement, contain asbestos, or are no longer capable of supporting the facility's mission and the science involved within the envelope, the preservation treatment approach is not recommended for mechanical or plumbing systems.

To rehabilitate the facility, major mechanical and plumbing system upgrades and replacements are necessary to meet current code requirements and support modern science needs. Specific recommendations are as follows:

- The exterior windows should be replaced with new, low emissivity (Low-E), double-pane windows. The windows should be fixed or operable where the original architecture indicated. Care should be taken to mimic the look of the original windows, but meet the current code-required thermal characteristics.
- Exterior doors should be replaced with new units that match the look of the original doors, but meet the current code-required thermal characteristics. Doors with glazing should utilize Low-E, double-paned windows. Solid doors should be internally insulated. All doors should have new weather stripping installed.
- The overall wall assembly should be enhanced and insulation installed to reach the minimum resistance (R) value of current codes. The insulation would need to be applied to the interior of the facility to maintain the exterior architectural façade.
- The existing roof assemblies should be replaced to meet the current R-30 (continuous insulation) value of the code. Roof slopes would need to be evaluated as the height of insulation above the roof deck may require the addition of height to the perimeter parapet.
- Existing steam and heating water piping should be abated and removed entirely. Existing ductwork should be evaluated and removed where necessary.
- A dedicated outdoor air system (DOAS) air-handling unit should be installed in each wing to provide code-required ventilation air to all occupied spaces. The DOAS may utilize steam and/or heating water coils, chilled water coils, and humidifiers as required to maintain environmental conditions within the spaces. Interior mechanical spaces should be utilized in lieu of roof or exterior units where possible to mimic original design intent and reduce the impact to exterior architectural features.
- The existing fan coil units conditioning each space should be evaluated for condition and replaced where necessary.
- The heating water boilers should be evaluated for need and removed if found to be deficient. The CUP is capable of supporting the facility. The existing boiler room should be re-utilized as the incoming steam reduction and heating water generation and distribution plant.
- All rooftop equipment should be evaluated and replaced if found to be deficient. Laboratory exhaust fans should be replaced with code-compliant fans and stacks.

- Roof-mounted cooling towers should be removed as possible. Process cooling loops should be created utilizing the chilled water from the CUP.
- Any remaining window-mounted air conditioners should be removed.
- Existing domestic hot water heaters should be replaced, either in-kind or with a system capable of utilizing the mechanical heating water as a source. Any galvanized iron piping in the building should be replaced with copper. New hot water circulation loops should be provided to meet code requirements. Localized point-of-use hot water heaters should be utilized where remote areas of low hot water demand are identified, reducing the amount of piping and recirculation pumping required.
- All existing plumbing fixtures (water closets, lavatories, sinks, drinking fountains) should be fitted with water-conserving automatic flush valves and faucets. The entire sanitary system should be scoped, repaired where necessary, and flushed prior to reuse.

6.2.3 *Electrical*

Rehabilitation of the Building 1's electrical systems is recommended. To rehabilitate the facility, electrical system upgrades and replacements are necessary to meet current code requirements and support modern scientific needs. Specific recommendations are as follows:

- To preserve functionality of the building, the electrical service should be upgraded to 480Y/277V service transformers. The current 280Y/120V system limits the scientific research practices. As practices have evolved, scientific equipment depends on a more reliable distribution system. Most electrical distribution equipment, conductors, and overcurrent devices are over 60 years old. Users and personnel would be provided with a greater level of safety with new equipment and distribution.
- Power metering should be added to comply with the Department of Energy, Energy Policy Act of 2005 and Executive Order 13693. Additional building and large load metering would enable the project to reach LEED goals.
- Lightning protection should be added to protect the personnel, laboratory, and office equipment, and building components.
- Upgrading the lighting systems to primarily LED and high efficacy fluorescent-based luminaires would increase the energy efficiency of the building lighting system. This upgrade would allow the system to be designed in accordance with ASHRAE 90.1 with respect to lighting power densities (LPD) and control. Local control and dimmable LED fixtures would enable the user to control the luminescence local to their area. Occupancy and vacancy sensors would provide automatic control when an area is not occupied.
- Upgrading the support structure for the telecommunication system is recommended. The fire alarm, security, and telecommunication systems should evolve to enable first responders and users to identify the local area of an alarm initiation. Greater bandwidth, speed, and data volumes should increase to meet the current demands of scientific research technology, and the security system should be upgraded to ensure the security of personnel and data.

PART 3: REFERENCES AND APPENDICES

7. References

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APPENDIX A
2016 BOULDER LABORATORIES
HISTORIC ASSESSMENT

APPENDIX B
ARCHITECTURAL DRAWINGS

APPENDIX C
PHOTOGRAPHS

APPENDIX D
PRESERVATION ZONING PLANS

APPENDIX E
PRESERVATION BRIEFS