United States Department of the Interior
National Park Service

National Register of Historic Places Continuation Sheet

National Astronomy and Ionosphere Center
Name of Property
Arecibo, Puerto Rico
County and State
070000525
NR Reference Number

State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act, as amended,

I hereby certify that this X additional documentation ___ move ___ removal
___ name change (additional documentation) ___ other

meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60.

Carlos A. Pratts August 4, 2020

Signature of Certifying Official/Title: Date of Action

National Park Service Certification

I hereby certify that this property is:

___ entered in the National Register
___ determined eligible for the National Register
___ determined not eligible for the National Register
___ removed from the National Register
__ additional documentation accepted
___ other (explain:) _____

Signature of the Keeper Date of Action

Amendment to the National Astronomy and Ionosphere Center Historic District

This nomination expands the period of significance and amends the contributing and noncontributing resources to the National Astronomy and Ionosphere Center (NAIC) Historic District, also known as Arecibo Observatory. The period of significance was previously from 1963 to 2008; this amendment extends the period to 2017, making the period of significance from 1963 to 2017. This expansion captures important scientific discoveries and upgrades completed at the property between 2008 and 2017. A total of 34 resources are now sited in the Historic District. Therefore, the resulting resource count also changes from 9 contributing and 5 noncontributing to 15 contributing and 19 noncontributing properties. No amendment to the 118-acre Historic District boundary is required.[1] Additionally, the 2008 nomination used a numbering system that differs from the system used by Arecibo Observatory. This addendum seeks to revise the numbering system to align the building numbers in the nomination with those in the system used by Arecibo Observatory. A Historic District site map is attached as Figure 1 and a U.S. Geological Survey topographic map is attached as Figure 2.

Summary

The NAIC Historic District, also known as Arecibo Observatory, was determined nationally significant and listed in the National Register of Historic Places (NRHP) in 2008 under Criterion A because of its contribution to the history of the science of ionosphere studies and the development of radio and radar astronomy in the United States. The NAIC Historic District was also listed in the NRHP under Criterion C because the district collectively represents a significant and distinguishable entity whose components may lack individual distinction. The 1963 construction of the William E. Gordon Telescope and Support Towers (305-meter-diameter radio telescope and three support towers) led to a series of significant events associated with advancements in science and education. The property has continued to operate as a scientific research and educational center. Subsequently, ongoing studies at the observatory have led to advancements of national importance in science since its nomination in 2008.

Since the 2008 nomination, important radio astronomy surveys have been carried out within the district. These significant events include important studies and discoveries, such as the timing of a pulsar in a triple system in 2013, the Galactic Arecibo L-Band Feed Array Survey in 2014, the North American Nanohertz OBS for Gravitational Waves in 2015, the discovery of the first-ever repeating fast radio burst (FRB) in 2016, and the discovery of two vanishing, or random, pulsars in 2017.[2] These discoveries contributed to the knowledge of radio astronomy, planetary science, and space science. Improved processing speeds and other physical advancements at the observatory aided these discoveries. A High Frequency (HF) Transmitter Building (Building 73) was added to the district in 2010. The William E. Gordon Telescope (305-meter-diameter radio telescope and support towers) and the HF Transmitter Building are part of the Arecibo Observatory's mixed-use instrumentation for incoherent scatter and HF studies. Modifications from 2008 to 2017 are considered contributing to the property's historic association, feeling, and setting, and the property meets Criteria Consideration G for having achieved its significance in the last 50 years. Contributing resources are considered those that house actively used instruments and scientific research activities important to discoveries carried out at Arecibo Observatory. Because of these important discoveries, the period of significance is extended from an ending date of 2008 to an ending date of 2017. Fifteen contributing resources are located within the Historic District (Table 1).

[1] A total of 47 resources are sited at the Arecibo Observatory. Thirteen resources are sited outside the Historic District boundary. One of these 13 resources, the North V.S.Q. Building (Building 57, NRHP Building 10), was recorded as noncontributing by the 2008 nomination, even though it is outside the Historic District boundaries. These 13 resources were evaluated and determined not eligible for listing in the NRHP under any criteria (Table 3).

[2] Arecibo Observatory. 2018. Discoveries: The Arecibo Observatory. Accessed June 21, 2018. http://www.naic.edu/ao/legacy-discoveries.

Table 1. NAIC Contributing Resources

Building Number [2008 Nomination]	Resource Name	Year of Construction	Location (UTM) 19 Q
N/A [N/A]	William E. Gordon Telescope and Support Towers T4, T8, and T12 (305-meter-diameter radio telescope and three support towers)	1963	737295.58 m E 2029601.43 m N
Building 1 [Building 1]	Operations Building	1963 (addition in 1983)	737395.87 m E 2030000.43 m N
Building 2 [Building 2]	Administration Building	1963 (addition in 1997)	737402.22 m E 2030059.99 m N
Building 5*	Cable Car House	1963	737414.69 m E 2029968.81 m N
Building 12 [Building 13]	Maintenance Building	1967	737579.51 m E 2030034.27 m N
Building 17 [Buildings 11 and 12]	Warehouse and Business/Purchasing	1967	737619.95 m E 2030067.19 m N
Building 27 [Building 7]	Photometry Shack and Optical Lab	1985/1997	737335.67 m E 2030029.00 m N
Building 54 [Building 5]	Visitor Center (Fundación Angel Ramos Visitor and Educational Facility)	2001 (addition 2015)	737510.00 m E 2029968.58 m N
Building 55	LIDAR Laboratory Building	1996	737322.75 m E 2030065.49 m N
Building 60	Antenna Testing Range Building	circa 1995	737316.53 m E 2030040.89 m N
Building 61 [Building 6]	Learning Center	2001	737486.00 m E 2029999.00 m N
Building 65	Shielded Trailer	1983	737422.26 m E 2030022.46 m N
Buildings 66 and 68 [Building 1A]	Atmospheric Science Trailer, and Visiting Science Trailer (counted as one building)		737389.00 m E 2030044.00 m N
Building 73	HF Transmitter Building	2009	737574.41 m E 2030011.37 m N
Building 77	Phase Reference Antenna (12-meter) and Building (counted as one structure)	2010	737597.47 m E 2030187.28 m N

*Shaded row indicates newly determined contributing resource.

The following are contributing resources within the Historic District boundary:

	Previously Listed	Newly Identified	Total
Buildings	8	5	13
Sites	0	0	0
Structures	1	1	2
Objects	0	0	0
Total	**9**	**6**	**15**

The 15 contributing resources are built with common materials, including concrete block, stucco, and metal. Some common alterations have occurred due to ongoing material maintenance. These common alterations include painting and updates to the heating, ventilation, and air conditioning (HVAC), electrical, and plumbing systems, which are required for the continued use of the resources. All contributing resources remain in continuous use. Therefore, the common alterations have not altered the historic integrity of the contributing resources, because the original 2008 NRHP nomination discussed the significance of the contributing resources in terms of use as well as design. The feeling, setting, association, location, and material integrity remain intact for all the contributing resources.

Of the contributing resources, two have more than one building or structure in their resource count: (1) the Atmospheric Science Trailer and Visiting Science Trailer (Buildings 66 and 68), and (2) the Phase Reference Antenna (12-meter) and Building (Building 77). Because the contributing resources are not considered individually eligible for listing in the NRHP unless otherwise noted, and to align the NRHP listing with the numbering system used by Arecibo Observatory, the resource count combines these resources into a single building and a structure instead of two buildings and one structure and one building, respectively. Other resources, such as the Cable Car House (Building 5) and the Shielded Trailer (Building 65), may contribute to the function of another contributing resource, but they are counted individually as a building by Arecibo Observatory. Because they are counted individually, and this addendum seeks to align the resource numbers with the numbering system at Arecibo Observatory, the resource count reflects this previously developed grouping or building count.

All of the contributing resources are significant because the William E. Gordon Telescope (305-meter-diameter radio telescope and support towers) would not be able to operate without the support of many functions performed within these resources. The resources are instruments, contain important instruments, or house activities associated with important advancements in scientific research and education. The contributing resources are not considered significant for architecture, design, engineering, materials, or workmanship, but instead, their importance is their association with the use of the property for scientific research and education. The William E. Gordon Telescope (305-meter-diameter radio telescope and support towers) is the exception, as it is considered significant for engineering. All other contributing resources are utilitarian in design and feature common material types such as concrete blocks with parged concrete exteriors. Most buildings feature rectangular or square plans with flat roofs. The Visitor Center (Fundación Angel Ramos Visitor and Educational Facility, Building 54) and the Learning Center (Building 61) are two buildings that differ in plan more than the other contributing resources. These two resources may be visually interesting for their architecture, but their architecture does not necessarily rise to the level of individual importance, and as a result, they are eligible only as contributing resources to the district.

Some of the resources may also be important for their engineering activities, such as the LIDAR Laboratory

Building (Building 55), HF Transmitter Building (Building 73), or the Phase Reference Antenna (23-meter) and Building (Building 77). However, these resources have not reached the same level of achievement for their engineering design as the William E. Gordon Telescope (305-meter-diameter radio telescope and support towers). These resources were not the first of their type, or they may have been relocated from another location. These resources, while important, are significant for their association with scientific research and education activities completed at Arecibo Observatory.

Typically, properties that have achieved significance within the past 50 years shall not be considered eligible for the NRHP. However, such properties will qualify if they are integral parts of districts that have achieved significance of exceptional importance within the past 50 years. In this case, at the time of NRHP listing, the NAIC Historic District had achieved significance of exceptional importance within the past 50 years due to the engineering of the William E. Gordon Telescope (305-meter-diameter radio telescope and support towers [T4, T8, and T12]), as well as several notable scientific discoveries in the atmospheric sciences, astronomy, and physics that have occurred in the last 50 years. The NAIC Historic District is significant for its association with science and education under Criterion A, and the property is eligible under Criterion C because the Historic District represents a significant and distinguishable entity whose components lack individual distinction. The NAIC Historic District was determined to be eligible for listing on the NRHP based on Criteria Consideration G, as many of the contributing resources gained significance within the last 50 years.

Contributing Resources

The contributing resources described in this section are added to the NAIC Historic District through this amendment.

Photo 1. Cable Car House (Building 5), above, facing south, and below, facing northeast.

Building 5, Cable Car House

The Cable Car House is a one-story concrete-block building with a rectangular plan and a shed roof (Photo 1). The shed roof features an open rake design with a slight overhang. The roof is covered by rolled asphalt. The building is sited on a slope and built at grade. The building has a front patio on the north elevation. The patio is covered by a corrugated metal shed roof that extends from the front elevation of the main building. The patio roof rests on metal posts and beam. The patio roof support posts rest on a concrete-block retaining wall that runs along the front (north) and side (east) elevations. There are no windows on the building, although the rear (south) elevation features an open bay near the roofline. The open bay serves as an access point for the cable or rigging to enter the building. The open bay is above another opening that serves as an access point for riders to enter the cable car. The cable car meets the exterior of the building. There is a one bay projection with a shed roof directly next to the cable car entry point on the rear (south) elevation near the side (east). A small, metal-louver-covered opening is found on the rear (south) elevation of the one-bay projection. The foundation is concrete block.

Built in 1963 as part of the original site design, the Cable Car House is located near the Operations Building (Building 1) and the Lewis Building-Rigging Loft (Building 11). Based on historical drawings and site plans, the building does not appear to have any additions or substantial alterations.[3] The patio roof is an addition that does not detract from the overall original form or use. The Cable Car House is essential to the maintenance and access of the platform of the William E. Gordon Telescope (305-meter-diameter radio telescope and support towers). The Cable Car House is not a location where scientific discovery occurs; however, the building provides a key function in the maintenance and use of the instrument. The building may be considered an accessory building to the William E. Gordon Telescope (305-meter-diameter radio telescope and support towers).

Photo 2. LIDAR Laboratory Building (Building 55), above, facing west, and below, facing southwest.

Building 55, LIDAR Laboratory Building

The LIDAR Laboratory Building is a one-story concrete-block building with a one-bay shed addition and ancillary equipment inside a fenced compound (Photo 2). The LIDAR Laboratory was built in 1996 after the original airglow laboratory, known as the Optical Labs (Building 7), because of upgrades in the instrumentation used for observations of the upper atmosphere.[4] The concrete block building features a parged concrete exterior. It has a rectangular plan with two double-leaf metal doors on the front (south) elevation. A shed roof and stoop porch provide access to each of the double-leaf doors on the front (south) elevation. The roof is flat; however, near the front half of the building, there are four gable roofs. The gables are corrugated metal structures placed on the rooftop to provide additional overhead space for the instruments housed within the building. The rear (north) elevation features an overhead door made accessible by a poured concrete slab. Metal handrailing runs along the roofline. A metal staircase is found on the side (west) elevation that provides access to the roof. The foundation is a poured concrete slab.

The use of the LIDAR Laboratory Building is to house LIDAR that is fully pointable and primarily used to measure the neutral winds and the temperatures of the middle atmosphere. Arecibo Observatory has expanded its studies over time from the study of the upper ionosphere to include study from the ground to upper space.[5] LIDAR serves as a tool to provide better understanding of how human agriculture and technology impact the

[3] Arecibo Observatory. 1972. Site plans for the Cable Car House (Building 5). Available at the Arecibo Observatory, Engineering and Maintenance Office, Warehouse.
[4] Isham, B., C.A. Tepley, M.P. Sulzer, and Q.H. Zhou. 2000. "Upper atmospheric observations at the Arecibo Observatory: Examples obtained using new capabilities." *Journal of Geophysical Research*. Volume 105. Number A8. Pages 18,609-18,637. August 1. Accessed June 26, 2018. https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/1999JA900315.
[5] Cho, J. Y. N. and B. Isham. 1997. Panel 1: Arecibo Observatory Atmospheric Sciences: Introduction and Atmospheric Change and Panel 3: Arecibo Observatory Atmospheric Sciences: Clouds and Plasma. Arecibo Observatory, Arecibo, Puerto Rico. March. Accessed June 26, 2018. http://web.mit.edu/jync/www/aoexhibit.html.

atmosphere.[6] Optical observations at Arecibo Observatory began in 1967 using a photometer, and by 1968, a Fabry-Perot interferometer was used at Arecibo Observatory.[7] By the early 1990s, "Arecibo scientists also study the atmosphere using optical radars known as LIDARs. A LIDAR works almost exactly like a radar—the difference is that pulses of light instead of radio pulses are used. This difference can be seen in their names: RADAR stands for Radio Detection and Ranging, while LIDAR stands for Light Detection and Ranging. LIDAR can measure atmospheric density, temperature, winds, as well as dust and pollutants. The extraterrestrial metal atoms deposited in the upper atmosphere by meteors can also be observed by the Arecibo LIDAR."[8]

The use of LIDAR at Arecibo Observatory is further discussed:

> At Arecibo we have a variety of airglow and LIDAR [LIDAR] instrumentation. […] The "active" optical instruments (LIDARs) have the capability to monitor the upper stratosphere to lower thermosphere. We have three systems, two of which are configurable to monitor one each of the meteoric metals: Na, Fe, Ca, or Ca+. Alternatively, one of the two metal LIDARs [LIDAR] can be configured as a Rayleigh LIDAR to measure temperature from the upper stratosphere to the mesosphere, from about 35 to 70 km. The third LIDAR [LIDAR] is a Doppler-resonance LIDAR [LIDAR] that measures temperatures within the metal layer by sensing the Doppler broadening in the D1 resonance line of K.[9]

The LIDAR Laboratory Building is near the Antenna Testing Range Building (Building 60). Based on observation, the building appears to have had one metal shed addition but no other substantial alterations. The addition does not detract from the overall original form or use. The building was constructed during the period of significance for the NAIC Historic District. The instruments within the building are essential to educational and scientific uses of the historic property. The LIDAR Laboratory Building is a location where scientific discovery occurs, and the building houses a key function in the continued scientific use of the NAIC Historic District.

Photo 3. Antenna Testing Range (Building 60), facing northwest.

Building 60, Antenna Testing Range Building

The Antenna Testing Range Building is a one-story concrete block building with a one-bay metal shed addition (Photo 3). The building has a flat roof with closed soffits and overhanging eaves. The front (north) elevation features an overhead door accessed by poured-concrete stairs. The stairs are oriented to the side from west to east and feature a metal handrail. A single-leaf metal door is located on the side (west) elevation and accessed by poured-concrete stairs. The stairs are oriented from north to south and feature a metal handrail. A ladder is located behind the side entrance.

[6] ibid.
[7] Isham et al., 2000.
[8] ibid.
[9] National Astronomy and Ionosphere Center (NAIC). 2016. Arecibo Call for Ionospheric Modification (HF facility) Proposals: Thursday, August 12, 2016 Deadline. Accessed June 26, 2018. http://www.naic.edu/~astro/call_hf16_top.shtml.

The one-bay metal shed addition is located on the side (east) elevation. The addition is composed of corrugated metal and features a low-pitched shed roof of the same material. The addition is recessed from the front (south) elevation.

Built circa 1995, the Antenna Testing Range Building is the second of such buildings at Arecibo Observatory. The new Antenna Testing Range Building replaced the use of the original Antenna Testing Range Building (still extant as Building 21 and now used to house a deionization system). The Antenna Testing Range Building (Building 60) is located to the north of the LIDAR Laboratory Building (Building 55). The building has a single-bay shed addition with no other substantial alterations. The single-bay shed addition does not detract from the overall original form or use. The building supports educational aspects of Arecibo Observatory and research uses of the William E. Gordon Telescope (305-meter-diameter radio telescope and support towers). The Antenna Testing Range Building was built within the period of significance for the NAIC Historic District, and the building supports the educational and scientific use of the historic property.

Photo 4. Shielded Trailer (Building 65), facing southwest.

Building 65, Shielded Trailer

The Shielded Trailer (Photo 4) is placed through an opening in the wall of the Operations Building (Building 1). The trailer, like some vehicles at Arecibo Observatory, is shielded so that electromagnetic emissions from instrumentation within the trailer do not interfere when the William E. Gordon Telescope (305-meter-diameter radio telescope and support towers) is operational. The trailer is next to transformers. The trailer does not demonstrate a remarkable building type or method of construction; however, temporary spaces, like trailers, tend to be used long-term at Arecibo Observatory. Because use is a contributing factor to the significance of the NAIC Historic District, the use of the Shielded Trailer was evaluated. The Shielded Trailer provided space for necessary instrumentation and equipment utilized for significant scientific activities that occurred at the historic property during the designated period of significance.

Sited at the location in 1983, the Shielded Trailer is located on the side (east) elevation of the Operations Building (Building 1). Based on observation, the trailer does not appear to have had any additions or substantial alterations. The instrumentation in the Shielded Trailer is essential to the activities undertaken within the Operations Building (Building 1) to support the William E. Gordon Telescope (305-meter-diameter radio telescope and support towers). The Shielded Trailer was sited at the property during the period of significance, and it is a location that supports that facilitation of scientific discoveries and is a contributing resource to the NAIC Historic District. The trailer may be considered an accessory building to the Operations Building (Building 1).

Building 73, HF Transmitter Building

Photo 5. HF Transmitter Building (Building 73), facing northeast.

Built in 2010 as part of upgrades to increase research capability, the HF Transmitter Building (Photo 5) is located near the Maintenance and Engineering Buildings (Building 17 and 79), just north of the 305-meter-diameter reflector dish. The HF Transmitter Building is a one-story Quonset hut building with an attached one-story concrete block wing. The building has an L-plan. The Quonset hut is oriented east to west, while the one-story concrete block wing extends from the side (south) elevation of the hut near the rear (west) elevation. The Quonset hut has an arch design with overhead door on the front (east) elevation. A single-leaf metal door is located just north of the overhead door. A concrete ramp runs from east to west toward the overhead door. A small ramp extends to the north, which provides access to the single-leaf door. The ramp features a metal handrail. The Quonset hut has a poured-concrete slab foundation. Twelve 3-inch coaxial lines feed the individual antenna elements, totaling 1,500-feet in length. The coaxial lines extend from the side (south) roof. Six transmitters and associated equipment are located inside the Quonset hut. "Another important instrument at Arecibo is the HF facility, which is an upward-pointing shortwave radio transmitter used to study plasma waves and turbulence in the Ionosphere."[10] Michael P. Sulzer, Head of the Ionospheric Modifications Group, further discusses the original plan for the HF Transmitter Building:

> The problem of illuminating the Arecibo 300 m dish was solved in the 1970s by hanging first a dipole antenna and later a long periodic antenna from the central area of the azimuth arm. This approach somewhat blocked the area, added undesirable weight to the structure, and did not provide optimum illumination. The new HF facility, now under construction and to be completed next year, uses a very different approach. For each of two frequency bands, there is a set of three crossed dipoles located relatively near the surface of the dish. The dish acts as a reflector for each of these dipoles. They transmit to a reflecting screen that is supported from the three main towers and hangs below the astronomy and radar feeds supported from the platform above. Modeling results give an expected antenna gain of about 25.5 db at 8.175 MHz. A building has been constructed for six transmitters, which were originally used in the Maine Over-the-Horizon Radar Facility. Each of these transmitters has a maximum power of 100 KW, and it will be possible to transmit various modulated waveforms. The effective radiate power will thus be greater than 150 MW. The power at 5.1 MHz will be about 80 MW. The transmitters have been installed in the building. There are three main tasks underway which must be completed before the transmitters can be used. These are electrical power input, the rf transmission line system, and the cooling systems, air and water. The electrical power will be supplied by generators which will replace the observatory's aging turbine. These are expected to be available at the end of February. The dipole antennas and the reflecting screen have been designed and are in the process of bidding for construction. Also, a control system will be built to allow the certain transmitter parameters to be set from the observatory control room to allow coordinated experiments with the radar. The dipole antennas are to be constructed in a manner that will allow their length to be modified so that the frequency band can be shifted somewhat by constructing

[10] ibid.

> different length sections. The [impedance] matching is designed so that loading networks can be added to give additional degrees of freedom to match the new impedance at the altered frequency. We plan for the facility to be ready for use in the coming year.[11]

Ultimately, the "HF facility started operations in November 2015. Three successful campaigns have been performed, totaling more than 20 experiments. The HF facility consists of six 100 kW transmitters that feed two sets of three crossed dipoles, centered at 5.1 [megahertz] MHz or 8.175 MHz. The antenna elements transmit a high-frequency (HF) electromagnetic radio beam that illuminates the 305 m Arecibo dish using a Cassegrain feed. For the 8.175 (5.1) MHz, the obtained gain is 25.5 (22) dB, and the HPBW is 8.5 (13) degrees."[12]

Alfredo Santoni, a transmitter engineer who works in the HF facility, escorted the transmitters from Alaska, where they were shipped after the Over-the-Horizon Radar Facility in Moscow, Maine, was dismantled in 2005. The Over-the-Horizon Backscatter Radar was described as the world's largest radar, which was developed by the U.S. Air Force over 25 years for $1.5 billion and occupied an area nearly double the area covered by New York's Central Park.[13] The radar was designed to monitor Cold War threats nearly 2,000 miles away, until the U.S. Air Force divested the "outdated warhead silos and other relics of the arms race."[14] The transmitters were repurposed by Arecibo Observatory to study the ionosphere.

By 2010, the HF Transmitter Building was sited at a location where a paint storage building was previously sited. Inside the building, each transmitter is patched identically to aid efficiency when troubleshooting. Generators channel a total of 150 megawatts (MW) to power the transmitters. To better understand the scale of a MW, a single MW from a coal-powered plant can generally power 650 homes.[15] Chilled water is piped into radiant tubes to cool the equipment. The control room features a board with a model of the antenna so that operators can easily know the source of potential concerns. Filters are used to clean up any harmonic frequencies found in feeds, which are problematic for testing. The one-story, concrete-block building next to the Quonset hut that houses the six transmitters functions as the control room. The concrete-block building has a flat roof with closed soffit and overhanging eaves. The exterior of the concrete-block building is covered with parged concrete. Windows on the front (north) and rear (south) elevations feature metal-louver shutters. A single-leaf metal door is located on the front (north) elevation next to a single window. The foundation is a poured-concrete slab. Inside the concrete-block building, operators monitor the transmittal feed and make necessary adjustments.

The HF Transmitter Building continues work that began with the first HF radio wave ionospheric interaction experiments in 1971 using an HF feed mounted above the 305-meter-diameter reflector dish, which led in the late 1970s to a dedicated high-power HF transmitting facility in Islote, Puerto Rico, that no longer exists.[16] As stated by Isham and others, "Although Arecibo does not operate the only such high-frequency transmitter facility, nor the only one located near an incoherent scatter radar, it is uniquely situated under the relatively smooth

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[11] Sulzer, M.P. 2009. The new Arecibo HF facility: Design, Construction, and Approaching Scientific Use. American Geophysical Union, Fall Meeting 2009, abstract id.SA11B-03. December. Accessed June 26, 2018. http://adsabs.harvard.edu/abs/2009AGUFMSA11B..03S.

[12] Nossa, Eliana, Christiano Garnett Marques Brum, Michael P. Sulzer, Alfredo Santoni, Phil Perillat, Luis Quintero, and Felix Fernandez. 2018. Arecibo Observatory—HF Facility. TESS Triennial Earth-Sun Summit. May 20-24. Leesburg, Virginia. Abstract. Accessed July 3, 2018. https://agu.confex.com/agu/2018tess/preliminaryview.cgi/Paper334784.html.

[13] Associated Press. 2005. "Maine's Cold War-era radar system being scrapped." *The Boston Globe.* February 21. Accessed June 26, 2018. http://archive.boston.com/news/local/articles/2005/02/21/maines_cold_war_era_radar_system_being_scrapped/.

[14] ibid.

[15] Eskom. 2015. Fact Sheet: What is a Megawatt. March. http://www.eskom.co.za/AboutElectricity/FactsFigures/Documents/GI_0097WhatIsMegawatt.pdf.

[16] Isham et al., 2000

midlatitude bottom side F region. This, in conjunction with the sensitivity of the 430-MHz incoherent scatter radar and the extensive instrument cluster, allows studies to be performed at Arecibo that are not possible elsewhere."[17] The building has not undergone any alterations since original construction. The HF Transmitter Building is essential to the use of the William E. Gordon Telescope (305-meter-diameter radio telescope and support towers) for HF testing. The HF Transmitter Building was built within the extended period of significance for the NAIC Historic District. The building is a location where scientific discovery occurs because the building serves a key function in the use of the 305-meter-diameter reflector dish for research activities, leading to the advancement of understanding of the ionosphere.

Building 77 and the Phase Reference Antenna (12-meter)

In 2010, the Phase Reference Antenna (12-meter) was added to support Very Long Baseline Interferometry (VLBI) studies (Photo 6). Arecibo Observatory joined the VLBI network in the late 1990s as part of the Highly Advanced Laboratory for Communications and Astronomy (HALCA) mission of the Japanese VLBI Space Observatory Project (VSOP).[18] The Phase Reference Antenna has a 12-meter-diameter dish set on a squat steel column with an attached metal ladder. The column is welded onto a plate on top of a poured-concrete slab.

Photo 6. Phase Reference Antenna (12-meter), facing south.

Photo 7. Building 77, facing south

The building is a one-story concrete-block building (Photo 7). The rectangular plan building has a flat roof with closed soffits and overhanging eaves. The building exterior is covered with parged concrete. A double-leaf metal panel door is located on the front (east) elevation. The side (north) elevation has a small, metal-louver window. The foundation is a poured-concrete slab. The material condition is good.

Built in 2010, the Phase Reference Antenna (12-meter) and Building 77 are located northeast of the William E. Gordon Telescope (305-meter-diameter radio telescope and support towers) on a steep embankment. The antenna and building are accessed by a secured road just outside the Entrance Guard House (Building 4) and parking lot. The building is built onto the north side of the embankment below the 12-meter antenna. Based on observation, the antenna and building do not appear to have had any additions or substantial alterations. The Phase Reference Antenna (12-meter) and Building 77 were built within the extended period of significance for the NAIC Historic District. The Phase Reference Antenna (12-meter) and building are essential to the activities undertaken as part of the scientific research associated with the property. The building may be considered an accessory to the Phase Reference Antenna (12-meter). Because the building is not individually considered contributing, and the antenna and its building are

[17] ibid.
[18] National Astronomy and Ionosphere Center (NAIC). 2013. Very Long Baseline Interferometry (VLBI) at Arecibo. NAIC. Accessed June 27, 2018. http://www.naic.edu/~astro/aovlbi/.

labeled as Building 77 by Arecibo Observatory, Building 77 and the Phase Reference Antenna (12-meter) are counted as one structure in this addendum.

Upgrading Arecibo Observatory

Since the 2008 nomination, the HF Transmitter Building (Building 73) and Phase Reference Antenna (12-meter) and Building 77 were added to Arecibo Observatory in 2010.[19] The HF Transmitter Building (Building 73) is a metal Quonset hut building with a concrete-block wing was constructed to house high frequency transmitters and an operations room. The HF facility expanded Arecibo Observatory's capacity for ionospheric modification by high frequency and incoherent scatter radar.[20] This allows atmospheric scientists to enhance plasma and ion lines in the ionosphere to better understand natural plasma density irregularities, specifically layers and holes in the upper atmosphere.[21] The new facility added to the overall function of Arecibo Observatory, which includes the radio telescope with six receivers, four transmitters, and other extensive instrumentation.[22] The Phase Reference Antenna (12-meter) and Building 77 were added to improve efficiency of VLBI observations.[23] This addition followed an initial structural problem with the William E. Gordon Telescope (305-meter radio telescope) and the ALFA 7-horn array.[24] "Phase referencing in Very Long Baseline Interferometry (VLBI) observations has made it possible to study very weak radio sources by increasing the effective coherence time for them from, at maximum, a few minutes to hours (Wrobel et al., VLBA Sci. Memo 24). Currently, some 50 percent of VLBI observations are carried out using the phase-referencing technique."[25]

Previous updates included the reflector dish surface upgrade in 1973, and the addition of high-power lasers or LIDAR for studies of the middle and upper atmosphere in 1995. [26] In 1997 extensive updates included the addition of the Gregorian dome and ground-screen, upgrading the S-band transmitter to a 1-MW system, and constructing the Visitor Center. In 2004, ALFA, a radio camera for broad coverage and images, was completed to help map the sky.[27]

Scientific Achievements from 2008 to 2017

Since 2008, additional significant events or discoveries have occurred at the NAIC Historic District (Arecibo Observatory). The contributing resources are associated with these significant scientific discoveries, as they were either part of instrumentation used during the studies or they housed the research activities that led to the discoveries. Three core scientific research areas are completed at Arecibo Observatory: astronomy, planetary science, and space science.[28] This research directly applies to four identified natural threats: gamma ray bursts, asteroid or comet impact, space weather, and global climate change.[29] Most often the initial studies that lead to

[19] Arecibo Observatory. 2015. *Large Facility Workshop.* May 12. SRI. UMET. USRA. Accessed March 7, 2019. https://www.nsf.gov/attachments/134059/public/15LFW_WelcometoAreciboObservatory_KerrR.pdf.
[20] Nossa, Eliana. 2017. *The Arecibo Observatory – HF facility.* SRI International. USRA. UMET. Accessed March 7, 2019. http://cedarweb.vsp.ucar.edu/wiki/images/e/e4/ElianaNossa-AO-HFStatusJuly2017.pdf.
[21] ibid.
[22] ibid.
[23] Campbell, Donald. B. 2011. "Arecibo Observatory Report." *XXXth URSI General Assembly and Scientific Symposium.* August 13-20. Accessed March 18, 2019. https://ieeexplore.ieee.org/document/6051231.
[24] ibid.
[25] NAIC. N.D. "HAAT: the Humancao-Arecibo Astrometric Telescope." Proposal. Accessed March 18, 2019. http://www.naic.edu/~tghosh/haat/humacao_paare_old.doc.
[26] Santos, Juan Llanes. 2007. National Astronomy and Ionosphere Center (Arecibo Observatory). National Register of Historic Places Continuation Sheet. Prepared by the Puerto Rico State Historic Preservation Office for the U.S. Department of the Interior, National Park Service. March 20.
[27] Arecibo Observatory, 2015.
[28] ibid.
[29] ibid.

discoveries often occur years, or decades, prior to the published discovery. This addendum uses the recognized discovery date as published by Arecibo Observatory. This list of discoveries is not inclusive of all scholarly surveys or studies conducted at Arecibo Observatory with credible findings, but it is limited to those discoveries deemed nationally important by leaders in their respective field of science. Since the 2008 nomination, the discoveries made leading up to, and including, 2017 are as follows:

- Timing of a pulsar in a triple system (2013)
  - Important to astronomy and physics
  - The North American Nanohertz Observatory for Gravitational Waves (NANOGrav) Collaboration used telescopes from the Arecibo and Green Bank Observatories and millisecond pulsars to directly measure how gravitational waves impact the forces on an object in distance and time. [30] This further allows scientists to test a concept called the Equivalence Principle. The principle states that the effect of gravity on a body does not depend on the nature or internal structure of that body.[31] Founded in 2007, NANOGrav is a consortium of astronomers in North American, who are partnered with European and Australian astronomers, to create a galactic scale gravitational wave observatory sensitive to gravitational waves.[32] Gravitational waves are part of Einstein's general theory of relativity that describes the space-time dynamics from matter in motion.[33] Pulsar timing array provides the ability to observe supermassive black hole binaries following galactic mergers, or other early universe phenomena such as inflation, with the ultimate potential to revolutionize how the universe is viewed.[34]
- Comet 209P/Linear became the fourth (of seven) comets to have its nucleus, or the solid center part that is composed of rock, dust, and frozen gases, imaged from Earth (2014)
  - Important to planetary science
  - Researchers at Arecibo Observatory took radar images of the comet.[35] The comet was the third nearest orbit of any comet in two centuries.[36] Arecibo Observatory used its radio telescope like a radar gun to shoot pulses at the comet.[37] Imaging with radio telescopes is an active technique that requires the antenna to broadcast a signal at the object and then receive the reflected signal that bounces off the object.[38] The time it takes for the signal to bounce can be measured by the speed of light, and the distance between the two points can be measured.[39] The points are put together to form a map of the object. Arecibo Observatory was able to take advantage of this closeup image because the comet passed so near the

[30] Arecibo Observatory. 2012. Annual Astronomy Report. Accessed March 7, 2019. http://www.naic.edu/~astro/reports/Arecibo_Observatory_Annual_Astronomy_Report_2012.pdf.
[31] Ransom, Scott. M. 2014. "A millisecond pulsar in a stellar triple system." January 5. *Nature*. Accessed March 7, 2019. https://newsroom.usra.edu/pulsar-in-a-stellar-triple-system-makes-unique-gravitational-laboratory/.
[32] Jenet et al. 2009. "The North American Nanohertz Observatory for Gravitational Waves." *Cornell University.* Accessed March 16, 2019. https://arxiv.org/abs/0909.1058.
[33] Ibid.
[34] Ibid.
[35] Universe Today. 2014. "New Arecibo Radar Images Show Comet Responsible for Camelopardalis is an Icy, Cratered Mini World." May 30. Accessed March 7, 2019. https://www.universetoday.com/tag/comet-209plinear/.
[36] Schleicher, David G. and Matthew M. Knight. 2016. "The Extremely Low Activity Comet 209P/LINEAR During its Extraordinary Close Approach in 2014."
[37] Plait, Phil. 2014. "Arecibo Pings a Comet." *Slate.* Accessed March 15, 2019. https://slate.com/technology/2014/06/comet-209p-linear-radar-observations-show-it-was-bigger-than-expected.html.
[38] Lakdawalla, Emily. 2011. "How radio telescopes get "images" of asteroids." The Planetary Society. Accessed March 15, 2019. http://www.planetary.org/blogs/emily-lakdawalla/2011/3248.html.
[39] Ibid.

Earth. Details were visible, such as the comet's nucleus, that would otherwise be less distinct or unrecognizable due to what typically would be a large distance.

- Galactic Arecibo L-Band Feed Array (GALFA) Survey (2014)
  - Important to astronomy and physics
  - Studied how hydrogen enters the Milky Way to form new stars.[40] Revealed slender structures in interstellar space that are aligned with dust polarization and the magnetic field. The survey was built on work that began in 2004 when the Arecibo L-Band Feed Array (ALFA) was installed onto the 305-meter radio telescope.[41] The ALFA can monitor seven positions at once, whereas its predecessor, the L-Band wide receiver, could cover only one.[42] Because of the increased mapping efficiency, different science teams came together to consider the next generation of high-fidelity, high-resolution sky atlases.[43] The GALFA consortium, which consists of three independent groups, arose out of that discussion and is divided by what each group studies: radio recombination lines (GALFA-RRL), continuum radiation (GALFACTS), and the 21-centimeter line transition of Galactic neutral hydrogen (HI) (GALFA-HI).[44] The GALFA-HI survey studied a broad range of tops under the umbrella of the neutral hydrogen and the Galactic interstellar medium (ISM).[45] High-resolution data from the GALFA-HI survey was used to show that the linear structure in HI correlates with the magnetic field, or that the structure of a neutral ISM is more closely related to the magnetic field than previously known.[46] This discovery provided a new tool in the search for inflationary gravitational wave B-mode polarization in the cosmic microwave background, or the theory of inflation in the universe.[47] Inflation is thought to be the period of extreme expansion that occurs during the first few moments of a universe, or the Big Bang; it then expands relatively gradually over time.[48]
- Discovery of the first-ever repeating FRB (2016)
  - Important to astronomy and physics
  - FRB 121102 was discovered on November 2, 2012, at Arecibo and Green Bank Observatories, and it has been seen to repeat more than 150 times since its discovery.[49] FRBs were first identified in 2007 using archival data from 2001.[50] The discovery was possible because of advances in computing hardware, software and data processing.[51] "FRB 121102 was found to repeat and is the only known FRB source to

[40] Putnam, Mary E. and Snezana Stanimirovic. 2012. *The Galactic Arecibo L-Band Feed Array HI (GALFA-HI) Survey*. Proposal A2763. Arecibo Observatory. Accessed March 7, 2019. http://www.naic.edu/vscience/schedule/2013Spring/PutmantagA2763.pdf.
[41] Peek et al. 2009. "The GALFA- HI Survey: Data Release 1." *APJS.* November 1. Accessed March 16, 2019. https://arxiv.org/pdf/1101.1879.pdf.
[42] Ibid.
[43] Ibid.
[44] Ibid.
[45] Ibid.
[46] Clark et al. 2015. "Neutral hydrogen structures trace dust polarization angle: Implications for cosmic microwave background foregrounds." Phys. Rev. Lett. 115, 241392. Accessed March 16, 2019. https://arxiv.org/abs/1508.07005.
[47] Ibid.
[48] NASA. 2010. Inflation Theory. Website. Accessed March 16, 2019. https://wmap.gsfc.nasa.gov/universe/bb_cosmo_infl.html.
[49] Klesman, Alison. "The Single Strange Repeating Fast Radio Burst is at it Again." *Astronomy.* Accessed March 7, 2019. http://www.astronomy.com/news/2017/09/15-new-bursts-from-frb-repeater.
[50] USRA. 2018. "Astronomers peer into a lair of mysterious source of comic radio bursts." USRA. Website. Accessed March 15, 2019. https://newsroom.usra.edu/astronomers-peer-into-a-lair-of-a-mysterious-source-of-cosmic-radio-bursts/.
[51] Chatterjee, Shami. 2017. "Focus on Repeating Fast Radio Burst 121102." *The Astrophysical Journal Letters.* Accessed March 7, 2019. https://iopscience.iop.org/journal/2041-8205/page/Focus_on_FRB_121102.

do so," noted Dr. Andrew Seymour, Universities Space Research Association (USRA) postdoctoral researcher at Arecibo Observatory.[52] The burst originated from beyond the Milky Way galaxy at a distance of 3 billion light years from Earth.[53] For a burst, which only lasted a few seconds, to reach the Earth, it would have required 100 million times the energy produced by the Sun in a day.[54] In January 2018, Arecibo Observatory announced that the FRBs likely originated from bursts from a neutron star in an extreme environment of magnetized plasma, possibly from near a giant black hole, or one embedded in a powerful nebula. The studies were conducted at high frequencies at Arecibo and Green Bank Observatories, which confirmed this new information.[55]

- Discovery of vanishing or random pulsars (2017)
  - Important to astronomy and physics
  - A pair of intermittent pulsars, or rapidly rotating, highly magnetized neutron stars, shifted a widely shared belief that pulsars are constant, like clockwork. Dr. Andrew Seymour, USRA, as part of a 34-person team, used the 7-beam receiver to carry out the Pulsar Arecibo L-Band Feed Array Survey (PALFA) to discover the two intermittent pulsars.[56] The pulsars were discovered at Arecibo Observatory and then observed over several years at Jodrell Bank Observatory in Manchester, United Kingdom.[57] The discovery is important to further understand the physical mechanisms that cause intermittency.[58]

Noncontributing Resources

A noncontributing resource is considered to lack direct association with the scientific research and educational activities at the NAIC Historic District. Noncontributing resources to the Historic District function as residential, general operations, or utility structures. Noncontributing resources may share similarities of age, design, material, and workmanship with contributing resources, but they do not contain actively used instruments or house research activities. This amendment increased the noncontributing resource count from 5 to 19. The 2008 nomination evaluated 13 architectural resources within the Historic District, 5 of which were determined not to contribute to the Historic District. However, this addendum accounts for all 34 architectural resources within the Historic District boundary: 15 contributing and 19 noncontributing resources. Noncontributing resources within the boundaries are listed in Table 2. The North V.S.Q. Building (Building 57, NRHP Building 10) was recorded as a noncontributing resource in the 2008 nomination, but it is now correctly attributed as being outside the Historic District boundaries.

[52] USRA, 2018.
[53] Ibid.
[54] Ibid.
[55] Ibid.
[56] Verschuur, Gerrit, and Joan Schmelz. 2017. The Mystery of Part Time Pulsars. July 18. Arecibo Observatory. Accessed March 7, 2019. https://www.naic.edu/ao/blog/mystery-part-time-pulsars.
[57] Lyne, A.G., B.W. Stappers, P.C.C. Freire, J. W. T. Hessels, V.M. Kaspi. B. Allen, S. Bogdanov, A. Brazier, F. Camilo, and F. Cardoso. 2017. "Two long-term intermittent pulsars discovered in the PALFA Survey." *The Astrophysical Journal*. Volume 835. Number 1. Accessed March 16, 2019. https://iopscience.iop.org/article/10.3847/1538-4357/834/1/72.
[58] Ibid.

Table 2. Noncontributing Resources

Building Number [2008 Nomination]	Resource Name	Year(s) of Construction	Location (UTM) 19 Q
Building 3 [NRHP Building 3]	Visiting Scientist Quarters and Cafeteria	1963	737412.93 m E 2030111.70 m N
Building 6*	Pump House/Water Treatment Building	1963, 2010	737380.71 m E 2030056.63 m N
Building 10 [NRHP Building 4]	Swimming Pool/Restrooms	c. 1965	737438.92 m E 2030166.43 m N
Building 11	Lewis Building – Rigging Loft	c. 1965	737426.58 m E 2029947.82 m N
Building 13	Bowl Shack	1963	737454.41 m E 2029738.15 m N
Building 21	Antenna Testing Range	c. 1985	737489.00 m E 2029968.00 m N
Building 25	Paint Storage Building	c. 2010	737657.08 m E 2030068.49 m N
Building 34	High Voltage Power Supply Building	1973	737462.00 m E 2030002.00 m N
Building 35	Cummins Generator Control Building	2010	737677.55 m E 2030041.40 m N
Buildings 41, 42 [NRHP Building 8]	West Hill V.S.Q. Bachelor Unit 1 and 2	c. 1970s	737366.79 m E 2030174.00 m N
Buildings 43, 44 [NRHP Building 9]	West Hill V.S.Q. Family Unit 1 and 2	c. 1970s	737394.31 m E 2030288.22 m N
Building 50	Interference Monitoring Shack	1992	737338.66 m E 2029971.25 m N
Building 51	Grease Pit	Not extant	737580.48 m E 2030071.21 m N
Building 53	Emergency Generator Building	1992	737468.00 m E 2030024.00 m N
Building 67	Cryogenics Lab Trailer	1967	737601.00 m E 2030032.00 m N
Building 76	Visitor Center Trailer (Inspiration for Science)	2016	737490.63 m E 2030034.58 m N
Building 78	Coffee Hut	2002	737507.00 m E 2030047.00 m N
Building 79	Engineering Office Building	2010	737649.00 m E 2030034.00 m N
Building 80	Cummins Diesel Generator Building	2010	737693.92 m E 2030025.25 m N

*Shaded row indicates newly determined noncontributing resource.

The following are noncontributing resources within the Historic District boundary:

	Previously Identified	Newly Identified	Total
Buildings	3	14	17
Sites	0	1	1
Structures	1	0	1
Objects	0	0	0
Total	**4**	**15**	**19**

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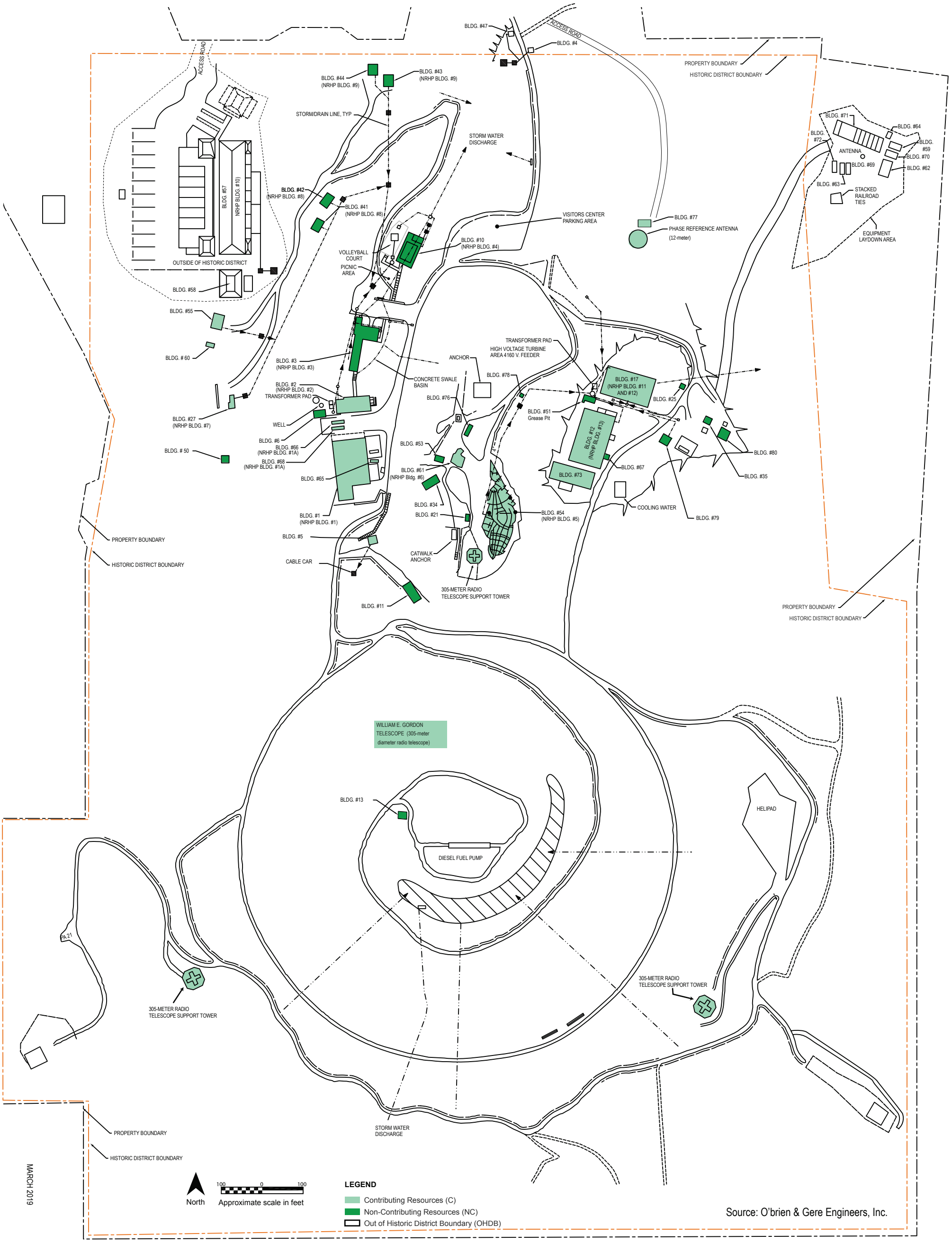

BUILDING NO. DESCRIPTION

WILLIAM E. GORDON TELESCOPE AND SUPPORT TOWERS (305M diameter radio telescope) (1963) - C

1. OPERATIONS BUILDING (1963) - C
2. ADMINISTRATION BUILDING (1963) - C
3. VISITING SCIENTIST QUARTERS AND CAFETERIA (1963) - NC
4. ENTRANCE GUARD HOUSE (1963) - OHDB
5. CABLE CAR HOUSE (1963) - C
6. PUMP HOUSE/WATER TREATMENT BLDG. (1963) - NC
10. SWIMMING POOL/RESTROOMS (ca. 1965) - NC
11. LEWIS BUILDING–RIGGING LOFT (ca. 1965) - NC
12. MAINTENANCE BUILDING (1967) - C
13. BOWL SHACK (1963) - NC
17. WAREHOUSE (1967) - C
21. ANTENNA TESTING RANGE (ca. 1985) - NC
25. PAINT STORAGE BUILDING (ca. 2010) - NC
27. OPTICAL LABS (1985/1997) - C
34. HIGH VOLTAGE POWER SUPPLY BLDG. (1973) - NC
35. CUMMINGS GENERATOR CONTROL BLDG. (2010) - NC
41. WEST HILL V.S.Q. BACHELOR UNIT NO. 1 (ca. 1970s) - NC
42. WEST HILL V.S.Q. BACHELOR UNIT NO. 2 (ca. 1970s) - NC
43. WEST HILL V.S.Q. FAMILY UNIT NO. 1 (ca. 1970s) - NC
44. WEST HILL V.S.Q. FAMILY UNIT NO. 2 (ca. 1970s) - NC
47. MAIN GATE RESTROOM (1963) - OHDB
50. INTERFERENCE MONITORING SHACK (1992) - NC
51. GREASE PIT (n.d.) - NC
53. EMERGENCY GENERATOR BLDG. (1993) - NC
54. VISITOR CENTER BLDG. (2001) - C
55. LIDAR LABORATORY BLDG. (1996) - C
57. NORTH V.S.Q. BLDG. (2002) - OHDB
58. NORTH V.S.Q. UTILITY BLDG. (2002) - OHDB
59. VISITOR CENTER TRAILER (2016) - OHDB
60. ANT. RECE. TESTING BLDG. (ca. 1995) - C
61. LEARNING CENTER (2001) - C
62. HFF STORAGE TRAILER (2007) - OHDB
63. IONOSONDE TRAILER (2007) - OHDB
64. ELECTRONIC TRAILER (1990) - OHDB
65. SHIELDED TRAILER (1983) - C
66. ATMOSPHERIC SCIENCE TRAILER (n.d.) - C
67. CRYOGENICS LAB TRAILER (1967) - NC
68. SCIENTIFIC OFFICES TRAILER (n.d.) - C
69. ELECTRONIC TRAILER (WAVEGUIDE) (2007) - OHDB
70. COMPUTER TRAILER (2005) - OHDB
71. ELECTRONICS CABLE TRAILER (2005) - OHDB
72. ELECTRONIC TRAILER (CRYOGENICS) (2005) - OHDB
73. HF TRANSMITTER BUILDING (2009) - C
76. INSPIRATION FOR SCIENCE TRAILER (2016) - NC
77. PHASE REFERENCE ANTENNA (12M) AND BUILDING 77 (2010) - C
78. COFFEE HUT (2002) - NC
79. ENGINEERING OFFICE BUILDING (2010) - NC
80. CUMMINGS DIESEL GENERATOR BUILDING (2010) - NC

Figure 1
National Astronomy and Ionosphere Center Historic District
Arecibo Observatory, Puerto Rico

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

The National Map US Topo

BAYANEY QUADRANGLE
PUERTO RICO
7.5-MINUTE SERIES

National Astronomy and Ionosphere Center Historic District
19Q 737449 mE 2029635 mN

Bayaney
Lares
Island of Puerto Rico
Cerro Palma
Cerro La Torre
Tres Pueblos Sinkhole
Hoya Caña
Río Camuy
Río Tanamá
Río Criminales
Río Grande de Arecibo
Río Pellejas
Río Cunas
Río Saliente
Río Arenales
Río Tetuán
Quebrada Arón
Quebrada de los Platanos
Quebrada Palma
Quebrada Pasto
Cementerio de Quebrada
Cementerio de Alborito
Cementerio de Angeles
CAMUY LARES
LARES HATILLO
HATILLO ARECIBO
HATILLO UTUADO
UTUADO LARES
ARECIBO UTUADO
PR- 129
PR- 111
PR- 453
PR- 454
PR- 455
PR- 489
PR- 4489
PR- 625
PR- 415
PR- 4453
PR- 4454
PR- 4443
PR- 134
CLL GALLERA
CLL SUAREZ
CLL JUAN PEREZ
CLL RALAT
CLL LOPEZ
CLL LA PIRA
CLL CHEO SANTIAGO
CAM EL VERTEDERO
CAM EL NEGRO MARELA
CAM VECINAL EL JOBO
CAM MANOLO TOLEDO
CAM JUAN LUIS MONTALVO
SEC LA GLORIA
SEC LAS MINAS
SEC SIERRA
SEC ONOFRE MENDEZ
Expressway
Secondary Hwy
Ramp
Interstate Route
Local Connector
Local Road
4WD
US Route
State Route

Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid:Universal Transverse Mercator, Zone 19Q

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

Imagery.....Hexagon Inc., March 2017
Roads.....U.S. Census Bureau, 2017
Names.....GNIS, 1981 - 2018
Hydrography.....National Hydrography Dataset, 1994 - 2018
Contours.....National Elevation Dataset, 2018
Boundaries.....Multiple sources; see metadata file 2016 - 2017

Wetlands.....FWS National Wetlands Inventory 1983

UTM GRID AND 2019 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000-m Square ID
GA
Grid Zone Designation
19Q

SCALE 1:20 000

1 0,5 0 KILOMETERS 1 2
1000 500 0 METERS 1000 2000
1 0,5 0 1
MILES
1000 500 0 1000 2000 3000 4000 5000 6000 7000 8000
FEET

CONTOUR INTERVAL 20 FEET
DATUM IS LOCAL MEAN SEA LEVEL

This map was produced to conform with the National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.13

PUERTO RICO
QUADRANGLE LOCATION

1 Quebradillas
2 Camuy
3 Arecibo
4 San Sebastian
5 Utuado
6 Maricao
7 Monte Guilarte
8 Adjuntas
ADJOINING QUADRANGLES

BAYANEY, PR
2018

MSN 78430163919773
NGA REF NO. USGSX20K2724

Photolog – National Astronomy and Ionosphere Center Historic District – National Register of Historic Places – Addendum – Taken June 2018

Photo 1a. Building 5, Cable Car House, facing south.

Photo 1b. Building 5, Cable Car House, facing northwest.

Photo 2a. Building 55, LIDAR Laboratory Building, facing west.

Photo 2b. Building 55, LIDAR Laboratory Building, facing southwest.

Photo 3. Building 60, Antenna Testing Range, facing northwest.

Photo 4. Building 65, Shielded Trailer, facing southwest.

Photo 5. Building 73, HF Transmitter Building, facing northeast.

Photo 6. Phase Reference Antenna (12-meter), facing south.

Photo 7. Building 77, facing south.