CHAPTER ONE: THE WRIGHT BROTHERS AND EARLY FLIGHT AT KITTY HAWK, NORTH CAROLINA, 1900-1903

BACKGROUND ON CONTEXT

The period of significance for this context is based on the span of years that Orville and Wilbur Wright spent on the Outer Banks of North Carolina during their earliest period of experimentation, 1900 to 1903. It was during these years that they worked with gliders and with the first successfully flown, powered aircraft—efforts that culminated in what is now generally recognized as the first powered flight of December 17, 1903. The work of the Wrights' predecessors is important to an understanding of the Wright brothers' own successes; however, the primary period of significance is clearly that in which they lived and worked at their Kill Devil Hills camp.

The geographical area considered for this context and for the National Register historic district is the approximately 43l-acre site now known as the Wright Brothers National Memorial. The boundary of the park defines the district boundary. The Kill Devil Hills area is an expanse of sand hills located about four miles south of the village of Kitty Hawk, at the edge of Colington Creek and within view of the Atlantic Ocean to the east. Kill Devil Hill, where the Wright brothers' experiments with gliding occurred, was the highest of the hills, or dunes. Therefore, as Outer Banks historian David Stick emphasized, both appellations "Hill" and "Hills" are appropriate for the site (Stick 1958:267).

This study is confined to property owned or managed by NPS'as the Wright Brothers National Memorial and therefore limited to resources within the boundaries of the park. Reference is inevitably made to occurrences outside the park boundaries. The Wright brothers had close connections with people in the village of Kitty Hawk and at the U.S. Weather Station located there, as well as at the Lifesaving Station at Kill Devil Hills. Other parts of the country and world that have a direct bearing on the events at Kitty Hawk also receive attention in this study.

The grassy hill and surrounding land at Kill Devil Hills is significant as the site of Orville and Wilbur Wrights' glider and powered flight experiments of the early 1900s and especially as the site of the now generally recognized first powered flight of December 17, 1903. There are no structural remains associated with the Wright brothers' period of occupation and use of the area; the originally sandy hills and dunes that attracted the Wright brothers have been sodded and

otherwise planted and developed as part of a longstanding effort to stabilize the site and provide a setting for the recognition of the Wrights' achievements.

THE WRIGHT BROTHERS IN PERSPECTIVE

The site of the first generally recognized successful powered air flight, conducted by Wilbur and Orville Wright on December 17, 1903, near Kitty Hawk, North Carolina, has been recognized and preserved in some way since at least 1928. The Wright brothers conducted experiments in flight intermittently for three years in the Kill Devil Hills area before achieving success with four powered flights, the longest of which was 852 feet in 59 seconds. Now viewed as a seminal event in the history of aeronautical development and the beginning of a near century of further advances in aeronautics, the Wright brothers' efforts at Kill Devil Hills stand as striking testimony to the ingenuity and fortitude of two individuals.

THE WRIGHT BROTHERS' PREDECESSORS

The Wright brothers' experiments in both powered and unpowered flight were the culmination of many centuries of air flight experimentation. Historians of air flight have traced the beginnings of mankind's infatuation with the possibility of flight to speculations and fantasies of ancient philosophers and, more directly, to the theoretical ideas of the Renaissance (Gibbs-Smith 1954, 1970, 1974b; Joseph 1962; Howard and Gunston 1972; Boyne 1987).

In the late fifteenth century, Leonardo da Vinci offered a number of innovative possibilities for flight, suggesting in his notebooks devices for human-powered flying machines, with harnesses and movable bird-like wings. He also offered an early design for a helicopter as well as for parachutes—astutely predicting the future military applications of flight in the process (Josephy 1962: 12-13; Gibbs-Smith 1970:8-9; Hart 1961). Most early theoretical treatments, such as those of Leonardo, emphasized the character of the flight of birds as a model for human flight. However, it was really the acceptance of fixed-wing principles, which were adopted early in the Wright brothers' experiments, that opened up the possibility for successful, heavier-than-air human flight (Gibbs-Smith 1970: 8).

The fixed-wing idea originated in experiments of the late-eighteenth and nineteenth centuries. Fixed-wing experiments, in the form of primitive gliders, often occurred in conjunction with the development of balloons, or lighter-than-air flight, and parachutes. Among the earliest experimenters with fixed-wing devices was Sir George Cayley (1773-1857), identified by one flight historian "as the basic originator of the modern aeroplane" (Gibbs-Smith 1970:21). The success of balloon flights by Pilatre de Rozier and the Marquis d'Arlandes in a craft designed by the French Montgolfier brothers in 1783 initially inspired Cayley. In 1799, after years of research, Cayley designed a glider, featuring a fixed-wing for lift, a paddle-like mechanism for propulsion, and a tail, providing stability through both horizontal and vertical planes. Cayley's design was important in that for the first time, the process of lift was separated from that of propulsion—a striking readjustment from the ornithopter or movable wing concept (Anderson 1985:6). Cayley, who continued his experiments until his death in 1857, immortalized his design on a silver medal

and also built a series of successful model gliders, including one that carried a small boy for several yards. However, as Cayley himself emphasized, the problem with achieving sustained flight was in discovering a means of supplying sufficient power to decrease the air resistance offered to the crafl.

PRECEDENTS OF THE LATE NINETEENTH CENTURY

Cayley's experiments and those of his contemporaries led to a number of other minor successes and advances during the nineteenth century. Much of the work, understandably, concentrated on providing the necessary power to propel heavier-than-air crafts. In 1857, Felix du Temple, a French naval officer, constructed a monoplane design fitted with a locomotive-like boiler and smokestack but was unable to get his craft airborne (Gibbs-Smith 1954, 1963a, 1966, 1970). He was followed in the 1870s by Thomas Moy, a British engineer, who managed to get his steam-powered craft a few inches off the ground, and in 1890, by the French engineer and mechanical genius Clement Ader, who actually succeeded in leaving the ground in his craft, though later historians have tended to interpret this as more of a "hop" than genuine sustained flight, as achieved by the Wright brothers (Gibbs-Smith 1954, 1966, 1974b).

Another contribution to early flight was the continuing work of model makers and kite designers, several of whom directly influenced the Wright brothers. The mid-nineteenth-century collaborative designs of the Englishmen Samuel Hensen and John Stringfellow prophetically anticipated later airplane designs (Josephy 1962; Stewart 1972; Boyne 1987). The invention of the box kite in 1893 by Lawrence Hargrave in Australia similarly impacted the configuration of early aircraft, including the Wrights' biplane gliders and flyers (Gibbs-Smith 1970:54). Miniature balsa models introduced by the Frenchman Alphonse Penaud (1850-l880), with twisted elastic band propulsion, suggested an immediate prototype for the Wright brothers, down to the fixed tapered wings shaped in the form of a positive dihedral, and was later incorporated in the Wright design (Gibbs-Smith 1970:43). Significantly, the young Wright brothers played with just such balsa toys in their childhood home at Cedar Rapids, Iowa (Howard 1988:4).

It was not simply the isolated work of individuals that was important for early experimenters such as the Wright brothers, but rather the collective momentum of the scientific establishment by the end of the nineteenth century that, in a sense, determined the cause of flight. Flight experimentation increasingly took place in the context of scientific societies, journals, publications, and correspondence among researchers. The Wright brothers' work built directly upon publications issued by scientific bodies, such as the Smithsonian Institution (with which, in fact, they corresponded at the beginning of their own research), as well as both popular and more scientific writings of air flight pioneers. The more important of these, especially for the Wrights, included Octave Chanute, whose *Progress in Flying Machines* was published in 1884; the Smithsonian's Secretary, Samuel P. Langley, whose *Experiments in Aerodynamics* followed in 1891; and James Means, whose popular journal the *Aeronautical Annual* was issued over three years between 1895 and 1897 (Combs 1979:51).

The Wright brothers, who appear to have become interested in the problems of flight around the mid-1890s, drew upon a great number of sources (Kelly 1943; Miller 1978; Howard 1988). They also made their own empirical observations, based on a kind of common-sense approach to problem solving. Despite later disclaimers that the knowledge and observation of bird flight made up only a part of their approach, it is clear that the brothers, led by the elder Wilbur, looked at Jules Marey's study *Animal Mechanism: A Treatise on Aerial Locomotion* of 1890 as well as making their own observations. In addition, the research of Louise-Pierre Mouillard (1834-1897) who wrote a significant treatise on the soaring and gliding characteristics of birds, published in 1881 as *L'Empire de l'Air* and excerpted and translated for popular consumption in the Smithsonian *Annual Reports,* also influenced the Wright brothers (Gibbs-Smith 1970:52; Howard 1988:28).

Even more directly, the work of German scientist and inventor Otto Lilienthal (l848-1896) influenced the two brothers. Lilienthal's successful experiments with gliders were widely publicized (Howard and Bunston 1972:38-39). His death in a glider accident in 1896 appears to have initially caught the Wright brothers' attention (Howard 1988:15); and in 1899, when they first wrote to the Smithsonian Institution for further information on flight, the organization recommended Lilienthal's experiments (Howard 1988:30-31).

One of the principal innovations of Lilienthal's gliders was his translation of the shape of birds' wings—based on his own years of study—into glider wings. Lilienthal believed the "gentle parabolic curve across [the wings'] upper surface" (Combs 1979:41) gave his gliders the necessary lift. The Wright brothers agreed that Lilienthal's curved wing contributed significantly to flight experimentation, and allowed him to make over 2000 successful glides-including one that took him sixty-five feet in the air. Lilienthal published meticulous accounts of his work, complete with diagrams and photographs, which the Wright brothers used (Combs 1979:79). While the Wright brothers improved continually on Lilienthal's work—they realized, for instance, that the movable wings of Lilienthal's gliders caused instability as did the wings' relatively short length and the pilot's or flyer's overall lack of control—it is clear that his legacy played a major role both in inspiring and guiding their experiments.

Of the aerial pioneers who influenced the Wright brothers, probably the most direct source was the work of Octave Chanute (1832-1910). The Smithsonian sent Chanute's book, *Progress in Flying Machines* of 1894, a compilation of popular magazine articles, to the Wrights in response to their 1899 request for information. The historian Charles Gibbs-Smith refers to it, together with Lilienthal's work, as one of "the two bibles of flying" (Gibbs-Smith 1970:83). Like the Wright brothers, Chanute at an early age became interested in the idea of human flight. However, he withdrew from research until he established a successful business career. Beginning around 1889, the French-born, Chicago-based amateur scientist resumed flight experimentation. His work resulted in a series of articles published in *The Railroad and Engineer Journal* between 1891 and 1893, which he in turn compiled in a book in 1894. In 1896, at the age of 64, he and a group of assistants began a series of gliding experiments in the sand dunes of Lake Michigan. From 1896 to 1897, his group built five different glider types and completed over 1,000

experimental flights, many 200 to 300 feet in length. The *Aeronautical Annual* published his carefully recorded results. After 1900, the Wright brothers began a correspondence with Chanute, who in time advised them on aspects of their experimentation. He eventually visited the Wright brothers at Kitty Hawk and witnessed some of their early glider experiments (Kelly 1951; Gibbs-Smith 1963b; Glines 1968; Hallion 1978).

The last truly pivotal figure in the development of the Wrights' own interests and their first successful experiments was Samuel P. Langley (1834-1906). Langley served as Secretary of the Smithsonian Institution (Crouch 1978) and originally corresponded with the Wrights in 1899, when they wrote to the organization stating their serious interest in flight (Kelly 1951; Combs 1979; Howard 1988). Langley was personally involved in flying experiments and, by the mid-1890s, worked on powered flying machines. Langley built at least six prototypes (which he called the *Aerodromes),* the last of which employed innovative gasoline-fueled engines. His 1890s aeronautical experiments largely failed (Oesher 1949: 157-60; Vaeth 1966). However, later versions of his *Aerodromes,* rebuilt roughly according to Langley's specifications by his champion Glenn Curtiss, made successful flights

Langley was generally considered the leading figure in heavier-than-air flight experimentation at the time of the Wrights' early experiments. The beginning of the Spanish-American War provided additional incentive for Langley, as grant funds were made available to him through the influence of Theodore Roosevelt, then President William McKinley's Assistant Secretary of the Navy (Bilstein 1984:9). Langley's efforts, however, were fraught with problems, and he never accepted the curved-wing theories of previous experimenters such as Lilienthal (Combs 1979:5). Throughout the first years of the twentieth century Langley continued his efforts, with a first attempt in October 1903, and a final attempt December 9, 1903, nine days before the brothers' successful flights. Following Langley's death in 1906, the Wright brothers argued with the Smithsonian Institution over conflicting claims to priority (Abbot 1928; Crouch 1978). Though now considered one of the treasures of the Smithsonian the original Wright *Flyer* was not donated to the museum until 1948, largely due to the Smithsonian's reluctant admission of the Wright brothers' contribution to aeronautics (Kelly 1943 :300-27; Oehser 1970: 100; Crouch 1978:46).

THE WRIGHT BROTHERS' EARLY WORK

When Wilbur wrote a letter of inquiry to the Smithsonian in May 1899, the Wright brothers were relative newcomers to the science of aeronautics (Crouch 1978:41). Employed in their own bicycle manufacturing and repair business, these two sons of a non-conformist bishop developed a fascination with the notion of heavier-than-air powered flight during the mid- 1890s. Working together in the evenings after work, they applied their mathematical and mechanical skills to the analysis of earlier writers. Particularly influenced by Lilienthal, they referred to him as having provided "the best data available" (Combs 1979:42), but they also found errors in Lilienthal's research, particularly with wing-surface-to-weight ratios and his search for a satisfactory steering method.

The brothers' first experiments occurred in the early part of 1899. Employing a five-foot, double-foiled kite, they tested their own theories on lift and their "wing-warping" method for the control of altitude and direction method requiring the differential twisting of the curved wings in order to shift the kite's direction, which the Wright brothers eventually called "helical twisting" (Gibbs-Smith 1970:95). Combined with a rudder, this principle of warping or twisting eventually became the key to the Wright brothers' success, allowing the pilot to lean into turns while maintaining aerial stability (Crouch 1978:41).

Throughout 1899 and 1900 the Wright brothers applied their experimental efforts toward creating a glider capable of carrying the weight of a man. They tested different materials, further analyzed the flight of birds and the shape of birds' wings, and further developed the notion of wing-warping (Combs 1979:51; Ritchie 1976). A final kite test in the summer of 1899 achieved only limited results. However, the Wright brothers advanced their designs and the understanding of the processes at work. The immediately significant wing-warping technique allowed them to develop gliders with greater wing spans and therefore greater carrying capacity (Anderson 1985:24-28).

THE MOVE TO KITTY HAWK, 1900

During the period of their initial Dayton experiments the Wright brothers realized the need for a more practical site to conduct their research. They needed a wide, open space with steady winds of up to fifteen to sixteen miles per hour. The seasonal nature of their business gave them time between September and January to conduct experiments. Writing to the U.S. Weather Bureau as well as to experimenters such as Octave Chanute, the brothers considered sites near San Diego, California, and along the coasts of Georgia and South Carolina-both recommended by Chanute before finally settling on the Kitty Hawk, North Carolina, area (Howard 1988:39-40; Bonney 1962). Kitty Hawk had the requisite open space and, according to the *Monthly Weather Review* reports, steady winds. Additionally, it was the closest of the proposed sites to their Dayton, Ohio, home base (Howard 1988:39).

Correspondence with Kitty Hawk residents also attracted the Wright brothers to North Carolina. Joseph J. Dosher of the Kitty Hawk U.S. Weather Bureau Station replied enthusiastically to Wilbur's site inquiry. He described the area as a treeless strip of land, a mile wide, without hills or other obstructions (Howard 1988:40; Wescott and Degan 1988:24-26). He also emphasized the prevailing winds from the north and northeast during the months of September and October, when the Wrights wished to begin their work. As to housing, Dosher suggested the two brothers bring a tent. The Wrights also received a letter from native Kitty Hawker Captain William Tate, a former postmaster and county commissioner (Stick 1958: 198-99). He emphasized, to the brothers' relief, the existence of hills in the area known as Kill Devil Hills, which aided ultimately in their experiments, but also cautioned them about more inclement weather in November (Howard 1988:40).

The Wright brothers first traveled to the village of Kitty Hawk, North Carolina, in September 1900, traveling by train to Elizabeth City and taking a small boat to the Outer Banks. The two

traveled separately; Wilbur arrived first, on September 13, following a two-day, storm-ridden trip on Israel Perry's schooner. He enjoyed a hospitable stay at the Tates' home in Kitty Hawk, while waiting for the arrival of the glider from Elizabeth City, where he left it temporarily. The brothers eventually employed Mrs. Tate's sewing machine to make wing covers (Stick 1958: 199; Howard 1988:46).

Orville arrived at Kitty Hawk two days later, following a less eventful trip. After a brief stay with the Tates, the brothers set up a tent just outside the village of Kitty Hawk, in the dunes immediately to the south. In a letter to their sister, Orville wrote enthusiastically of the site, calling attention especially to the impressive expanse of sand.

> The site of our tent was formerly a fertile valley, cultivated by some ancient Kitty Hawker. Now only a few rotten limbs, the topmost branches of trees that then grew in this valley, protrude from the sand. The sea has washed and the wind blown millions and millions of loads of sand up in heaps along the coast, completely covering houses and forest (Combs 1977: 105).

By October the Wrights' completed their preparations and began experiments with their first large glider. This first craft featured a 17-foot wingspan and a horizontal rudder, which functioned essentially as a front elevator. They designed the original craft with an 18-foot wingspan, but Wilbur was forced to substitute shorter pine strips for the intended spruce. Because the longest pine strips available at their Norfolk, Virginia, suppliers were only 16 feet, they augmented them with 6-inch sections, bringing the total length of the wings to 17 feet (Howard 1988:41). The pilot flew in a prone position, which departed from the method employed by other experimenters. The Wrights selected the prone position in order to make the operator "more comfortable, make landing safer, and to reduce head resistance" (Gibbs-Smith 1970:97). During that first short season the brothers succeeded in flying their craft as a kite, controlled from the ground using guide ropes. They were assisted by Kitty Hawk locals, including William (Bill) Tate and Tom Tate, the son of Bill's half brother. The wing warping and the front elevator proved successful. However, the dihedral, or curved, wings limited aerial stability. For a short time the brothers switched to flat wings by adjusting the struts, but this similarly proved ineffective (Gibbs-Smith 1970:97).

On October 18, the brothers shifted their experiments to a small hill about a mile south of their camp. There they met with only limited success, and their decision to man their glider came with too little time left in the day. The following morning, they moved farther south to the Kill Devil Hills area to begin their first manned glides. The first day, due to strong winds, they returned without a single attempt. However, on October 20, they made their first successful manned glides. Bill Tate again assisted the brothers. Wilbur apparently completed most if not all of the flying. The prone position proved successful, and they found that it was just as easy for the rider to remain in a recumbent position, rather than dropping down within the provided gap, when landing (Howard 1988:52).

In late October, the Wright brothers returned to Dayton reasonably encouraged. They asked Bill Tate to dispose of the glider, the cloth wings of which were made into dresses for his daughters (Howard 1988:53). Orville and Wilbur began work on a second glider, which they completed early the following year. The most significant change in the new model was an increased wing span of 22 feet, resulting in a new wing surface of 290 square feet. The new wing-warping mechanism, controlled by a "hip cradle," allowed the pilot to alter the warping by a shift of his torso. The wings also received a four-inch anhedral droop to help promote lift (Gibbs-Smith 1970:97). Wilbur wrote of the summer's successes and his theories to Octave Chanute. He also wrote two articles for publication in leading French and German aeronautical journals (Combs 1979:130).

THE SECOND SEASON, 1901

The Wrights took their second glider to the Outer Banks in July 1901 for initial testing. The Wrights also built a more permanent camp during the summer visit, constructing a combined workshop and storage building out of locally procured materials about four miles south of their old tent camp, just northeast of the main Kill Devil Hill (Stick 1958:204). Octave Chanute arrived on the scene in August to witness the work and provide advice. Other participants had arrived earlier that season. These included Edward C. Huffaker and George Spratt, both recommended to the Wrights by Octave Chanute (Howard 1988:61-77). The flights, launched from around the midpoint of the largest of the three hills, took place mainly during July and August. They tested both manned and unmanned flights, though increasingly they were piloted.

The experimental flights of early August largely succeeded, resulting in glides of up to 389 feet (Gibbs-Smith 1970:98). Still, difficulties existed and clearly frustrated both brothers. The Wrights gave up their final experiments toward the end of August to return to Dayton for further work.

Between September 1901, when they left Kitty Hawk, and August 1902, the Wrights remained in Dayton. While their tests of the previous summer showed some success, the accuracy of Lilienthal's calculations, upon which they based much of their own work, continued to cause concern. This realization led the Wrights to put aside other scientists' data and conduct their own experiments. Building a series of models of wing sections, they began a systematic wind-tunnel study of the aerofoil sections. They tested every wing configuration possible and, after only three months, used the new data to create a design which they incorporated into their 1902 glider and later powered aircraft (Baals 1981:6; Combs 1977: 146-47). They built the third Wright glider over the winter and spring with a further increased wing span and consequent wing surface area. They also installed a double-planed, rear rudder. This provided their aircraft, for the first time, with both the longitudinal and lateral stability necessary for successful sustained flight (Gibbs-Smith 1970:98).

THE THIRD SEASON, 1902

In August 1902, the Wright brothers returned to their old camp at Kill Devil Hills to begin their experiments again. The camp was largely in disrepair due to harsh winter winds and shifting sands. The brothers, with help from Bill Tate's half brother, Dan, carried out basic repairs to their camp, and added ten feet in length to the storage and workshop building (Combs 1979: 158) to provide for better living quarters. They also added battens to the exterior and properly tarpapered the roof (Wescott and Degan 1988:62-65, 71, 77-79). This substantially improved camp became the Wright brothers' home for the remainder of the summer and served as their base of operations the following year. The quarters included a makeshift dining room table, suspended burlap beds, and an operable kitchen. A photograph of the interior captured an enduring picture of life in the quarters, and eventually served as the basis for the present reconstructed exhibit at the site. (The camp also possibly included a chicken coop, though the evidence of this is less clear; the privy, if there was one, has similarly eluded researchers; Howard 1988:83.)

The tests that summer concentrated on improvements to the new glider. They engineered the aircraft to be unstable in order for the pilot to practice the control systems more thoroughly (Combs 1979:73). As a result, both brothers gained experience as pilots, an important prerequisite to the later longer flights (Gibbs-Smith 1970:99). Orville and Wilbur remained at their Kill Devil Hills camp until October. Octave Chanute visited for a period, and also their brother Lorin Wright, who assisted in some of their early flights. Augustus Herring, another of Chanute's proteges, and George Spratt also visited the site that year; Herring helped with tests of Chanute's own glider, all of which proved unsuccessful (Howard 1988: 66-67).

The Wrights set a number of new gliding records that season. Three glides traveled more than 600 feet, and five lasted between twenty and twenty-six seconds. To improve lateral stability, the Wrights added a vertical tail. This at first introduced new problems, most significantly a tendency for uncontrolled twisting, which they referred to as "well-digging." Orville apparently solved the problem, suggesting a moveable, rudder-like tail, which adjusted for the twisting. Wilbur, in turn tied its operating mechanism into the wing warping mechanism, overcoming the need for separate controls. As Fred Howard records:

> What the Wrights had stumbled on in the course of this gliding experiment at Kill Devil Hills in 1902 was to document that the principal function of the vertical rudder in an aircraft is not to steer but to supplement and refine the action of the lateral control mechanism. This was not an insignificant discovery, for it completed and brought to a patentable stage the Wrights' three-dimensional system of airplane control, which is the basic system used today in all winged vehicles that depend on the atmosphere for their support (Howard 1988:89).

The Wrights finally broke camp on October 28, returning to Dayton via Elizabeth City. With George Spratt and Dan Tate's help, during their stay they completed over 700 separate glides,

more than 375 in the final six days. One glide reached a distance of 622.5 feet and lasted more than twenty-six seconds. They gained increased control over their craft and logged a considerable number of hours of actual flight time, contributing to their later success as pilots (Combs 1979: 148-75). By the end of the 1902 season the Wrights had made great progress on the way to successful flight.

POWERED FLIGHT, 1903

Word of the Wrights' successes during the summer of 1902 began to leak out that autumn. They obviously impressed Chanute, and soon the scientific world began to hear of the brothers' work and their glider designs (Howard 1988:96-99). The military of several countries took an interest in their gliders (Combs 1979: 173); and in the spring of 1903, following their annual return to Dayton, the Wright brothers applied for their first patent on the wing-warping mechanism and rudder design. While the patent was not granted until 1906, the Wrights understood the greater significance of their efforts and the need to protect their enterprise (Gibbs-Smith 1970:99).

During the winter of 1902 and spring of 1903 the Wrights devoted time to developing an engine for their flying machine in order to finally attain powered flight—clearly their intention from the earliest period, but further reinforced by Octave Chanute's encouragement after 1902 (Howard 1988: 104). In order to carry the greater weight required for the engine, the brothers expanded the frame and wing span of the new *Flyer,* as they dubbed the craft (Howard 1988: 104), utilizing a biplane design. They also added wire stays to provide greater strength and stability. Unable to find a suitable engine, the Wrights decided to build their own calling upon Charles Taylor, the inventive and talented employee of the Wright Cycle Company, to complete the design and machine-work (Combs 1979: 176; Hobbs 1971).

Taylor's and the Wright brothers' work resulted in a 4-cylinder, 12-horsepower engine capable of translating 9.5 horsepower to propulsion, with the remaining 2.5 horsepower absorbed or lost in the system of drive shaft, sprockets, and chains (Combs 1979: 176). As work proceeded on the engine, Orville and Wilbur concentrated on the design of the propellers needed to provide the thrust required for flight. As with other aspects of this effort, no prototypes existed for experimentation, and again the Wright brothers developed their own equipment. Using their wind tunnel for testing, the Wrights settled on the now typical, two-bladed propeller design rejecting cork-screw designs and the examples offered by ship propellers (Combs 1979; Howard 1988:108-109). The final propellers, manufactured in the Dayton shop, measured a little over eight feet, and mounted on the rear of the plane.

By the summer of 1903, the machine-powered aircraft was ready for testing. The Wrights again shipped the aircraft, equipment, and provisions to Elizabeth City by rail, to be transported by schooner and wagon to the site. The Wrights' baggage arrived in September; the new *Flyer* arrived later. The amount of equipment and material had increased enormously since their first visit. It included the *Flyer,* now weighing close to 605 pounds with all its accessories, a large array of tools and equipment, including gauges, muslin, etc., and a more lavish supply of household goods (Howard 1988:111). Upon arrival they undertook repairs on their quarters and,

with the help of several local carpenters, added a second, adjacent frame shed to serve as a garage or hangar for the *Flyer* (Stick 1958:208). The new building, located a few feet west of the old camp building, consisted of an approximately 44-by-16-foot structure, braced on two sides against the wind. They fitted the ends with top-hinged doors for easy access. The brothers found the 1902 glider still intact, despite damage to its old storage quarters. For several weeks the brothers practiced on the glider, with Orville on October 26, 1903, soaring for one minute and eleven seconds. This record held until 1911, when Orville bettered his own mark (Howard 1988:115).

The *Flyer*, which finally arrived on site October 8, was fully assembled by early November, as was a 60-foot wood monorail used to launch the aircraft. The Wrights immediately experienced engine difficulties, which in turn resulted in damage to one of the propeller shafts. As a result, they sent the shaft to Dayton with Spratt for repairs. In the meantime, the Wrights improved the construction of the monorail, relaid for each flight along the northeast side of the Kill Devil Hill. Referred to by the brothers as a junction railroad, it consisted of four, 15-foot two-by-fours covered with a thin metal strip. Wooden crosspieces held the whole upright in the sand. A small wooden truck moved along the rail on two metal rollers made from modified bicycle hubs. Across the truck they placed a 60-foot plank, on which the skids of the *Flyer* rested during takeoff. A third bicycle hub, attached to a crosspiece under the horizontal front window, kept the machine from nosing over on the track (Howard 1988:118).

The repaired shafts arrived at the camp on November 20. They installed the shafts and tightened the sprockets, thought to be too loose. Extremely cold weather, however, delayed test flights throughout the month. Tests on the engine proved more successful. A crack discovered in one of the propeller shafts nearly ended the season; the brothers, eager to test the plane before the end of the year, decided to press on, and Orville traveled back to Dayton to retrieve the necessary replacements.

They decided only solid steel shafts could withstand the vibrations of the engine (Howard 1988: 122), so the brothers installed new propeller shafts on the *Flyer* on December 12, 1903, the day after Orville's return. The wind that day was too light to risk a flight, and the next day was Sunday, which was the brothers' traditional day of rest. On Monday, December 14, they decided to test the machine despite continuing low wind velocities. Following a pre-arranged agreement,, they placed a white sheet on one end of the hangar shed to invite men from the nearby Kill Devil lifesaving station, or inhabitants from Kitty Hawk, to be witnesses to the flight experiments. Shortly thereafter five men from the station arrived who helped move the *Flyer* up the Kill Devil Hill to make up for the lack of steady winds. The track was then adjusted on the hillside, and the *Flyer* placed at the high end (Howard 1988: 134).

Wilbur and Orville tossed a coin to see who would take the first turn. Wilbur won (Combs 1979:203). There was some difficulty in releasing the plane, but once released the *Flyer* proceeded down the rail, balanced by Orville, racing beside it. Wilbur adjusted the front rudder, causing the machine to jump into the air, before it clipped the sand with its left wing, sending it into the ground after only 3.5 seconds. Although this effort carried the *Flyer* over 100 feet, it

was not considered a successful first flight. Still, the accomplishment encouraged both brothers (Howard 1988:134).

The next day, December 15, the brothers spent making repairs, which they finally completed by midday the 16th. However, light winds delayed further flight attempts until December 17. At 10:00 A.M., despite threateningly high winds, they decided to chance another flight, and they notified the men from the lifesaving station. They laid the rail on level ground west of the hangar building and waited for the men from the station to arrive—three of whom finally appeared on the scene with two local men (Howard 1988:135-136).

Orville piloted this round of trials. At 10:35 A.M., he released the rope restraining the *Flyer*, which in turn moved slowly down the track, with Wilbur holding the right wing tip for balance. Although it lifted off at an air speed of 30 MPH, the wind, at over 20 MPH that day, represented fully 20 MPH of this speed. John Daniels, one of the lifesavers, took a photograph at the moment of lift off (Combs 1979:213).

The *Flyer* reached an elevation of about 10 feet before the shift in the rudder caused it to go downward. The total distance covered was about 100 feet. The stopwatch stopped due to the sudden impact, but the Wrights estimated a flight time of 12 seconds. Orville expressed it as:

> the first time in the history of the world in which a machine carrying a man had raised itself by its own power into the air in full flight, had sailed forward without reduction of speed, and had finally landed at a point as high as that from which it started (Howard 1988).

Following repairs to a damaged rudder, the brothers repeated the experiment. At 11:20 Wilbur made a second flight, totalling 175 feet. A half-hour later Orville made the third flight. By now, following earlier difficulties with the rudder, Orville was in a better position to make the necessary in-flight adjustments (Combs 1979:215-16). The third flight was steadier and longer, totalling a little over 200 feet and lasting about 15 seconds. At noon Wilbur made the fourth and longest flight of the day, covering a full 852 feet, though ending with a crushed front rudder frame. While the brothers recorded the distance, a sudden gust of wind toppled the craft, causing even more severe damage. This was the last of the flights with the 1903 *Flyer,* but the Wrights accomplished the main task of manned flight.

THE AFTERMATH

This epochal day and the success of the Wright brothers created an immediate world impact. Notice appeared in several journals and newspapers; and though universal recognition was not immediate, within a few days the public accepted the fact, if not the magnitude, of the Wright brothers' achievements (Combs 1979:228-31; Howard 1988:141-45; Harrison 1953; Bonney 1962:60). By December 19, the brothers broke camp and packed up the damaged *Flyer* for shipment to Dayton. They arrived home in time for Christmas. Wilbur and Orville Wright returned to the Kill Devil Hills camp in the spring of 1908 to test their modified *Flyer;* and

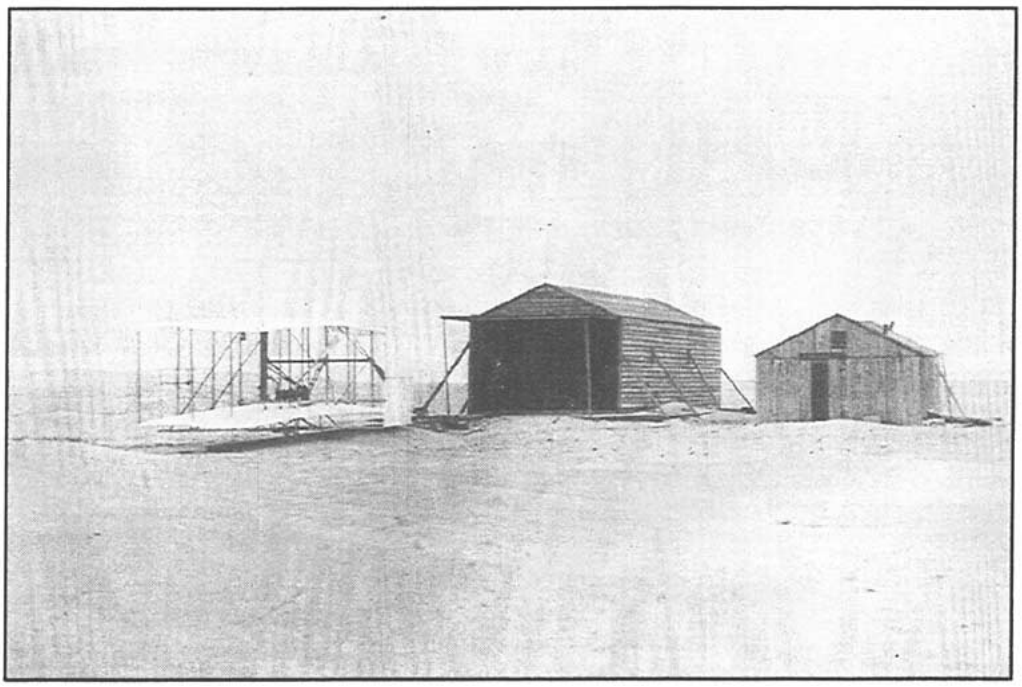

Figure 3 1903 Wright Brothers Hangar, Quarters, and *Flyer*

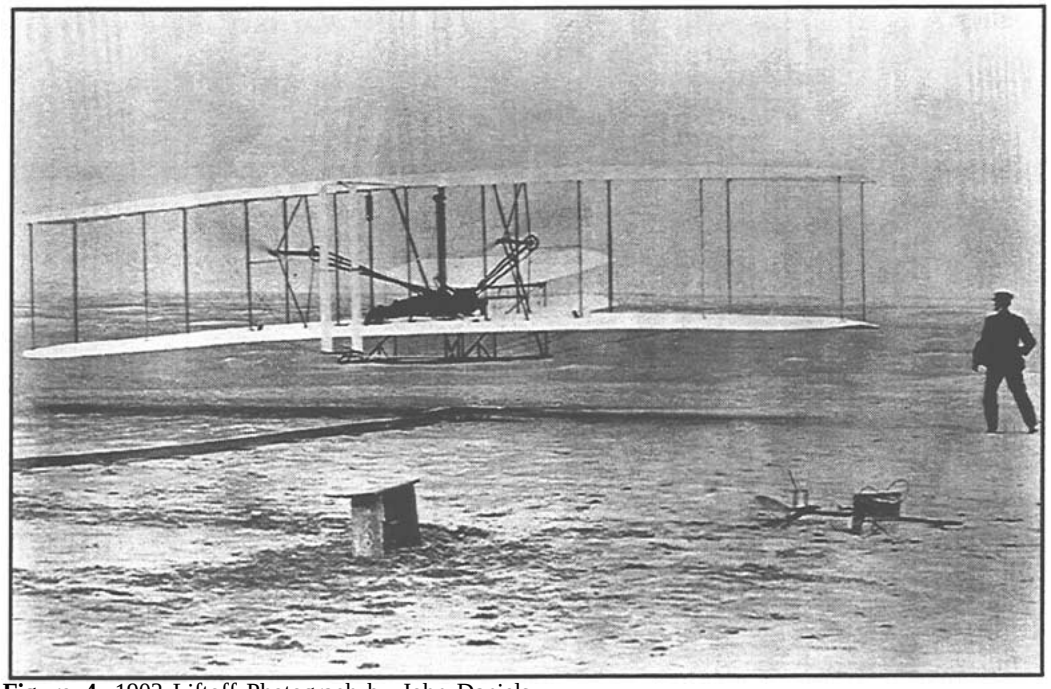

Figure 4 1903 Liftoff Photograph by John Daniels

Orville returned for a short period in 1911 for further glider experiments. After that date, however, the periodically repaired quarters and hangar buildings deteriorated, and the site, in a sense, returned to nature. Official commemoration of the first flight occurred twenty-five years after the success of 1903.

The Wrights achieved further success in the immediately succeeding years. The *Flyers* of 1904 and 1905 attained truly sustained flight in a series of tests conducted in a field outside of Dayton (Gibbs-Smith 1970: 101-102). In 1908, after further relatively secretive experiments, Orville and Wilbur signed a contract with the U.S. Army and with a French manufacturer for partial rights to their design. Although Wilbur died in 1912 as a result of typhoid fever, Orville enjoyed the fruits of their efforts and eventual recognition of the full value of their combined accomplishments.

ASSOCIATED RESOURCES

The Setting

The Wright Brothers National Memorial encompasses the site of the first powered air flight, undertaken by Orville Wright on December 17, 1903, and subsequent test flights of the same day piloted by both Orville and Wilbur Wright. The Wright brothers' earlier experiments with gliders also occurred here, particularly after 1901 when they moved their camp and operation from the south side of Kitty Hawk village to the area known as the Kill Devil Hills. The brothers continued their work at the site in 1908 and 1911.

At the time of the Wrights' experimental work, the Kill Devil Hills area consisted of sandy rolling dunes, rising to three more prominent sandy hillocks, known collectively as the Kill Devil Hills. The largest of these was called both Kill Devil Hill and—by the Wright brothers—Big Hill (Howard 1988:59). When the brothers began their operations at the site in 1901 it had an elevation of about 100 feet. Two smaller hills, known as Little Hill and West Hill, also occupied the site. The larger of these was about 60 feet high, the smaller and closer hill reached a height of about 30 feet (Howard 1988:59).

The site of the Kill Devil Hills changed substantially after the Wright brothers' experimental glides and flights. Subject to driving winds and the harsh weather typical of the Outer Banks, the three hills changed considerably in elevation, configuration, and location, with the largest drifting as much as 200 to 300 yards toward the southwest (Howard 1988:428-429; *New York Times* 12/18/28).

The War Department stabilized Kill Devil Hill beginning in 1927 following recommendations of an advisory committee to the Quartermaster General, the federal agency given the job of constructing a larger monument (Hewes 1967:24). An amount of $25,000 appropriated for stabilization enabled the planting of a variety of grasses over the sandy surface, supplemented by erosion-retarding barriers and a covering of woods mold or loam and fertilizer. The stabilized Kill Devil Hill served in turn as the base of the 1931-1932 Monument shaft, designed by the New York architectural firm of Rodgers and Poor.

The Wrights used the Kill Devil Hills site toward the end of their first season on the Outer Banks in the autumn of 1900, following earlier experiments on Lookout Hill just south of the Banker village of Kitty Hawk (Stick 1958:200). The first season consisted of only two days of work at the Kill Devil Hills site: October 19, when they decided not to fly because of high winds, and October 20, when they made several encouraging glider flights. They returned to the Kill Devil Hills site in 1901, this time pitching a tent about 1,000 feet east of the higher hill and building a rough shed to use as a workshop. They returned to the workshop for the 1902 season, and, together with Kitty Hawk resident Dan Tate, rebuilt the dilapidated shed, adding an additional 10 feet to use as a quarters. In 1903, when they began their powered experiments, the Wrights made further improvements to the quarters and also built a second frame shed, measuring about 44 by 16 feet, to hold the *Flyer* and serve as a sheltered work area. Located a few feet west of the camp building, it is clearly indicated in the Wrights' photographs of that year.

The quarters building and the hangar rapidly deteriorated after the departure of the Wright brothers in December 1903. In the spring of 1908 when the Wrights returned to the site to test their modified *Flyer,* both buildings needed significant repairs. John Daniels, one of the Kitty Hawk lifesavers who witnessed their earlier flight efforts, warned Wilbur when he arrived at Elizabeth City about the ruined camp buildings, and Wilbur purchased new materials for repairs. The sides of both buildings remained, but the roof of the old quarters was missing entirely and the interior was covered with sand. Wilbur hired two "semi-carpenters" to help make repairs and essentially to rebuild the structures (Howard 1988:239-241). Largely similar to those in place in 1903, the new buildings still differed in minor ways and constituted new structures overall. Orville reused the buildings in 1911, though again with changes. Following the 1911 season, the brothers abandoned the site, and the effects of wind, sand, and weather completely destroyed the buildings. In 1928, when the NAA placed the first commemorative marker at the site of the first flight, little remained of the structures on which to base the location of takeoff.

In 1953, NPS reconstructed the two Wright brothers' structures in recognition of the fiftieth anniversary of the first flight. The park based the approximate location on the point of take-off (William Harris, personal communication, 4/3/90). The Kill Devil Hills Memorial Society, a local promotional organization, supported the reconstruction. NPS, as well as the U.S. Air Force and private donors, provided funding and design guidance, reconstructing the buildings using photographs taken by the Wrights in 1903.

Neither of the reconstructed buildings survived storm and termite damage and the park removed both structures in 1963. Using treated materials, the park completed sturdier versions of the Hangar Building in early 1963 and the Quarters Building in 1965. However, the Hangar was replaced again in 1976 to 1977, due to continuing deterioration. The Quarters received substantial repairs the same year. Both the Hangar and the Quarters subsequently required occasional replacement materials and repairs.

Due to the evolution of the setting or site and the fact that the existing structures are relatively recent reconstructions of original features, there is little real physical match between

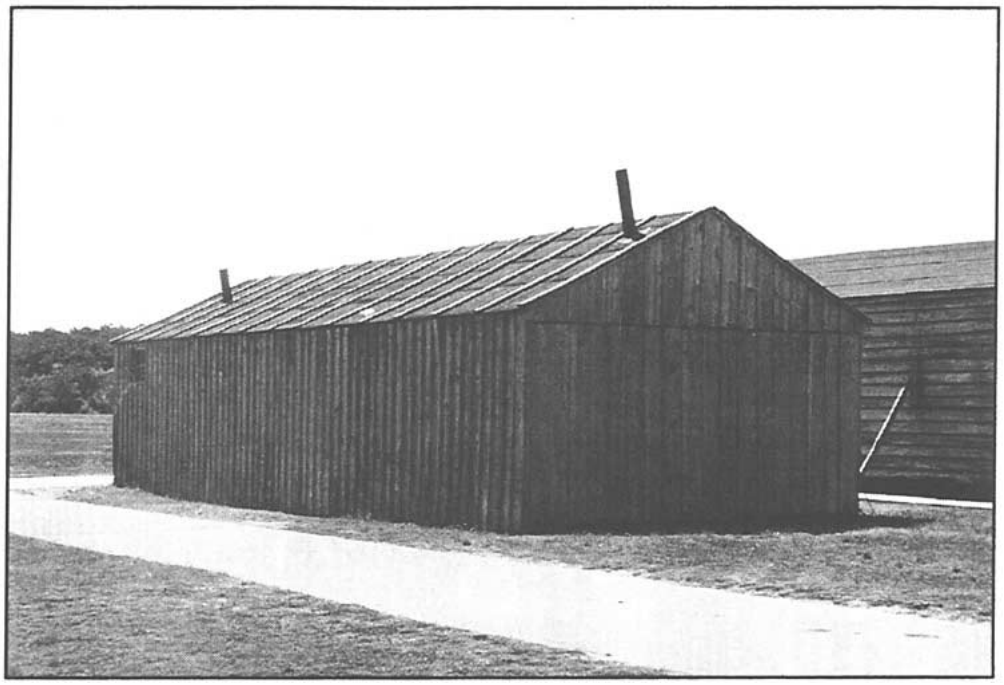

Figure 5 Reconstructed Wright Brothers Quarters, 1990

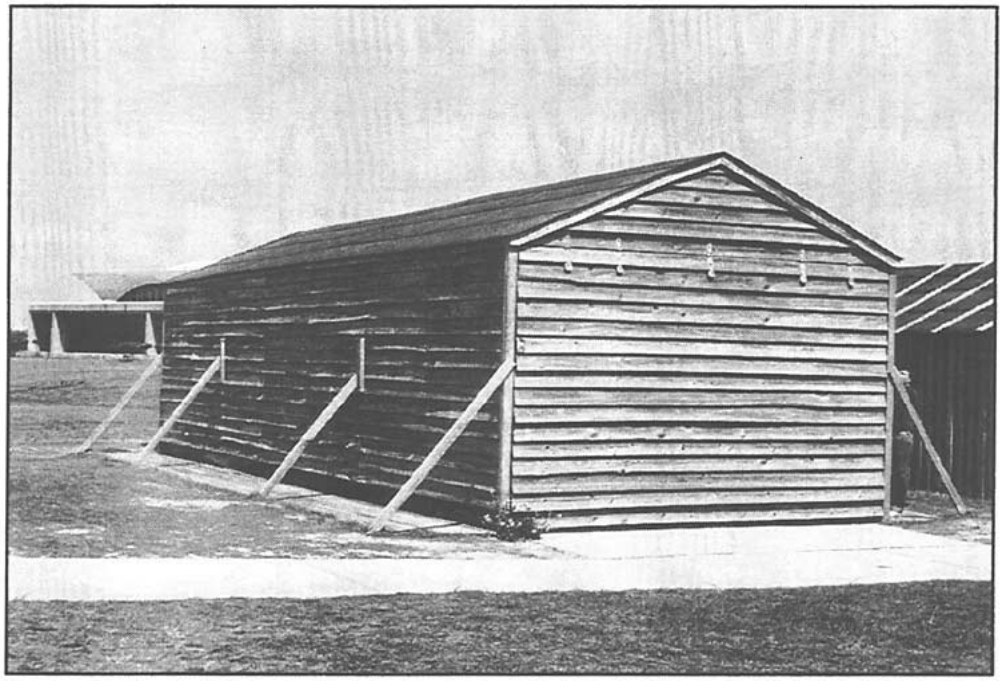

Figure 6 Reconstructed Wright Brothers Hangar, 1990

the event that occurred on the site and existing structures. The primary structural evidence of the event is tied to the later significance of the site as a subject of commemoration.

The Wright Brothers National Memorial and the coterminous National Register district are significant under National Register Criteria A and B as the site of the Wrights' successful flight experiments. Kill Devil Hill and West Hill are contributing natural features that were the sites of glider trials. The reconstructed Wright brothers' quarters (built 1953, rebuilt 1964-1965, 1976-1977, and 1993) and reconstructed Wright brothers' hangar (built 1953, rebuilt 1964-1965, 1976-1977, 1983, and 1993) are the only manmade structures evaluated under the first flight context. Both resources are included in the original National Register documentation of the Wright Brothers National Memorial district as elements of the district property. This report recommends the reclassification of the buildings as noncontributing features because they do not meet the requirements of Criteria Consideration E. They are not accurate reconstructions, and the location of the structures was based on limited evidence.

Physical Characteristics

The two buildings are simple frame structures typical of utilitarian architecture of the early twentieth century. Both structures have gable roofs, covered with rolled roofing. The construction material is pine plank with larger, mainly two-by-four-inch supporting pieces. The Quarters is sheathed in board-and-batten siding. The Hangar has conventional lapped weatherboards. Floors, where present, are also pine plank. The Hangar features wood buttresses, connecting with plank bases, which originally provided added support against harsh winds. Overall dimensions are approximately 16 by 42.5 feet for the quarters and 16 by 48 feet for the hangar. Height to wall plates is about 7.5 feet.

Associative Characteristics

The two reconstructed buildings are meant to evoke the period of the Wright brothers' residency on the Outer Banks in the summer and autumn of 1902 and the autumn of 1903. Specifically, the exhibit intends to convey a sense of the appearance of the camp in 1903, when the first powered flight occurred. The repaired, and in part replaced, buildings of 1908 are not represented by these two buildings. In 1900 there was no camp on the site and in 1901 a tent served as the Wrights' quarters with a wood building for a hangar. In the south section of the quarters building the park created an exhibit with beds, furniture, appliances, shelves, and food closely resembling the original configuration of Orville and Wilbur Wrights' sleeping and living areas. These interior arrangements have the greatest interpretive value and could be recreated in the visitor center.

Although the park hoped to convey a sense of the Wrights' living conditions at Kill Devil Hills when they reconstructed the hangar and quarters buildings, reconstructions provide no original historical evidence. These buildings should be managed as interpretive exhibits only and listed as noncontributing elements of the Wright Brothers National Memorial National Register district.

Significance

The two structures are recent, inaccurate reconstructions of historic features. The intended association is with the history of early flight and Orville and Wilbur Wright's unique accomplishments in the sand dunes of the Kill Devil Hills area between 1900 and 1903 The two structures do not relate to the second context developed for this study, "The Commemoration of the Wright Brothers, 1926-1941," because they fall outside the period of significance.

Criteria Consideration E stipulates that a reconstructed property is considered eligible "when it is accurately executed in a suitable environment and presented as part of a restoration master plan and when no other building or structure with the same associations has survived' (National Park Service [1991]a:37). The quarters and hangar do not meet these requirements.

The actual site of the Wright brothers' efforts changed considerably following the 1903 flight. The configuration of landscape features, the introduction of trails, new roads, and vegetation altered the site as part of a mostly 1930s effort by NPS to create a new setting for recognition of the Wright brothers' accomplishments. NPS further altered the site after 1947 as part of a new Master Plan for the park. The park reconstructed the hangar and quarters buildings during the post-1947 development of the park. The changes occurred during an effort to increase interpretation at the park and, as such, function principally as an exhibit on the site. Because of the loss of an appropriate physical context and the fact that the site is not being interpreted as a restored landscape, neither structure is eligible for listing in the National Register of Historic Places.

Requirements for Listing

Neither the Reconstructed Hangar nor the Reconstructed Quarters are eligible for listing in the National Register. They are not part of an overall restoration plan for the site and the site has suffered substantial loss of integrity. There is also a limit to the degree of accuracy of the reconstructions, given the available documentation for the structures.

Criteria Considerations

Criteria Consideration E has been considered, but the two properties do not meet all of the requirements set out: 1) a suitable environment; 2) part of the restoration master plan; 3) no other building or structure(s) with the same associations surviving. The Hangar and Quarters are best considered as exhibits within the context of the Wright Brothers National Memorial.

Integrity

Both structures are reconstructions completed in 1993. They have no integrity of location, design, setting, materials, workmanship, feeling, or association.

Contributing Resources

The site itself, defined by the National Register district boundary, is the significant resource under this context. It is nationally significant under National Register criteria A and B for its

association with the Wright Brothers and their work with glides and powered flight. Specific contributing features of the site are:

1. Kill Devil Hill or Big Hill (stabilized 1928) and
2. West Hill.

Surveyed Non-contributing Resources

1. Reconstructed Wright Brothers Quarters (reconstructed 1953, 1964-1965, 1976-1977, 1993).
2. Reconstructed Wright Brothers Hangar (reconstructed 1953, 1964-1965, 1976-1977, 1983, 1993).