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HISTORIC CONTEXT, CHARACTER-DEFINING ELEMENTS, AND PHOTOGRAPHIC RECORD FOR A 26.45-MILE SEGMENT OF THE 138-KILOVOLT POWER TRANSMISSION SYSTEM, AREAS 3, 5, 6, AND 23, NEVADA NATIONAL SECURITY SITE, NYE COUNTY, NEVADA

Prepared by

Gregory M. Haynes and Dylan Person

Cultural Resources Report TR124
Division of Earth and Ecosystem Sciences
Desert Research Institute, Las Vegas, Nevada

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Cover Photos: Upper left: 138 kV transmission line through Checkpoint Pass area (2113MIT-B_014); Upper right: Mercury Switching Station (2113MIT-PR_2534); Lower left: Frenchman Flat Substation (2113MIT-C_0013); Lower right: Typical H-frame structure (2113MIT-B_002).

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INTRODUCTION

The subject of this report is the 138-kilovolt (kV) power transmission line on the Nevada National Security Site (NNSS) (see Figure 1). The NNSS, formerly the Nevada Test Site (NTS), was the main continental nuclear test site for the United States between 1951 and 1992. Known as the battleground of the Cold War, the NNSS hosted a total of 928 nuclear tests during that period. It also served as the location of numerous scientific advancements in the fields of rocketry, big-hole drilling, nuclear waste management, and defense. From its construction in the 1960s through the present day, the 138 kV line has provided electrical power to the numerous buildings, facilities, experiments, and tests on the NNSS. The Department of Energy (DOE), in consultation with the Nevada State Historic Preservation Officer (SHPO), has determined that it may contribute to the character and significance of the Mercury Historic District (MHD) on the NNSS, as well as other historic districts that have not been recorded or evaluated yet.

The purpose of this report is to fulfill two of the stipulations in the *Memorandum of Agreement DE-GM58-22NA25553 between the U.S. Department of Energy and the Nevada State Historic Preservation Officer Regarding Installation of a 138-kilovolt Transmission Line from the Mercury Switching Station to the U1a Facility and the Removal of the Historic 138-kilovolt Transmission Line from the Mercury Switching Station to the U1a Facility in Areas 1, 3, 5, 6, and 23 of the Nevada National Security Site* (MOA). The MOA was executed as part of the DOE's obligations under Section 106 of the National Historic Preservation Act (NHPA) to mitigate the adverse effects of two undertakings on historic properties. In particular, this report fulfills MOA Stipulations III.C.1-3, which state that the Department of Energy (DOE) will prepare the following:

- A historic context for the 138 kV transmission line and identification of the line's character-defining elements;
- High-quality digital images of the 26.45-mile segment of the 138 kV transmission line that is subject to the two undertakings for which the MOA was executed; and
- Photograph catalogs and map keys showing photograph viewpoints and directions.

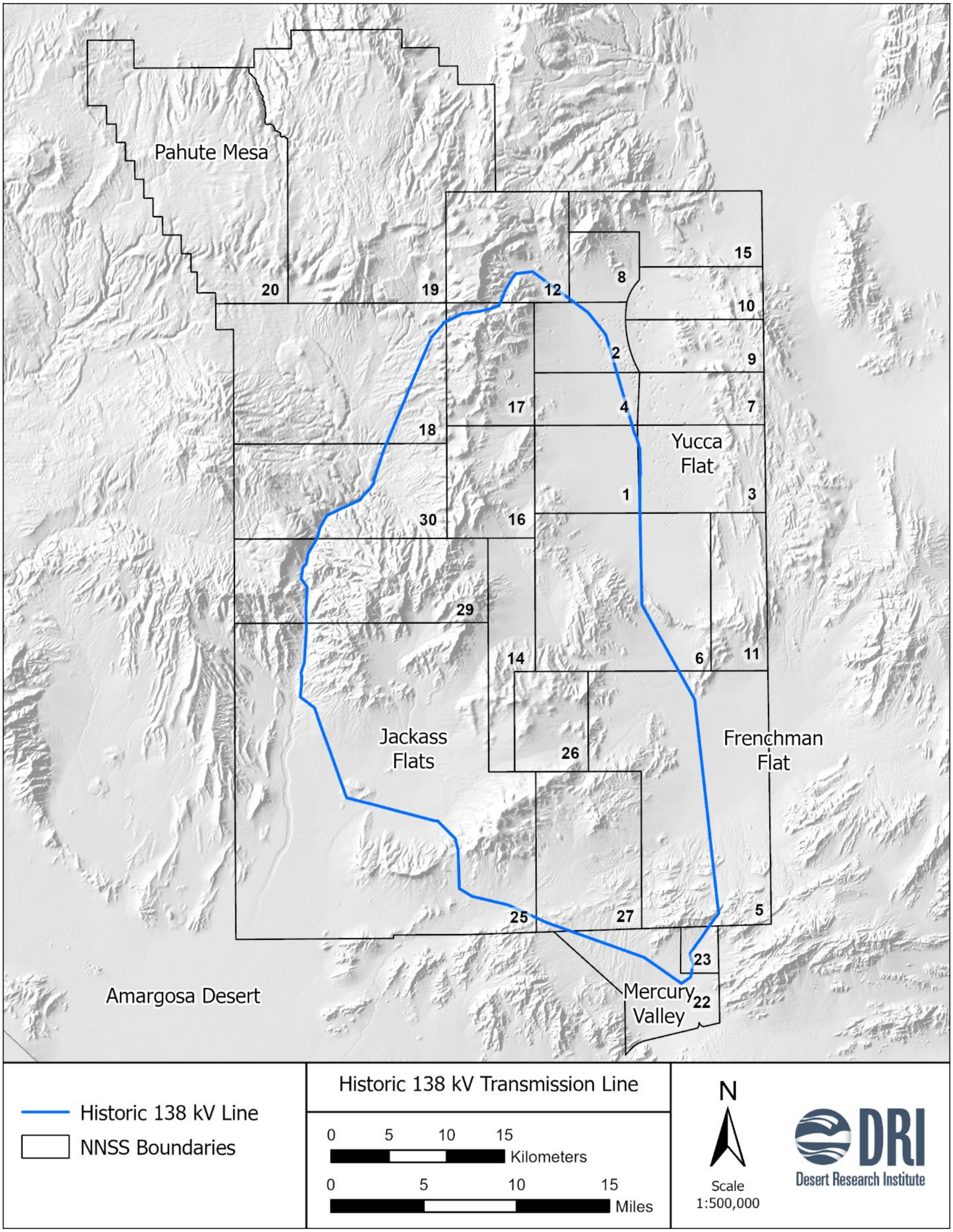

Figure 1. The 138 kV power transmission system loop on the Nevada National Security Site.

HISTORIC CONTEXT

The Cold War and Nuclear Testing on the NNSS

The Cold War was a conflict between the United States and its allies and the communist block of nations that lasted from shortly after the end of World War II in 1945 until the dissolution of the Soviet Union in 1991 (Anders 1978:4; Blohm 2003; Loeber 2002:80; Ogle 1985:20). The global conflict pivoted around themes of ideology, imperialism, strategic issues, and the nuclear arms race (Puzio 2013). It was a war fought via economic and cultural means, as well as a series of proxy wars by the United States and the former Soviet Union and their allies from 1947 to 1991 (Gaddis 2005; Walker 1995).

The NNSS played a crucial role in the United States nuclear testing program during the Cold War with the former Soviet Union. One of the significant results of this confrontation was a generally escalating arms race for nuclear weapon superiority (Anders 1978; Loeber 2002; Ogle 1985). This led to numerous nuclear detonations worldwide by the United States, the former Soviet Union, and other foreign powers. The DOE, including its precursors, and the U.S. Department of Defense (DOD) conducted these tests for the United States. Most of these tests occurred at the NNSS, where the operations included both atmospheric and underground tests.

The NNSS was first established by the U.S. Atomic Energy Commission (AEC) after the agency recognized the need for a continental test site following security and logistical issues with the nuclear testing program in the Pacific (NNSA/NFO 2011). The ideal continental test site would have favorable and predictable weather and terrain conditions for year-round testing, the land would be under federal control, and have an infrastructure already in place (Lay 1950; Tlachac 1991). Other factors were security, remoteness from populated areas, and proximity to the scientific laboratories in New Mexico. The Las Vegas Bombing and Gunnery Range in southern Nevada was the place chosen that best met these conditions (Fehner and Gosling 2006:43). The range also had flat terrain for conducting the tests, easterly prevailing winds away from the densely populated West Coast, and natural barriers to screen the test areas from public viewing. Based on the recommendations of Los Alamos National Laboratory, the Atomic Energy Commission (AEC), and the National Security Council, President Truman approved the new test site location on December 18, 1950.

Nuclear testing at the NNSS can be divided into two types: atmospheric tests from 1951 to 1962 and underground tests from 1951 to 1992. For atmospheric tests, nuclear devices were initially dropped from airplanes, but later were placed near the ground on top of towers, and eventually elevated by balloons to the desired height. The main objectives of this early atmospheric testing were to monitor and measure results, perfect testing methods, and improve the technological capacity of nuclear weapons. Other objectives included determining the physical effects of nuclear weapons. During this period of time, a permanent electrical system was impractical in the forward areas because of the overpressure (shock waves) and electrical transience (extremely high voltages) produced during atmospheric tests.

The first underground nuclear test, named Uncle, was a crater test in Yucca Flat in November 1951. Crater tests were designed to create a crater by placing a device shallow enough beneath the surface to produce an overburden of earth when the device was detonated (NNSA/NFO 2015). Several years later, underground containment of nuclear explosions became a major focus to protect workers and reduce public concerns (Carothers 1995; Johnson et al. 1959; Malik et al. 1981). Starting in 1957, underground tests designed to minimize the release of radioactive materials became common.

Both the United States and the former Soviet Union ceased nuclear testing in 1958 by self-imposed moratoria at the urging of internal and external forces (Ogle 1985:30-31), but by 1961 both superpowers were once again conducting tests. Except for a few surface and near-surface tests, most of the tests after the moratorium were conducted underground. After the Limited Test Ban Treaty among the United States, the Soviet Union, and Great Britain was ratified in 1963, all weapons-related tests were conducted underground (Friesen 1995). It would not be until after the Limited Test Ban Treaty, in the mid-1960s, that a permanent electrical transmission system was built throughout the entire NNSS.

Most underground tests on the NNSS between 1963 and 1992 were conducted either in vertical shafts or in horizontal tunnels on Yucca and Frenchman Flats, around Shoshone Mountain, and on Buckboard, Pahute, and Rainier Mesas. Most vertical shaft tests were for the purpose of developing new weapon systems, whereas the tunnel tests were generally for evaluating the effects of radiation from a nuclear explosion on military hardware and systems (Brady et al. 1989; OTA 1989; Wolff 1984). The vertical shaft tests were the most common, representing over 90 percent of tests, and were primarily placed on Yucca Flat or, if they were large-yield tests, on Pahute Mesa. To support these testing efforts, electrical substations were built on Yucca and Frenchman Flats, Rainier Mesa, and Stockade Wash on Pahute Mesa.

A total of 928 nuclear tests were conducted at the NNSS, with 119 performed in the 1950s, and 809 after testing recommenced following the short moratorium between 1958 and 1961 agreed to by both the United States and the former Soviet Union (Friesen 1995; NNSA/NFO 2015). In 1992, the United States established a second self-imposed moratorium on nuclear testing and testing on the NNSS ceased accordingly. In 1995, President Clinton announced a total ban on all critical U.S. nuclear weapons testing. In September 1996, the United Nations approved the Comprehensive Test Ban Treaty, which prohibited any nuclear explosions. However, the U.S. Senate failed to ratify this treaty (Medalia 2003).

Supplying Electrical Power to the Nevada National Security Site

1951–1962: Before the Loop

From the very beginning of nuclear weapons testing on the NNSS, providing power across the proving ground would be an important consideration. During the initial occupation of Camp Mercury, between 1951 to 1956, electrical power was provided by a power plant equipped with three diesel generators (REECo 1955). The power generated at this plant was transferred to a substation, located immediately adjacent to it, and then through an electrical distribution system that provided power to the various facilities across the camp. Electrical power in the forward areas where atmospheric nuclear testing took place was supplied by portable generators stationed where they were needed.

It was not until 1956 that Mercury would be connected to an electrical grid that could provide it with continuous and uninterrupted power. As for the forward areas where aboveground nuclear tests took place, it would not be until all nuclear tests were conducted underground, following the Limited Test Ban Treaty of 1963, that an electrical system that supplied continuous and uninterrupted power would be extended there. This is because atmospheric nuclear tests produced overpressure or shock waves that would have destroyed segments of the power system. In addition, atmospheric nuclear tests also produce electrical transience, a phenomenon characterized by extremely high voltage in a power system that can destroy its various components.

In 1956, the Southern Nevada Power Company completed a 64-mile-long power transmission line from what was then known as the West Side Station in Las Vegas to Mercury (Johnson 2006:111; Leihy 1962:157). According to William (Bill) Donahoe (personal communication, June 3, 2021) and Jim Anderson (personal communication, May 20, 2021), two electrical engineers who have long worked on the NNSS power transmission system, the initial line to Mercury was 69 kV, but the engineering specifications would allow it to be eventually upgraded to 138 kV. It was at this time that the initial Mercury Switching Station was likely constructed. Moreover, Mercury Substation was upgraded shortly thereafter to support the 69 kV electrical power.

One of the most important aspects of electrical power supply on the NNSS is redundancy. Redundancy was built into the system so that if one power supply source would drop below required levels or go out entirely, another system would be in place to ensure uninterrupted power to the ongoing scientific and technical programs. Redundancy was built into the Mercury power system in several ways. Once the Southern Nevada Power Company 69 kV line was installed, it became the primary source of power. However, the older power plant with the three diesel generators apparently remained in use. By 1959, Jackass Flats Substation had been built to accommodate a new 69 kV transmission line from the Amargosa Valley Cooperative (Burns & McDonnell Engineering Co. 1958). Although the exact date of construction is uncertain, it was probably around this same time that a tap-and-meter substation was constructed in Mercury, presumably to tie (tap) the two 69 kV lines into the Mercury distribution system and to measure (meter) the amount of electricity used by the town.

The construction of Jackass Flats Substation and the transmission line from that substation to Mercury, built between 1957 and 1962, constituted the first 18.45 miles of an NNSS-wide transmission system that would eventually extend nearly 100 miles in length. It may be that it was after the transmission line between the Mercury Switching Station and Jackass Flats Substation was completed that voltage was increased from the original 69 kV up to 138 kV (Arthur Benedict Associates 1962:38). It would not be until Mercury was transformed in the mid-1960s from a semipermanent camp into a permanent base that the rest of this 100-mile loop, along with five more substations, would be built.

1963–1966: Constructing the Loop

In October of 1958, the two superpowers in the Cold War, the United States and the Soviet Union, instituted self-imposed moratoria on all weapons tests. By 1963, the United States and Soviet Union initiated the Limited Test Ban Treaty, which prohibited aboveground or atmospheric tests but allowed for underground testing (Fenner and Gosling 2006:199). With the certain resumption of nuclear weapons testing, the AEC began improvements on the NNSS, most notably at Mercury (Arthur Benedict Associates 1962; Koebig & Koebig 1963), but also for an NNSS-wide power transmission system.

Between 1964 and 1966, the essential components of what is still the NNSS-wide power transmission system would be built. These components included the following 138 kV power line segments and associated substations:

- A 14.6-mile segment from Mercury Switching Station northward through Checkpoint Pass to Frenchman Flat Substation;
- A 12.8-mile segment from Frenchman Flat Substation northward through Yucca Pass to Yucca Flat Substation;
- A 10.35-mile segment from Yucca Flat Substation through the northern portion of Yucca Flat to Valley Substation;
- A 4.0-mile segment from Valley Substation west onto Rainier Mesa to Rainier Mesa Substation;
- A 5.15-mile segment from Rainer Mesa Substation west through Stockade Wash to Stockade Wash Substation;
- A 35.00-mile segment from Stockade Wash Substation south through Fortymile Canyon to Jackass Flats Substation;

- A 16.50-mile segment from Jackass Flats Substation east along Cane Spring Road to Frenchman Flat Substation.

Notably, this did not include the segment from Jackass Flats Substation to Mercury Switching Station, an 18.45-mile segment, because that had already been completed. With the creation of this loop, redundancy was created throughout the entire power transmission system. Power came into it from two sources, the Nevada Power Company line from Las Vegas and the Valley Electric Association line from the Amargosa Valley. (Amargosa Valley Cooperative became Valley Electric Association in 1965.) Power could flow from Mercury Switching Station northward or westward around the loop. Correspondingly, power could flow from Jackass Flats Substation northward or eastward around the loop. It could also flow between Frenchman Flat and Jackass Flats Substations via the Cane Springs segment.

A distinctive alphabetic designation system came to be used that identified different segments of the 138 kV power line and other lower voltage lines (James Anderson, personal communication, May 20, 2021; Holmes & Narver 1971).

- F = 138 kV
- E = 69 kV
- D = 34.5 kV
- C = 12.5 kV
- B = 2.4 and 4.16 kV

Each segment of the 138 kV transmission line, as well as individual distribution lines, were designated by three letters, of which the first was voltage. The second letter was a consecutive designator assigned to individual power lines constructed sequentially over time. In this case, the second letter, or "A," refers to the fact that the entire transmission line was built at one time and perceived as a single unified system. The third letter refers to unique segments within that system. Because that portion of the 138 kV line between Mercury and Jackass Flats Substation was owned and operated by Nevada Power Company, no such alphabetic designation was assigned to that portion of the loop. All of the alphabetic designations identified above are still in use today (James Anderson, personal communication, May 20, 2021; William Donahoe, personal communication, June 3, 2021). Therefore, the 138 kV transmission line designations are as follows (see Figure 2):

- FAC = Mercury Switching Station to Rainer Mesa Substation (mission corridor)
- FAE = Mercury Switching Station to Mercury Distribution Station
- FAG = Jackass Flats Substation to Stockade Wash Substation
- FAH = Jackass Flats Substation to Frenchman Flat Substation
- FAJ = Rainier Mesa Substation to Stockade Wash Substation

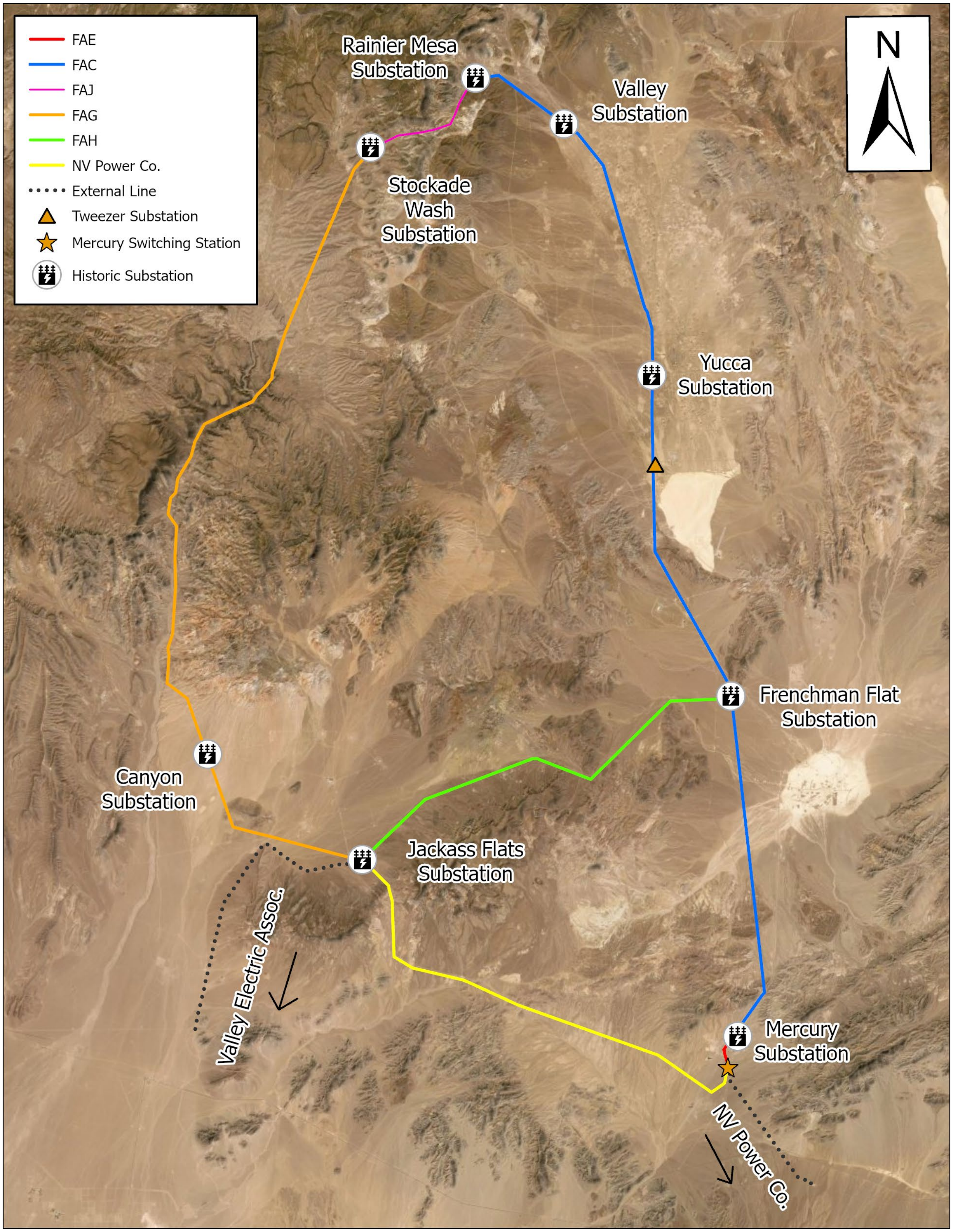

Figure 2. The 138 kV power transmission system segments and transmission substations.

Structures, Conductors, and Insulators

The 138 kV power transmission line has three types of wooden pole structures. The most common was an H-frame structure, which was used to suspend the power line or conductor wire on straightaways or low-angle turns (Figure 3). The H-frame structure had slight variations on the design depending on the length and weight of the conductor wire along a proposed span.

The second common pole type was a dead-end structure (Figure 4). These structures consisted of three poles, with each pole carrying its own conductor wire. These structures were called "dead end" because lengths or segments of conductor wire terminated at them. These structures were also used when the power line went into or out of a substation or where there were significant turns. When these structures were used at turns, they were sometimes alternatively referred to as large-angle structures.

The only other pole type was a high-tension suspension structure. This structure was constructed in places where the required power line span was particularly long, such as over braided drainages or on mountain slopes. It consisted of five poles: three shorter poles and two taller poles, with one taller pole placed between the outer and middle shorter poles.

Figure 3. NNSS H-frame structure, ca 1963 (REECo 1982:1673-11).

Figure 4. Series of dead-end structures near Mercury Switching Station, ca. 1958 (REECo 1982:367-5).

In terms of the power line or conductor wire, engineering drawings indicate that the 138 kV electrical current was conducted through an aluminum-conductor steel-reinforced cable, or ACSR for short. The same engineering drawings indicate that the individual insulators were long-rod insulators (Meyer 2014:4-13).

Transmission Stations

The first transmission station that was constructed was the Mercury Switching Station (Figure 5). This transmission station handled the transfer of incoming high-voltage electrical current from Las Vegas into the NNSS system. This was followed shortly thereafter by Jackass Flats Substation, which obtained high-voltage electrical current from the Amargosa Valley and transferred it to the Mercury Switching Station for redundancy and inclusion into the NNSS loop (Figure 6).

During the initial phase of construction, five substations were built: Frenchman Flat, Yucca Flat, Valley, Rainier Mesa, and Stockade Wash. The purpose of these substations was to reduce the 138 kV electrical current to 34.5 kV and deliver the reduced voltage through distribution lines to different facilities in the vicinity of the substations. Importantly, each transmission station or substation had a control house with instruments that monitored portions of the transmission and distribution system and, through a series of relays, allowed portions of them to be turned on and off as needed.

Figure 5. Mercury Switching Station, ca. 1968 (REECo 1982:2633-12).

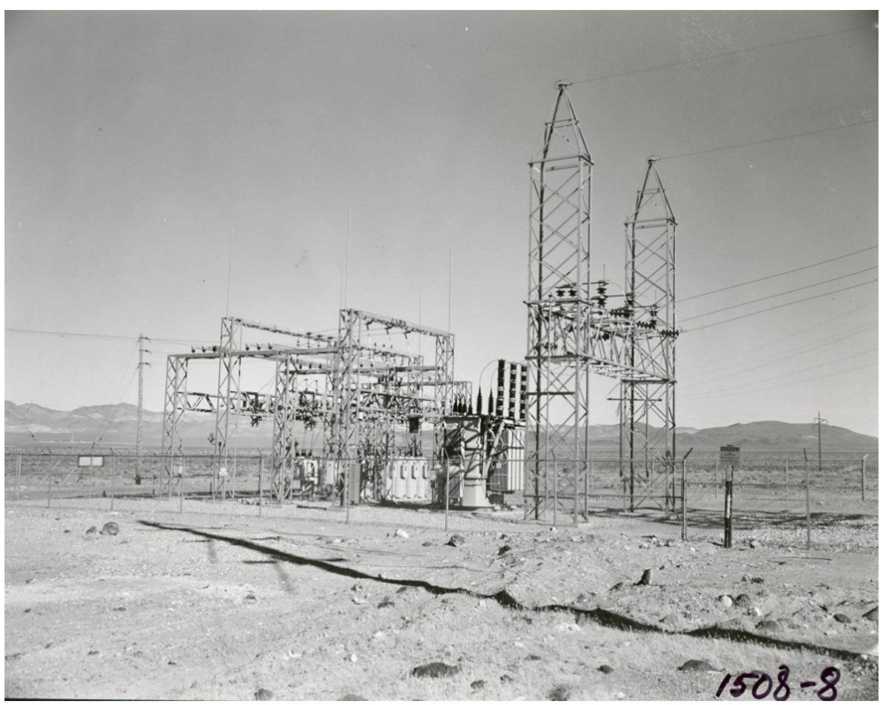

Figure 6. Jackass Flats Substation, ca. 1963 (REECo 1982:1508-8).

1967–1992: Maintaining the Loop

Several important changes to the power transmission system occurred between 1967 and 1992. As the mission of the NNSS expanded over time and new facilities were constructed across the landscape, lower-voltage distribution lines that supplied power to end users had to be constructed and this changed the number of overall components at each of the substations. Moreover, as old parts on structures and in the substations failed, these would be upgraded to newer models. These lower-voltage distribution lines were particularly abundant where most testing activities took place on the NNSS, from Mercury to Area 12 Camp. As lower voltage distribution lines were built, each of them would be given a specific designation following the nomenclature established for the 138 kV line.

According to documents at the Mercury Switching Station control house, by the middle of the 1970s, the NNSS power transmission system was composed of over 500 miles of power lines:

- 140 miles of 138 kV line
- 18 miles of 69 kV line
- 200 miles of 34.5 kV line
- 50 miles of 12.5 kV line
- 132 miles of 4.16 kV line

Another important change was a transition from oil circuit breakers to gas circuit breakers at the substations (Figure 7). This transition did not happen overnight but occurred as individual oil circuit breakers began to indicate a potential for failure.

Figure 7. Detail of oil circuit breakers (left) and gas circuit breakers (right) (2113MIT-A_3107; 2113MIT-A_3012).

Only one new substation would be constructed between 1965 and 1992, Canyon Substation in Fortymile Canyon. This substation was constructed in the late 1970s, although the initial planning phases had begun as early as 1966. The only other substation that has been built for the power transmission system is Tweezer Substation on Yucca Flat in Area 6, but it was built following the conclusion of nuclear testing on the NNSS, around 1995 or 1996. Tweezer Substation replaced Yucca Flat Substation, which has not been in service since the mid-1990s.

The NNSS power transmission system has been maintained over the last 50-plus years; items were only replaced when they were found to be faulty or no longer reliable. According to both William Donahoe and Jim Anderson, the 138 kV power transmission system remains surprisingly intact and strongly reflects its use during the NNSS period of significance (1951-1992). William Donahoe acknowledged that the power transmission system has been able to last for so long because of the linemen who worked on the system day in, day out. They were the ones to identify problems and create practical solutions to keep the system up and running for over 50 years.

CHARACTER-DEFINING ELEMENTS OF THE NNSS 138 KV POWER TRANSMISSION SYSTEM

The production and distribution of electrical power consist of three interrelated systems: the generating system, which makes the electrical power; the transmission system, which moves high-voltage power to substations; and the distribution system, which provides low-voltage power to end users. The NNSS electrical power is generated at various power plants, including Hoover Dam, and that current travels through a high-voltage 138 kV power transmission system. This transmission system is composed of wooden pole structures that suspend overhead electrical conductor wires made of thick aluminum cabling that carry the current to transmission substations. The transmission substations are located at various points along the line and house transformers and other equipment that reduce the voltage to a power level appropriate for a distribution system that supplies it to end users, which in this case includes various industrial and commercial facilities related to nuclear testing activities.

The discussion presented below only includes the various components associated with the NNSS 138 kV transmission system. It does not include the power generating system, which lies outside of the NNSS, nor does it include the lower-level distribution systems that fan out to various parts of the NNSS from the substations. The character-defining elements of the NNSS 138 kV power transmission system include the following:

- Structures (H-frame, dead-end, high-tension suspension)
- Conductors or conductor wire
- Insulators
- Transmission stations (switching stations, substations)

Structures

The public generally refers to the wooden and steel features that hold overhead electrical power lines as power poles, but the industry term is *structure* (Meyer 2014). The NNSS 138 kV power transmission system has three kinds of structures that carry overhead conductor wires throughout the entire 100-mile loop: 1) H-frame structures, 2) dead-end structures, and 3) high-tension suspension structures (Meyer 2014). During the period of significance for the line, ca. 1965-1992, all of the structures were made from wood, as opposed to steel.

H-Frame Structures

The most common wooden structure associated with the 138 kV electrical system on the NNSS is by far the H-frame and the loop is comprised of hundreds of these features. These structures consist of two 50-foot-tall wooden poles with a single crossbeam at the top and a wooden X-brace positioned underneath the crossbeam (Figure 8). Three electrical conductor wires are positioned equidistantly along the crossbeam and hang from a long-rod insulator (Meyer 2014:4-13). In addition, two lightning arrestor wires are attached to the top of each power pole and parallel the conductor wire. Attached to each lightning arrestor is a copper wire that runs down the pole and attaches to a buried ground plate at the base of the pole; this serves as an electrical ground. These H-frame structures resemble what Meyer (2014:4-7, Table 4.2; Appendix, Figures 13–14) defines as Type HS1 or Heavy Suspension or Type HA1 or Heavy Small Angle Suspension.

Dead-end Structures

Dead-end structures are comprised of three upright poles and used when one set of conductor wires is terminated (Figure 9). The term "dead end" is misleading because the electrical power is transferred to another set of wires on the opposite side of the pole. These kinds of structures are used primarily at substations where power is transferred either into or out of the substation, or when there is a large- or high-angle turn in the course of the transmission line. Dead-end structures on the loop resemble Type 3DE and Type 3AT (Meyer 2014:Appendix, Figure 18).

Figure 8. Typical H-frame structure (2113MIT-A_3020).

Figure 9. Typical three-pole dead-end structure (2113MIT-C_0004).

At least two engineering drawings that date to the period of original construction depict these elements (Stearns-Roger 1965, 1966a). These drawings show that they are generally approximately 33 feet in width and 54 feet in height. The two outer poles are approximately 10 to 12 feet taller than the middle pole and there is 15½ feet between the outer poles and the middle pole. The longer outside poles are sunk 8½ feet into the ground, whereas the middle pole is buried no more than 8 feet deep.

For structures in which the conductor wire dead-ends without a turn, there is no crossbeam, although each pole has a guyline attached at its top and buried into the ground for support. In those structures with a large-angle turn in the transmission line and two sets of conductor wires attached to it, two parallel crossbeams are placed above the conductor wires to support it. One set of conductor wires meets the pole at 90° and is attached to a parallel crossbeam by hanging insulators. The other set of conductor wires is attached to the opposite crossbeam by insulators and both the insulators and the conductor wires are positioned at the required angle or turn in the line. In both cases, lightning arrestors are placed at the top of the outside poles. Both structure types have copper ground wires, but in the case of dead-end structures associated with substations, the buried ground wire is attached to the substation's buried ground grid.

High-tension Suspension Structures

High-tension suspension structures are specially reinforced features with five poles that hold long, heavy spans of conductor wire, most notably in Fortymile Canyon and on the steep slopes through Checkpoint Pass (Figure 10). They are composed of three equidistant poles with two parallel crossbeams at the top. Between each of the outer poles and the middle pole are longer wooden poles, each with parallel crossbeams at the top that allow for special bracing features and the transfer of electrical current from one length of conductor wire to another.

One length of conductor wire dead-ends on either side of the three short poles and rather than being attached to hanging or angled insulators, they are attached to perpendicularly oriented insulators just below the lower set of crossbeams. Three other insulators hang from the upper crossbeams and a jumper wire that transfers current from one conductor wire length to another is attached between the two (see Figure 6). The lightning arrestor wires are attached to the top of the two longer poles. These particular elements resemble what Meyer (2014:Appendix, Figure 19) defines as structure Type 3SWT, a switch structure with overhead ground wire.

Conductors

Electrical current in transmission and distribution systems are carried through conductor wires, the so-called power line. Copper and steel were initially used for this purpose, but aluminum became common in the early twentieth century (Meyer 2014:4-9). Modern aluminum transmission wire is made by wrapping aluminum cables around a core of steel cables, resulting in an aluminum-conductor steel-reinforced cable, or ACSR.. Engineering drawings for the dead-end structures indicate the high voltage 138 kV current on the NNSS was conducted through a 4/0 ACSR 6/1 Penguin (Stearns-Roger 1965, 1966a) (Figure 11). The designation 4/0 refers to the size or gauge of the wire and 6/1 refers its stranding. Penguin is an industry term for a specific type of conductor wire and of the many different types of ACSR manufactured nowadays, each particular one is denoted by the name of a bird (prioritywire.com, accessed August 6, 2021).

Figure 10. Typical five-pole high-tension suspension structure (2113MIT-A_3049).

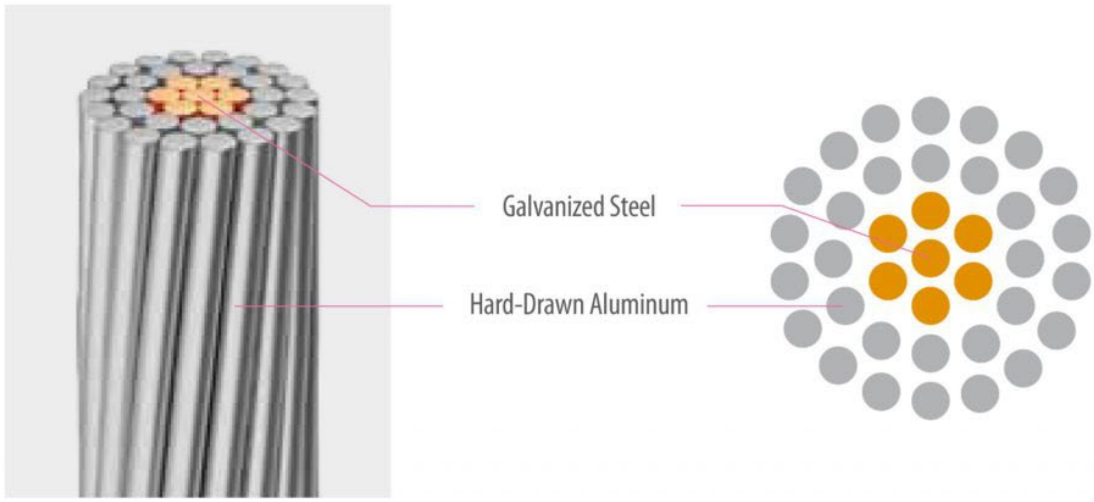

Figure 11. Example of aluminum-conductor steel-reinforced cable. Source: lsgmcable.com/product/aluminum-conductor-steel-reinforced-acsr.

Insulators

Based on the same engineering drawings, the insulators were composed of 10-inch by 5¾-inch ball and sockets, and nine of them were strung together for a length of 5 feet 6 inches. This kind of insulator is referred to in the industry as a long-rod insulator (Meyer 2014:4-13). Each consists of a long porcelain rod with multiple ceramic petticoats and cemented porcelain ends (Figure 12).

Transmission Stations

Mercury Switching Station (SHPO Resource # B15305)

The Mercury Switching Station (MSS) is where high-voltage electrical current, supplied nowadays by NV Energy in Las Vegas, enters the NNSS transmission system (Figure 13). Originally built around 1966, the station is just west of the main entry gate to the NNSS (Gate 100) and sits on a 295-foot by 295-foot pad surrounded by a chain-link and barbed wire fence. This compound consists of two primary components: (1) an array of electrical hardware that conducts the electricity from the NV Energy power line to the NNSS transmission system and (2) a control house (NNSS Building 23-1010).

A 1971 electrical drawing of the entire 138 kV transmission system depicts the various components of the MSS and how the station functioned (Holmes & Narver 1971). At that time, high-voltage current came from Nevada Power Company's grid in Las Vegas and entered the MSS from its south side, while high-voltage current derived from Valley Electric Association via Jackass Flats came into it from the north side. In keeping with the need for redundancy, another 138 kV line bypassed the MSS outside of its western perimeter, connecting the two high-voltage transmission lines.

The incoming high-voltage current was then connected to a busway on one side of the MSS, which in turn was connected to a series of oil circuit breakers. A series of switches separated the electrical lines in this busway with the oil circuit breakers. Jumper lines then went from the oil circuit breakers to two busways on the opposite side of the MSS. One of these busways provided power to Mercury Substation, the “east bus” in the engineering drawing, whereas the other busway provided power to the forward areas, the “west bus” in the engineering drawing.

Today, both NV Energy and Valley Electric transmission lines enter the MSS from the south via a large steel gantry that is set in the middle of the compound. Although both opposing busways appear positioned in much the same way as in the 1971 engineering drawing, the four original oil circuit breakers have been replaced by five modern gas circuit breakers.

Substations

Five substations were built during the initial construction phase of the 100-mile 138 kV power transmission loop: Frenchman Flat, Yucca Flat, Valley, Rainier Mesa, and Stockade Wash. Later, Canyon Substation was built in Fortymile Canyon to support the Nuclear Rocket Development Station. Finally, in the mid-1990s, Tweezer Substation in Area 6 was built to replace the aging Yucca Flat Substation.

The as-built engineering drawing for Frenchman Flat Substation highlights the standard components present at these substations when they were initially constructed (Stearns-Roger 1966b) (Figure 14a-d). This drawing shows that electrical power can be provided to the substation from three sources: Mercury Switching Station, Yucca Flat Substation, or Jackass Flats Substation.

Figure 12. Typical long-rod insulator (2113MIT-A_3023).

Figure 13. Mercury Switching Station, facing southwest (2113MIT-PR_2546).

Transformers at the substation reduce the 138 kV electrical current to 34.5 kV. Having reduced the electrical current, another series of power lines goes from the transformer to a bus, which distributes the 34.5 kV power to three separate distribution lines (Figure 14d). These distribution lines then exit the substation and go to different facilities in the vicinity of Frenchman Flat Substation.

The only other structure associated with the substation is a control house, which contains instruments that monitor portions of the transmission line and its associated distribution system. These instruments also include a series of relays that allow portions of the transmission line and its distribution lines to be turned on and turned off as needed.

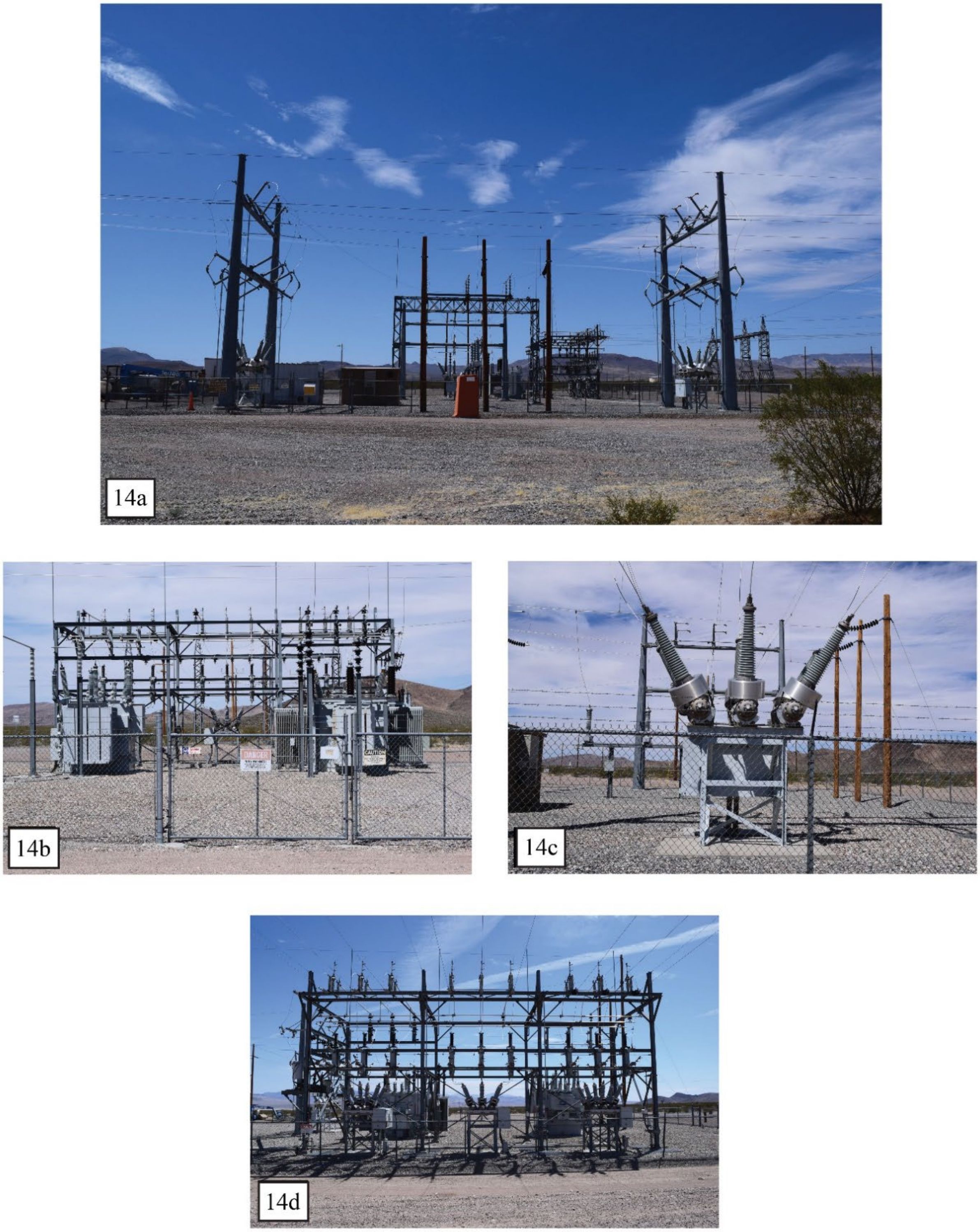

Figure 14a. Frenchman Flat Substation overview, facing west (2113MIT-C_006); Figure 14b. Detail of Frenchman Flat Substation 138 kV transformers (2113MIT-C_0011); Figure 14c. Detail of Frenchman Flat Substation 138 kV gas circuit breaker (2113MIT-C_0009); Figure 14d: Detail of Frenchman Flat Substation 34.5 kV distribution line system (2113MIT-C_0016).

SUMMARY

This historic context and its character-defining elements portray the construction and development of one relatively simple power transmission system during the mid- to late twentieth century. The simplicity of the NNSS electrical grid is in stark contrast to the complex array of technological facilities needed to test the nation's nuclear weapons. Background research revealed that although some of the initial facilities were constructed in the late 1950s, most of it was built within a three-year span of time, between 1964 and 1966. Since that time, only one substation was added and certain components, such as circuit breakers and transformers, have been replaced because they exhibited signs of failure. Despite these alterations, the current system remains much the same as it was during its period of significance, ca. 1965–1992.

ACKNOWLEDGEMENTS

This report culminates, in large part, several years of work by Desert Research Institute (DRI) on the NNSS 138 kV power transmission system. Over this time, a good many people employed by DRI on the Technical Research, Engineering, and Development Services (TREDS) Cultural Resources Management Program have had a hand in recording segments of the historic line, aiding in the compliance process for the installation of a replacement system in the mission corridor of the NNSS, and authoring the various reports about both the historic and the proposed systems. These reports were written to comply with regulatory obligations that the NNSA/NFO has under Section 106 of the National Historic Preservation Act. To the people at DRI who have worked on various aspects of these projects, you have our thanks, because we have relied on all of this previous work in so many ways.

For this project, Maureen King served as the Project Director and Principal Investigator for the TREDS Cultural Resources Management Program. Ms. King provided direction for the mitigation effort and technical expertise regarding the conduct of historic preservation work on the NNSS. In addition, and in consultation with the SHPO, she developed the MOA that would ultimately guide the stipulations for mitigation. Dr. Gregory Haynes served as lead Subject Matter Expert for mitigation efforts and senior author of this report. Jeffrey Wedding and Megan Stueve assisted with the detailed photographic series of the various character-defining elements of the power system. Dylan Person assisted with the photographic overview series of the 26.45-mile segment under review. Dylan Person also developed the GIS-based maps in this report using the geospatial data obtained during fieldwork. He then put together both photographic series found in Appendix A. Finally, Laura O'Neill, DRI's architectural historian, served as technical editor for the document ensuring that it followed professional standards for built environment historic contexts. Carrie Stewart, National Environmental Policy Act Compliance Officer for the NNSA/NFO, served as the program manager overseeing this project.

A number of other people aided the development of this document in special ways. William (Bill) Donahoe, Director of Operations and Technical services for The Delphi Groupe, spent a day with several of us from DRI explaining how the NNSS power transmission system works and taking us on a tour of the system from the Mercury Switching Station, northward through the mission corridor, to the mothballed Yucca Flat Substation. Bill began work on the NNSS power transmission system when it was initially built in the forward areas during the 1960s, so his insight on its development and function is unique. He graciously acknowledges that the hard work of keeping the system up and running was accomplished not by engineers like himself, but by the linemen who worked on it day in, day out; they were the ones to identify problems and develop practical solutions to keep the whole system running for so long.

Two other people were important to the success of this project. James (Jim) Anderson, the Power System Principal Engineer, Mission Support and Test Services, gave us a tour of the Mercury Switching Station

control facility. This building houses all the engineering drawings related to the historic 138 kV power transmission system, and Jim allowed us to review the innumerable drawings that are stored there in specialized cases. Finally, we received assistance from Martha DeMarre, former archivist at the Nuclear Testing Archive in Las Vegas and current archivist at DRI, who obtained engineering drawings, photographs, and manuals about the power system for our review. She also accompanied the senior author to the Mercury Switching Station control facility when Jim Anderson offered DRI access to the engineering drawings held there.

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APPENDIX A

Photographic Documentation
(Stipulation III.C.2)

Photograph Series

- 138 kV Power Transmission System Overview Series
- 138 kV Power Transmission System Character-defining Elements Series

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INDEX TO PHOTOGRAPHS

138 KILOVOLT POWER TRANSMISSION SYSTEM: OVERVIEW SERIES
State Historic Preservation Office Resource Number S1725
Mercury Valley to Yucca Flat, approximately 27 miles in length
Nevada National Security Site, Areas 3, 5, 6, and 23
Nye County, Nevada

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Dylan Person, Photographer, July 2021

1 Mercury Switching Station and southern terminus of power transmission line, facing south (Mile 0.12) (2113MIT-B_001).

2 Power transmission line bearing north-northwest from Mercury Switching Station, facing north-northwest (Mile 0.05) (2113MIT-B_003).

3 Power transmission line near Mercury Switching Station bearing along west side of Mercury, facing north-northwest (Mile 0.12) (2113MIT-B_002).

4 Dead end structure at turn in powerline, west side of Mercury, facing north-northwest (Mile 0.55) (2113MIT-B_004).

5 Power transmission line bearing along west side of Mercury, facing northeast (Mile 0.67) (2113MIT-B_006).

6 Power transmission line bearing northward toward Checkpoint Pass, facing northeast (Mile 1.37) (2113MIT-B_008).

7 Power transmission line bearing through Checkpoint Pass, facing northeast (Mile 2.65) (2113MIT-B_010).

8 High tension suspension structure on hill crest at Checkpoint Pass, facing north-northwest (Mile 3.32) (2113MIT-B_012).

9 Power transmission line on south side of Checkpoint Pass, facing south-southeast (Mile 4.37) (2113MIT-B_014).

10 Power transmission line bearing north from Burma Road, facing north-northwest (Mile 4.43) (2113MIT-B_015).

11 Power transmission line bearing northward across Frenchman Flat, facing north (Mile 5.97) (2113MIT-B_017).

12 Power transmission line bearing northward towards Frenchman Flat, facing north (Mile 6.09) (2113MIT-B_018).

13 Power transmission line from Mercury Highway bearing northward across Frenchman Flat, facing north (Mile 7.59) (2113MIT-B_019).

14 Power transmission line from Mercury Highway towards Check Point Pass, facing south (Mile 7.59) (2113MIT-B_020).

15 Power transmission line in southern portion of Frenchman Flat, facing south (Mile 11.38) (2113MIT-B_021).

16 Power transmission line in the central portion of Frenchman Flat, facing north (Mile 11.38) (2113MIT-B_022).

17 Power transmission line at Frenchman Flat Substation, south junction, facing north-northwest (Mile 14.3) (2113MIT-B_023).

18 Power transmission line from north side of Frenchman Flat Substation, facing northwest (Mile 14.67) (2113MIT-B_025).

19 Power transmission line in northern portion of Frenchman Flat, facing northwest (Mile 14.87) (2113MIT-B_026).

20 Power transmission line in northern portion of Frenchman Flat, facing southeast (Mile 16.37) (2113MIT-B_027).

21 Power transmission line in northern portion of Frenchman Flat bearing towards Yucca Pass, facing northwest (Mile 16.37) (2113MIT-B_028).

22 Power transmission line at northern margin of Frenchman Flat toward Yucca Pass, facing northwest (Mile 19.65) (2113MIT-B_029).

23 Power transmission line bearing through Yucca Pass, facing north (Mile 21.11) (2113MIT-B_031).

24 Power transmission line running through Yucca Pass, facing south (Mile 21.11) (2113MIT-B_032).

25 Power transmission line at Tippipah and Mercury Highways, view towards Yucca Pass (Mile 22.33) (2113MIT-B_033).

26 Power transmission line bearing northward through Yucca Flat along east side of Mercury Highway, facing north (Mile 22.33) (2113MIT-B_034).

27 Junction of power transmission line and Tweezer Substation, facing south-southeast (Mile 24.15) (2113MIT-B_035).

28 Power transmission line north of Tweezer Substation on Yucca Flat, facing north-northwest (Mile 24.15) (2113MIT-B_036).

29 Power transmission line bearing northward through Yucca Flat, facing north (Mile 26.55) (2113MIT-B_037).

30 Power transmission line from Yucca Flat Substation bearing southwards towards Yucca Pass, facing south (Mile 26.55) (2113MIT-B_038).

31 Power transmission line near the north end of U1a facility, facing south (Mile 27.32) (2113MIT-B_039).

32 Power transmission line bearing northward to Yucca Flat Substation, facing north (Mile 27.38) (2113MIT-B_040).

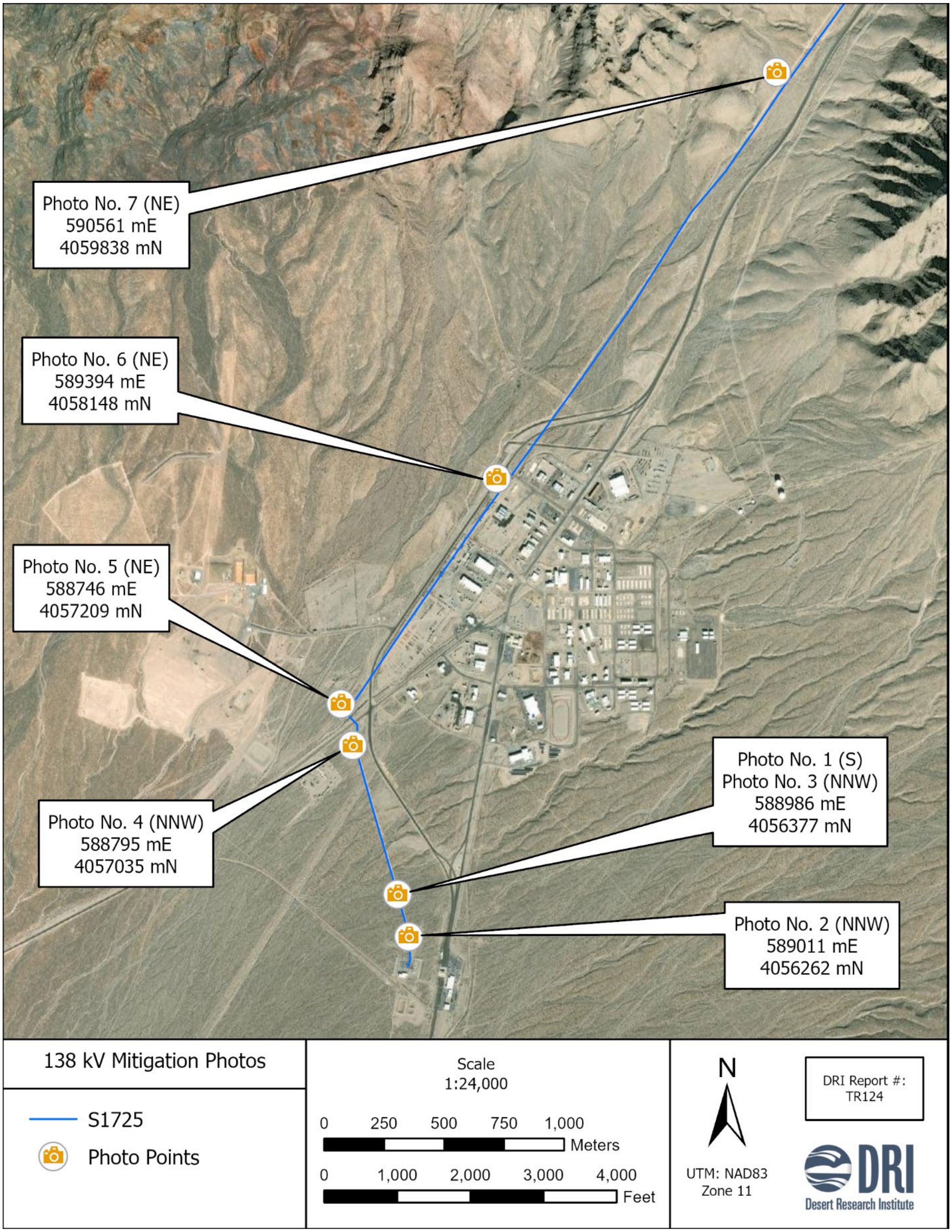

Photo Plan: 138 kV Power Transmission System Photographic Documentation: Overview Series, Map 1.

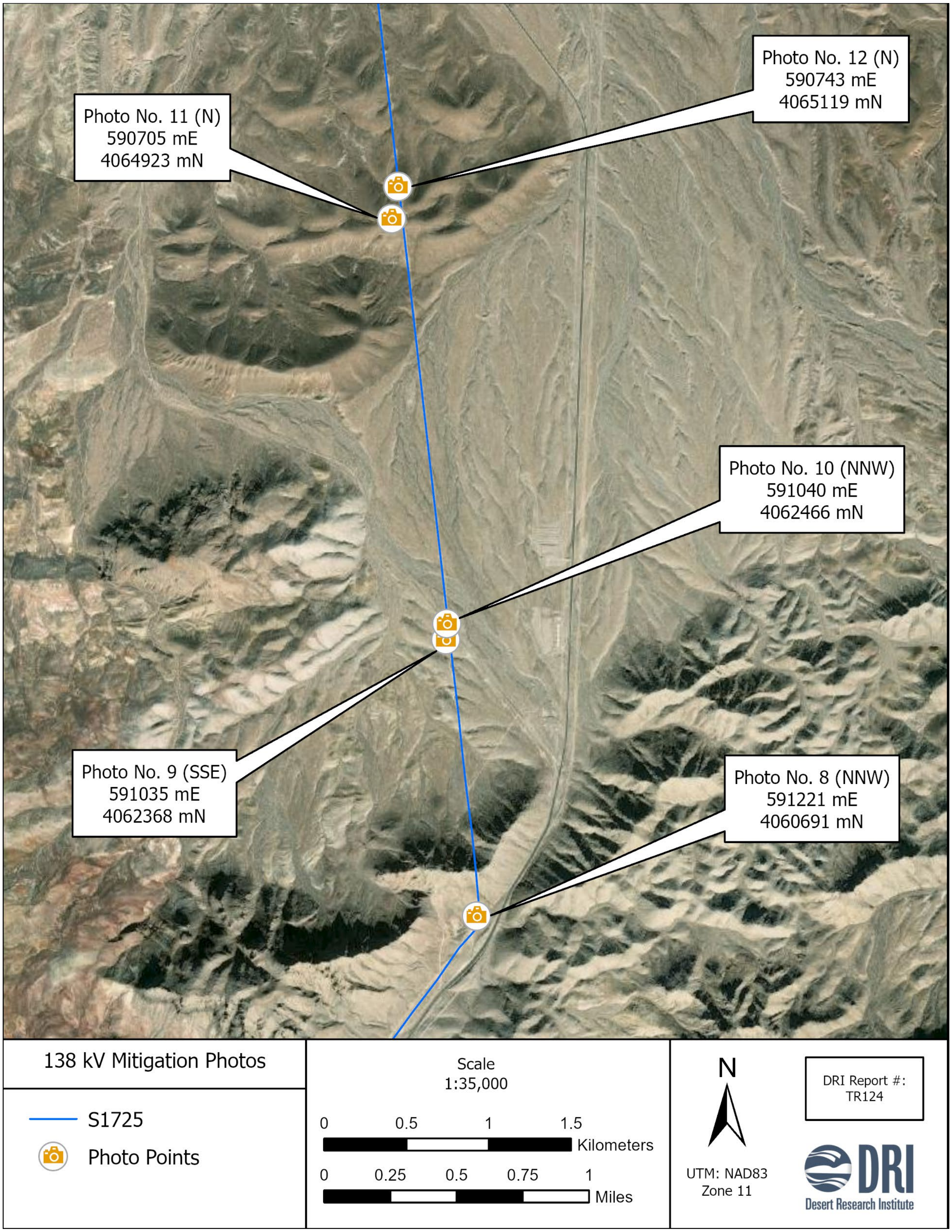

Photo Plan: 138 kV Power Transmission System Photographic Documentation: Overview Series, Map 2.

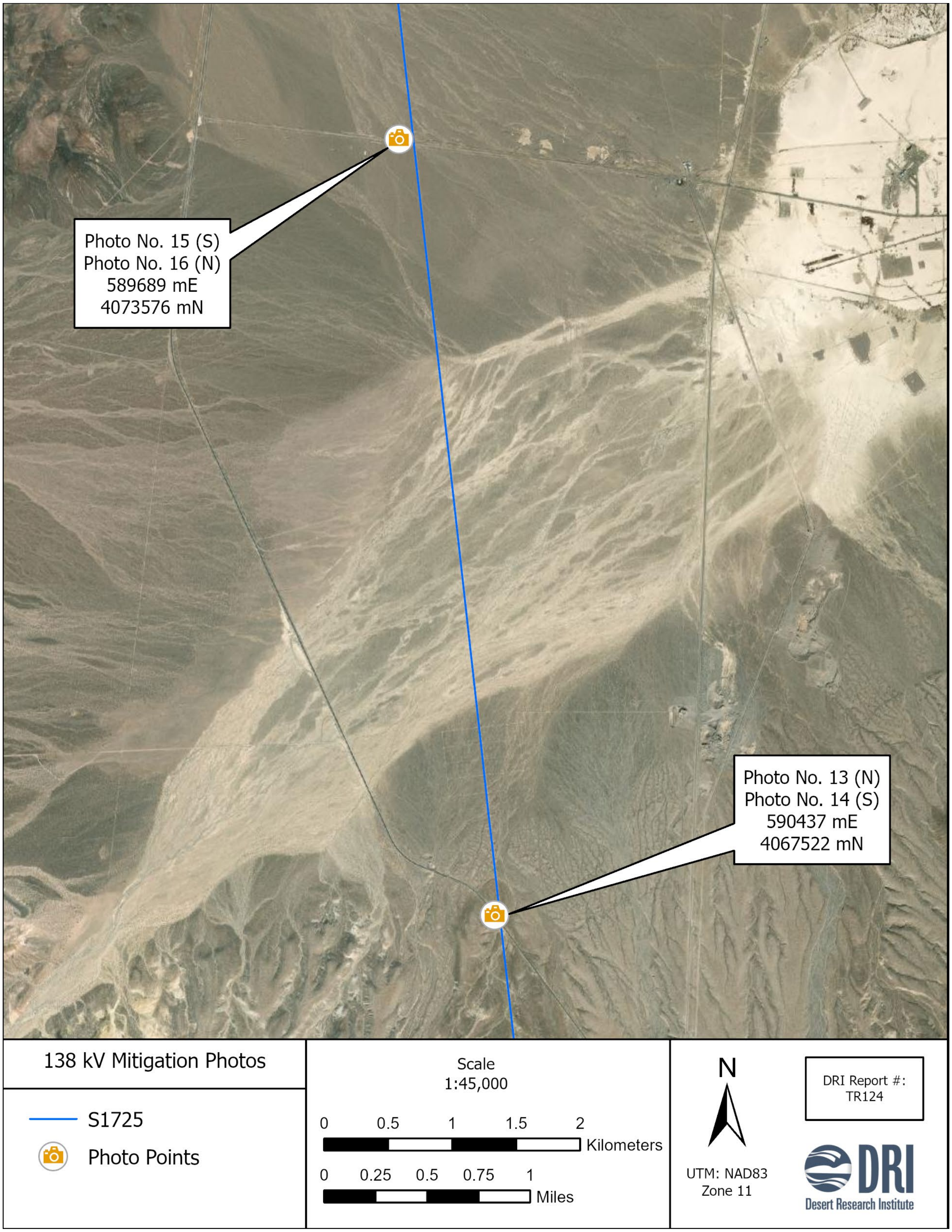

Photo Plan: 138 kV Power Transmission System Photographic Documentation: Overview Series, Map 3.

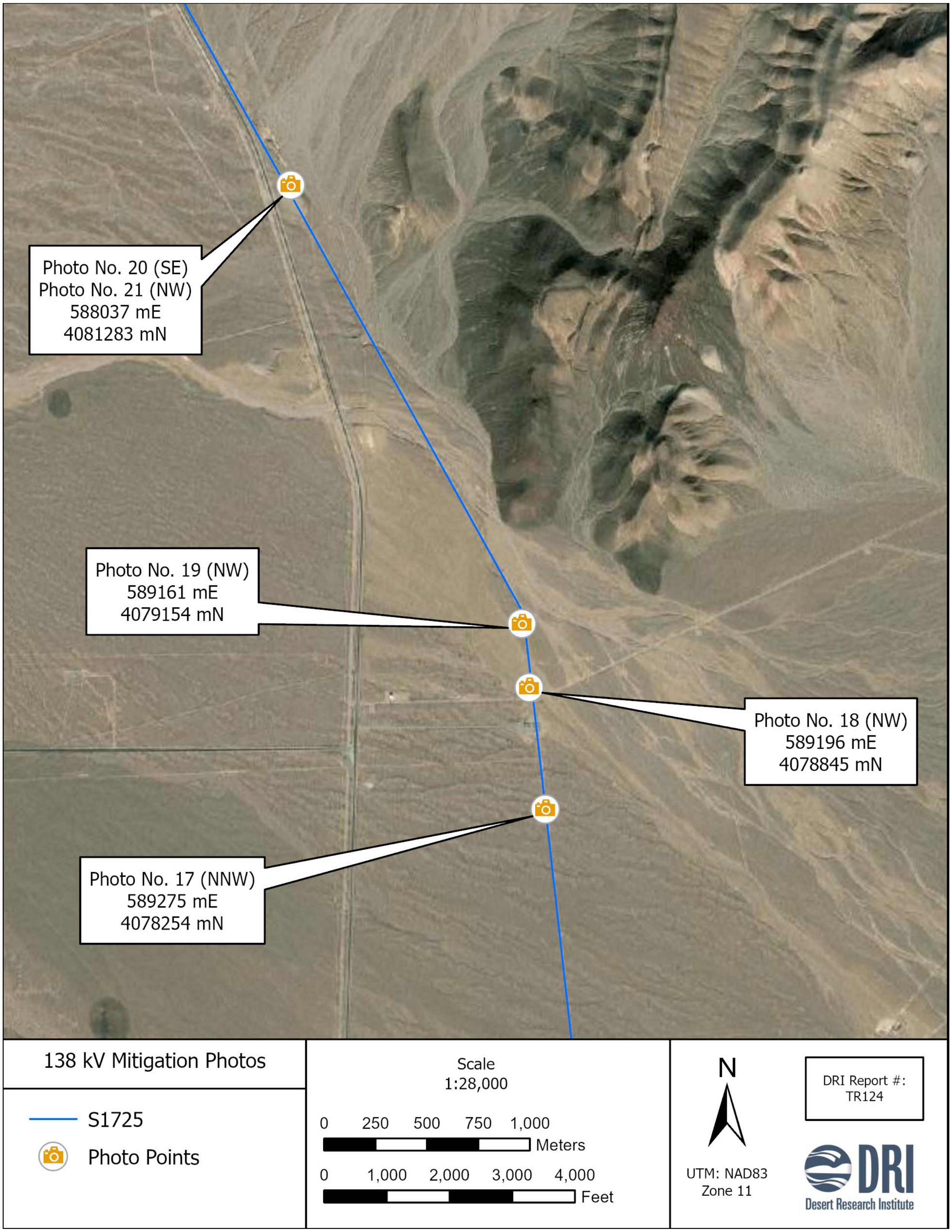

Photo Plan: 138 kV Power Transmission System Photographic Documentation: Overview Series, Map 4.

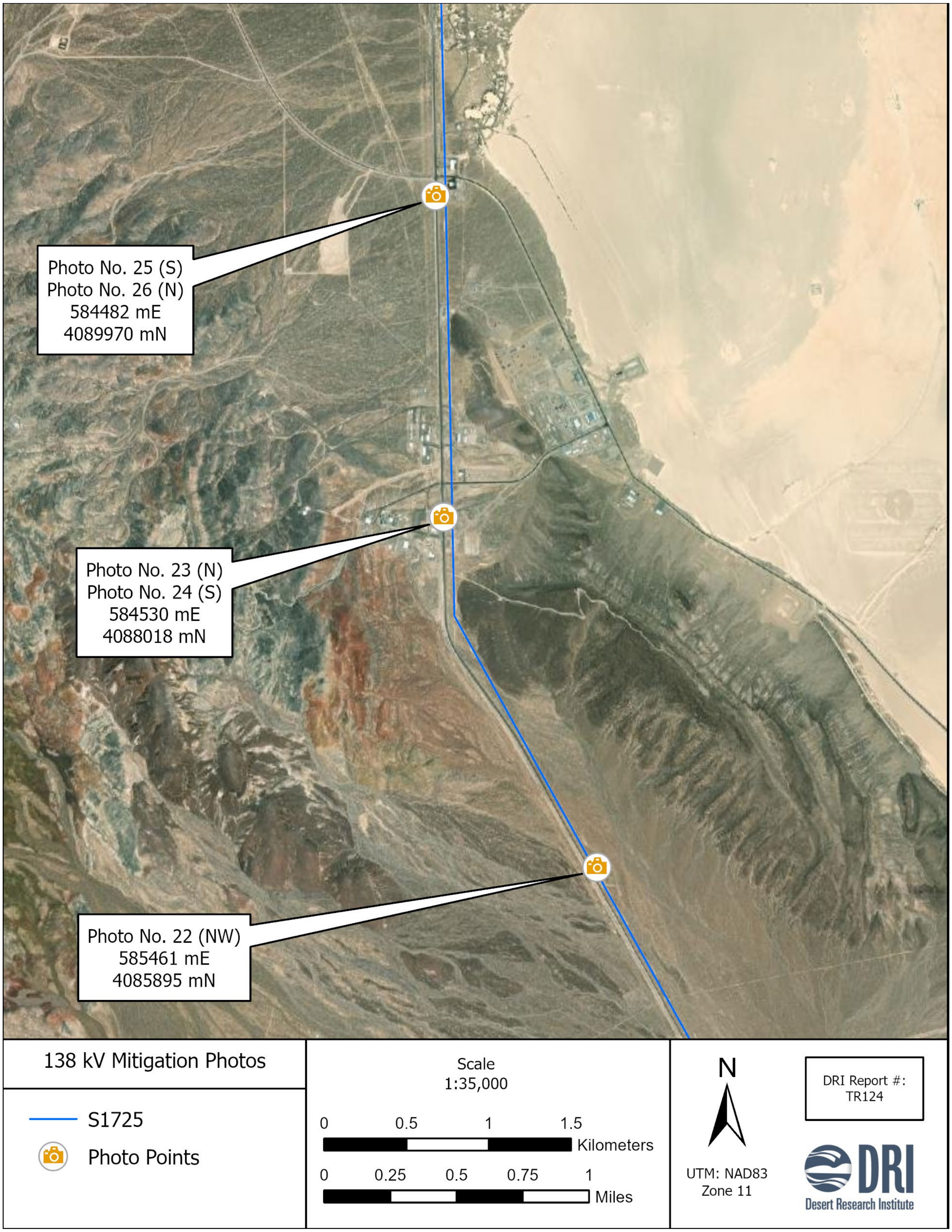

Photo Plan: 138 kV Power Transmission System Photographic Documentation: Overview Series, Map 5.

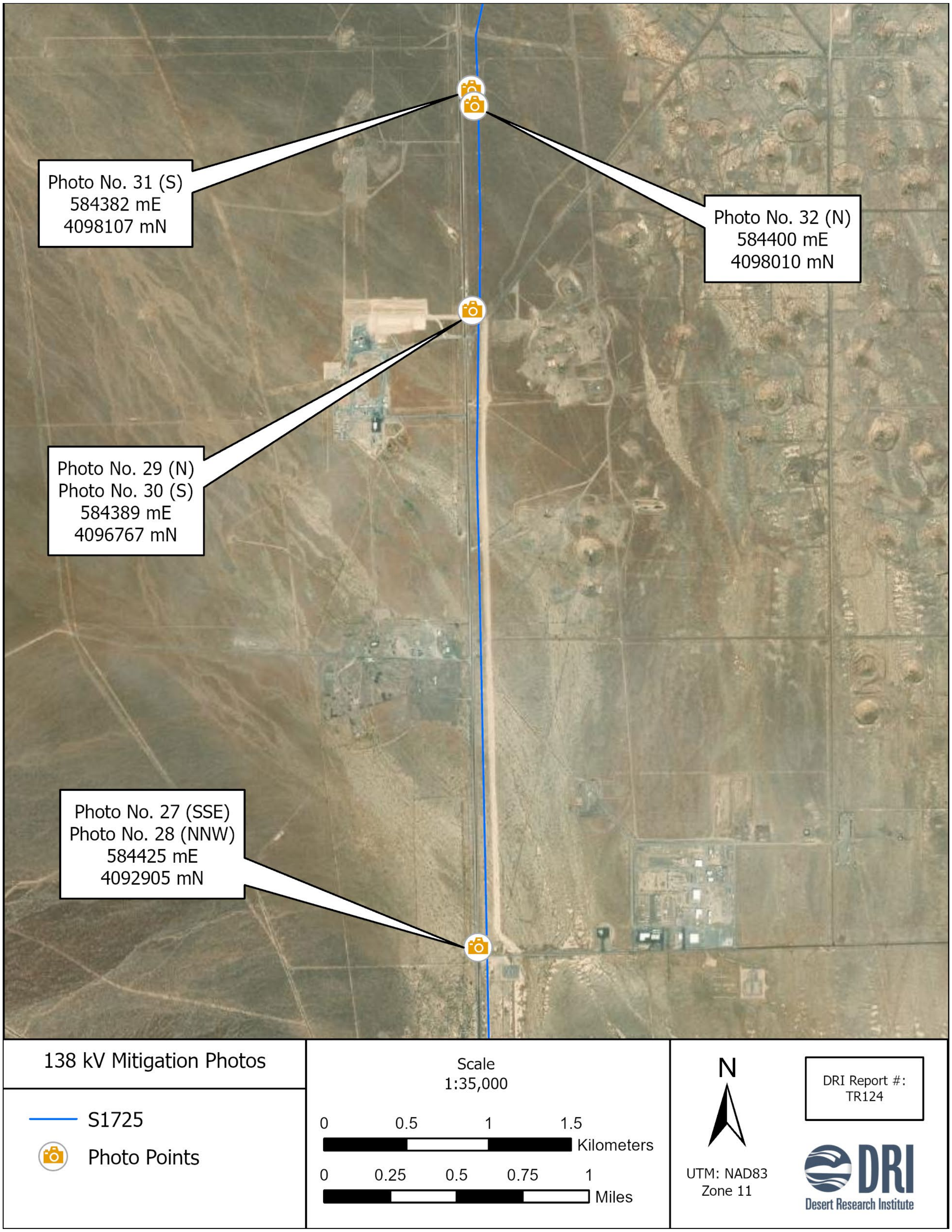

Photo Plan: 138 kV Power Transmission System Photographic Documentation: Overview Series, Map 6.

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Photo No. 2. Power transmission line bearing north-northwest from Mercury Switching Station, facing north-northwest (Mile 0.05).

Photo No. 3. Power transmission line near Mercury Switching Station bearing along west side of Mercury, facing north-northwest (Mile 0.12).

Photo No. 4. Dead end structure at turn in powerline, west side of Mercury, facing north-northwest (Mile 0.55).

Photo No. 5. Power transmission line bearing along west side of Mercury, facing northeast (Mile 0.67).

Photo No. 6. Power transmission line bearing northward toward Checkpoint Pass, facing northeast (Mile 1.37).

Photo No. 7. Power transmission line bearing through Checkpoint Pass, facing northeast (Mile 2.65).

Photo No. 8. High tension suspension structure on hill crest at Checkpoint Pass, facing north-northwest (Mile 3.32).

Photo No. 9. Power transmission line on south side of Checkpoint Pass, facing south-southeast (Mile 4.37).

Photo No. 10. Power transmission line bearing north from Burma Road, facing north-northwest (Mile 4.43).

Photo No. 11. Power transmission line bearing northward across Frenchman Flat, facing north (Mile 5.97).

Photo No. 12. Power transmission line bearing northward toward Frenchman Flat, facing north (Mile 6.09).

Photo No. 13. Power transmission line from Mercury Highway bearing northward across Frenchman Flat, facing north (Mile 7.59).

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Photo No. 15. Power transmission line in the southern portion of Frenchman Flat, facing south (Mile 11.38).

Photo No. 16. Power transmission line in the central portion of Frenchman Flat, facing north (Mile 11.38).

Photo No. 17. Power transmission line at Frenchman Flat Substation, south junction, facing north-northwest (Mile 14.3).

Photo No. 18. Power transmission line from north side of Frenchman Flat Substation, facing northwest (Mile 14.67).

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Photo No. 20. Power transmission line in northern portion of Frenchman Flat, facing southeast (Mile 16.37).

Photo No. 21. Power transmission line in northern portion of Frenchman Flat bearing towards Yucca Pass, facing northwest (Mile 16.37).

Photo No. 22. Power transmission line at northern margin of Frenchman Flat toward Yucca Pass, facing northwest (Mile 19.65).

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Photo No. 25. Power transmission line at Tippipah and Mercury Highways, view towards Yucca Pass, looking south (Mile 22.33)

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Photo No. 27. Junction of power transmission line and Tweezer Substation, facing south-southeast (Mile 24.15).

Photo No. 28. Power transmission line north of Tweezer Substation on Yucca Flat, facing north-northwest (Mile 24.15).

Photo No. 29. Power transmission line bearing northward through Yucca Flat, facing north (Mile 26.55).

Photo No. 30. Power transmission line from Yucca Flat Substation bearing southwards towards Yucca Pass, facing south (Mile 26.55)

Photo No. 31. Power transmission line near the north end of U1a facility, facing south (Mile 27.32).

Photo No. 32. Power transmission line bearing northward to Yucca Flat Substation, facing north (Mile 27.38).

138 KILOVOLT POWER TRANSMISSION SYSTEM: DETAIL SERIES
State Historic Preservation Office Resource Number S1725
Mercury Valley to Yucca Flat, approximately 27 miles in length
Nevada National Security Site, Areas 3, 5, 6, and 23
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Tatianna Menocal (DRI), Photographer, June 2017
Gregory Haynes (DRI), Photographer, April 2021
Jeffrey Wedding (DRI), Photographer, June 2021
Dylan Person (DRI), Photographer, September 2021

1 Mercury Switching Station general view, facing north-northwest (2113MIT_2534).

2 Mercury Switching Station, NV Energy 138 kV power transmission line junction with switching station, facing north (2113MIT-D_0002)

3 Mercury Switching Station, detail of lower bus system and circuitry, facing west (2113MIT-D_0005).

4 Mercury Switching Station, detail of lower bus system for NNSS 138 kV power transmission system, facing southwest (2113MIT-D_0018).

5 Mercury Switching Station, detail of gas circuit breakers, facing west-northwest (2113MIT-A_3012).

6 Frenchman Flat Substation general view, facing west (2113MIT-C_0006).

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8 Frenchman Flat Substation 138 kV gas circuit breaker and incoming transmission line scaffolding, facing northwest (2113MIT-A_3070).

9 Frenchman Flat Substation transformers, facing north (2113MIT-A_3074).

10 Frenchman Flat Substation, detail of old transformer model with cooling fins, facing north (2113MIT-A_3075).

11 Frenchman Flat Substation, detail of new transformer model with cooling turbines, facing east (2113MIT-A_3078).

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14 H-frame structure, detail of conductor wire with long-rod insulator attached to end of crossbeam, facing north-northeast (2113MIT-A_3023).

15 H-frame structure, detail of X-brace and pole tensioner, facing north-northeast (2113MIT-A_3024).

16 H-frame structure, detail of X-brace and pole tensioner hardware, facing north-northeast (2113MIT-A_3025).

17 Detail of structure alphanumeric designation with ground wire on right and modern fiber optic box on opposite side, facing northwest (2113MIT-A_3029).

18 H-frame structure, detail of ground wire placed vertically along length of pole, facing southwest (2113MIT-A_3031).

19 H-frame structure, detail of modern fiber optic box attached to wooden utility pole, facing southeast (2113MIT-A_3033).

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26 High tension suspension structure, detail of conductor wires, long-rod insulators, and associated hardware, facing west (2113MIT-A_3054).

27 High tension suspension structure, detail of base with modern fiber optic box, facing west (2113MIT-A_3056).

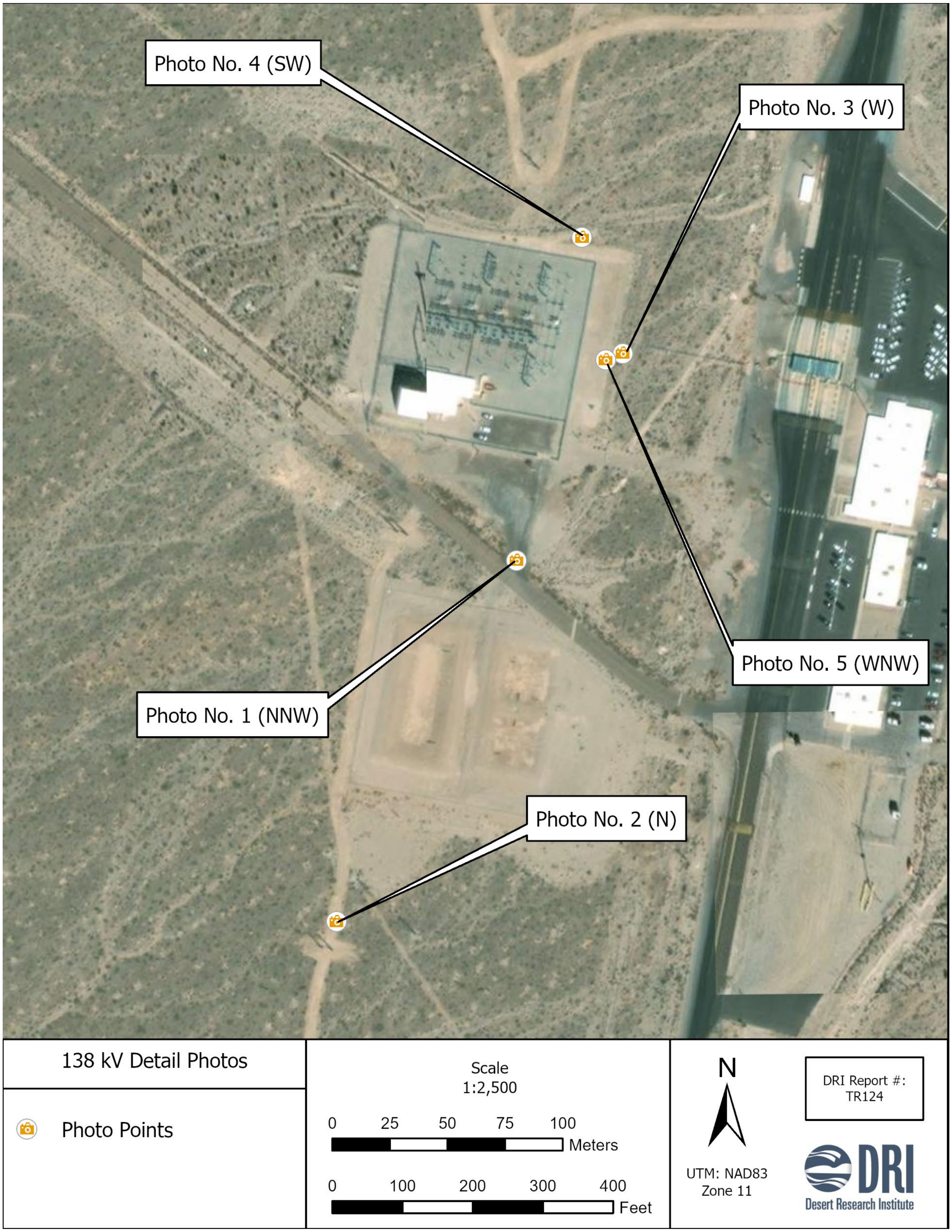

Photo Plan: 138 kV Power Transmission System Photographic Documentation:
Detail Series, Mercury Switching Station (588985 mE, 4056125 mN). Map 1.

Photo Plan: 138 kV Power Transmission System Photographic Documentation:
Detail Series, Frenchman Flat Substation (589180 mE, 4078695 mN). Map 2.

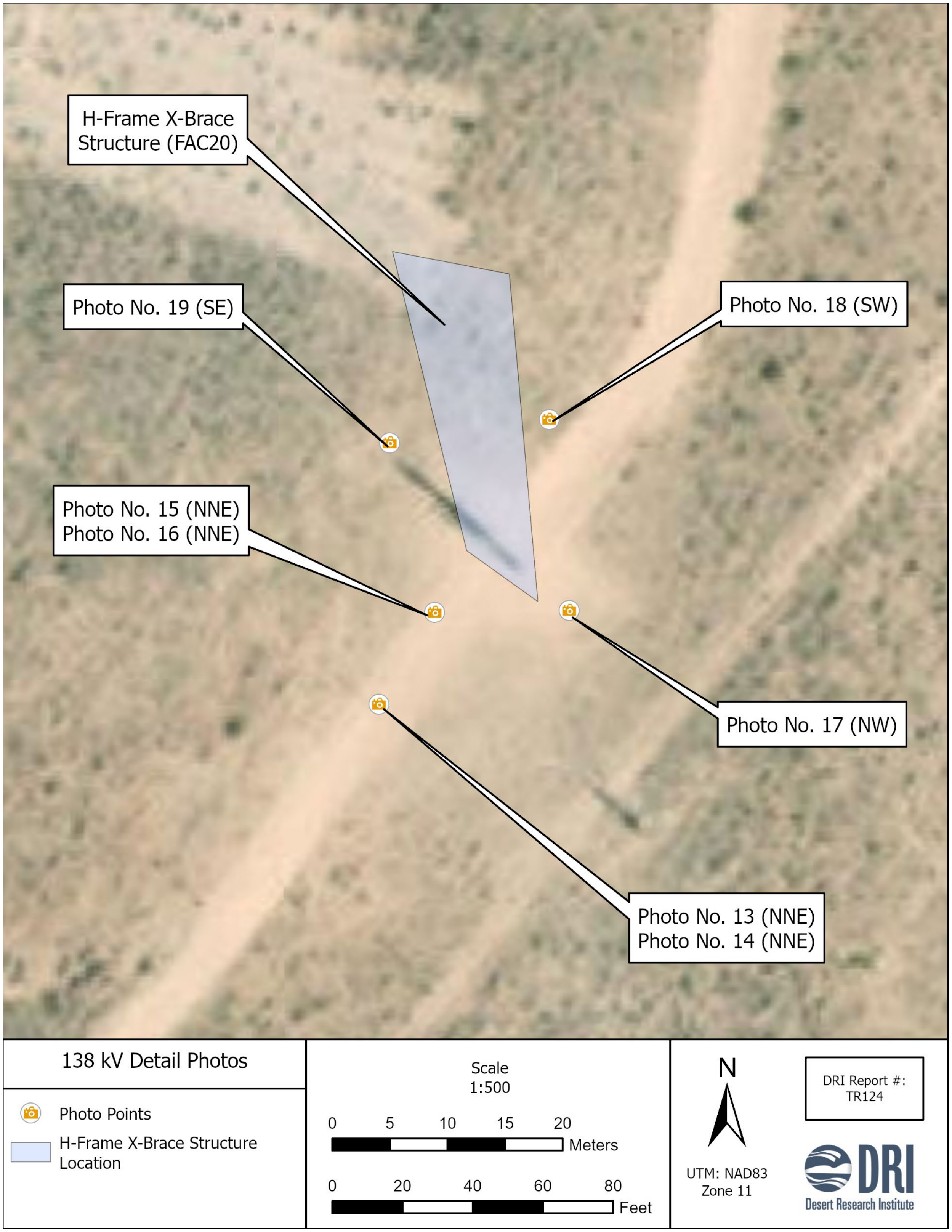

Photo Plan: 138 kV Power Transmission System Photographic Documentation:
Detail Series, H-frame Structure No. FAC 20 (591095 m E, 4060545 mN). Map 3.

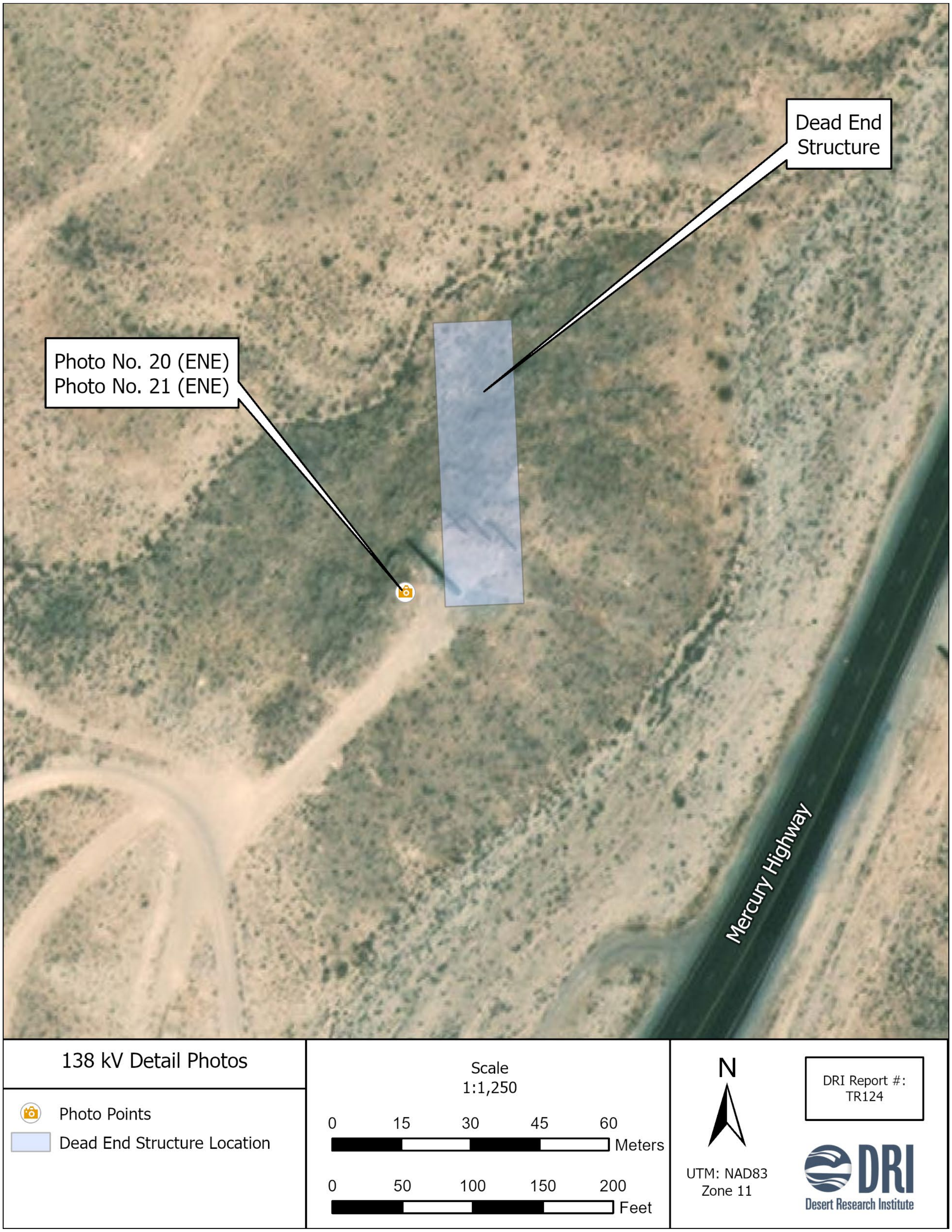

Photo Plan: 138 kV Power Transmission System Photographic Documentation:
Detail Series, Dead End Structure (591205 mE, 4060685 mN). Map 4.

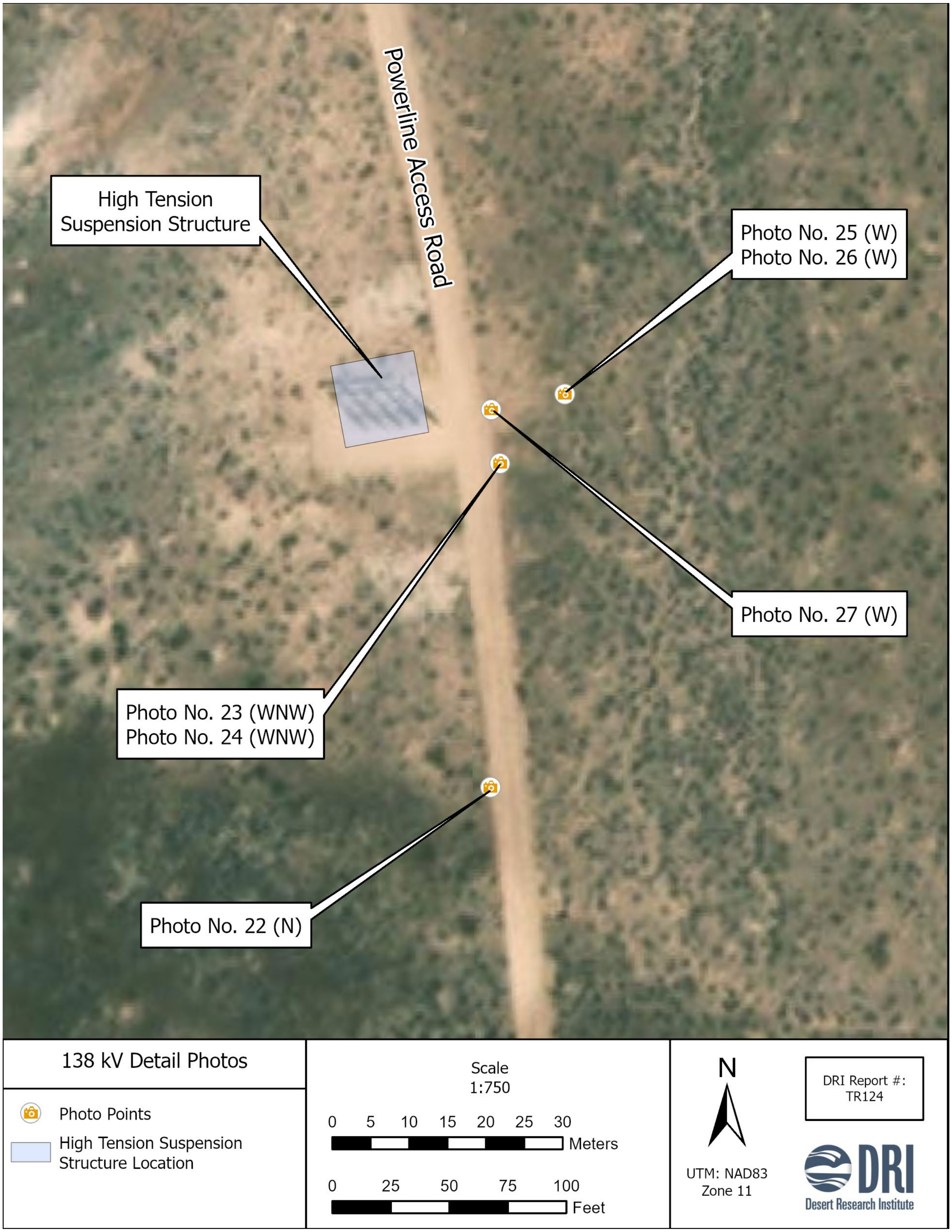

Photo Plan: 138 kV Power Transmission System Photographic Documentation: Detail Series, High Tension Suspension Structure (590788 mE, 4064658 mN). Map 5.

Photo No. 1. Mercury Switching Station general view, facing north-northwest (NV Energy 138 kV scaffolding tower in mid-frame; control houses in left frame).

Photo No. 2. Mercury Switching Station, NV Energy 138 kV power transmission line junction with switching station, facing north (power line junctions with switching station on large scaffolding tower mid-frame; control houses are below and left of tower).

Photo No. 3. Mercury Switching Station, detail of lower bus system and circuitry, facing west (NV Energy 138 kV powerline junction is on scaffolding tower in profile view mid-frame).

Photo No. 4. Mercury Switching Station, detail of lower bus system for NNSS 138 kV power transmission system, facing southwest (note scaffolding tower in mid-frame).

Photo No. 5. Mercury Switching Station, detail of gas circuit breakers, facing west-northwest.

Photo No. 6. Frenchman Flat Substation general view, facing west.

Photo No. 7. Frenchman Flat Substation control houses, facing east.

Photo No. 8. Frenchman Flat Substation 138 kV gas circuit breaker and incoming transmission line scaffolding, facing northwest.

Photo No. 9. Frenchman Flat Substation transformers, facing north (transformer to right is older model, whereas transformer to left is newer model).

Photo No. 10. Frenchman Flat Substation, detail of old transformer model with cooling fins, facing north.

Photo No. 11. Frenchman Flat Substation, detail of new transformer model with cooling turbines, facing east.

Photo No. 12. Frenchman Flat Substation 34.5 kV distribution system scaffolding and circuitry, facing southwest (transformers in background, scaffolding and 34.5 kV electrical circuitry foreground, 34.5 kV gas circuit breakers below scaffolding and circuitry).

Photo No. 13. Typical H-frame structure with X-brace, facing north-northeast.

Photo No. 14. H-frame structure, detail of conductor wire and long-rod insulator attached to end of crossbeam, facing north-northeast.

Photo No. 15. H-frame structure, detail of X-brace and pole tensioner, facing north-northeast.

Photo No. 16. H-frame structure, detail of X-brace and pole tensioner hardware, facing north-northeast.

Photo No. 17. Detail of structure alphanumeric designation with ground wire on right and modern fiber optic box on opposite side, facing northwest.

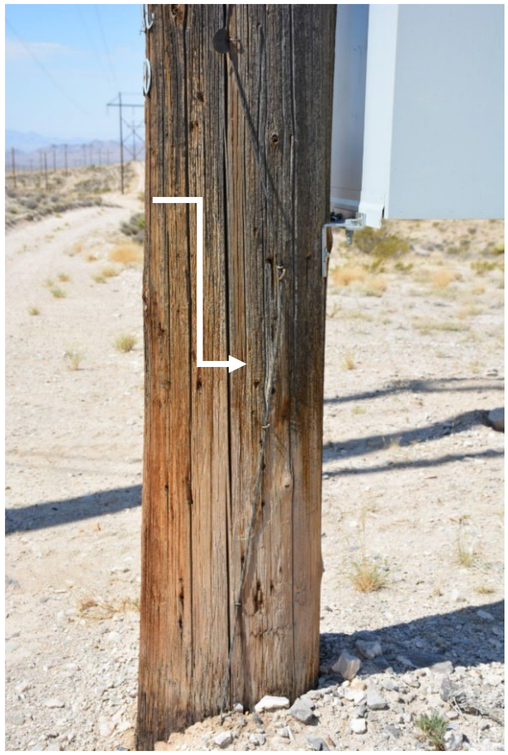

Photo No. 18. H-frame structure, detail of ground wire placed vertically along length of pole, facing southwest.

Photo No. 19. H-frame structure, detail of modern fiber optic box attached to wooden utility pole, facing southeast.

Photo No. 20. Dead end structure, facing east-northeast.

Photo No. 21. Dead end structure, detail of conductor wires, long-rod insulators, and hardware, facing east-northeast (lower insulator held transverse conductor wire, whereas upper insulator held angled conductor wire).

Photo No. 22. High tension suspension structure, frontal view, facing north.

Photo No. 23. High tension suspension structure, oblique view, facing west-northwest.

Photo No. 24. High tension suspension structure, detail with upper braces and power transmission hardware, facing west-northwest.

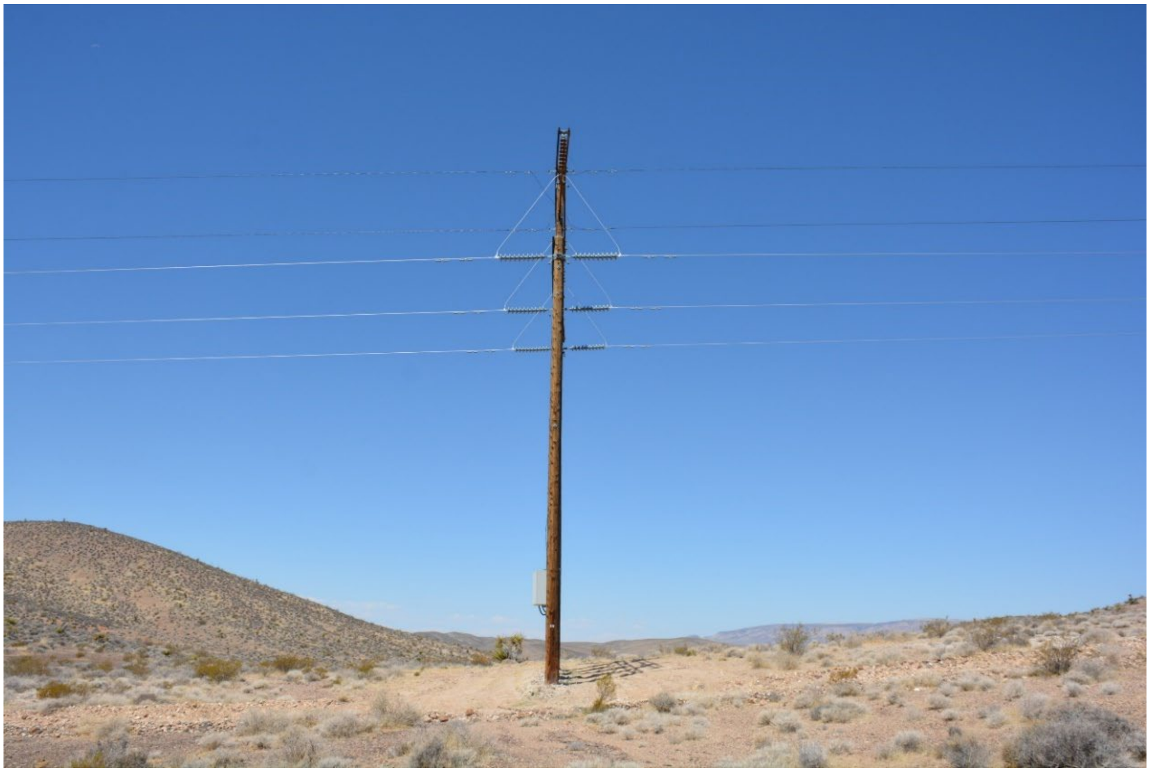

Photo No. 25. High tension suspension structure, side view, facing west.

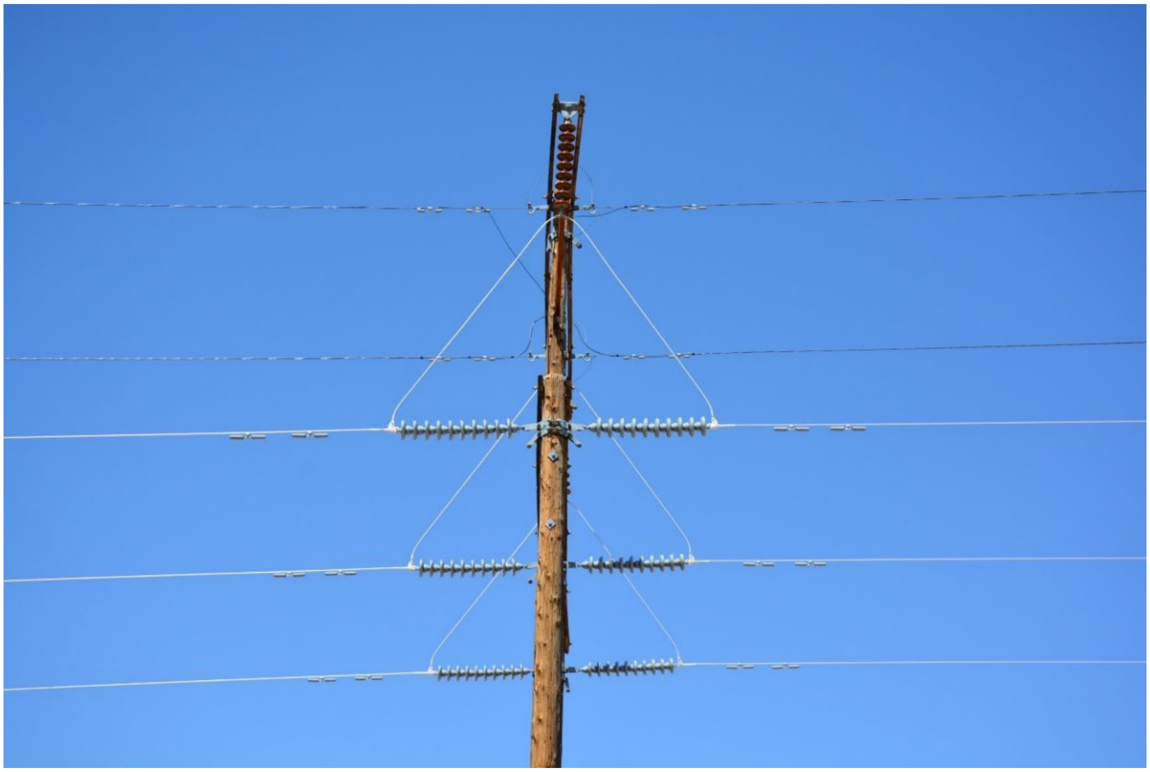

Photo No. 26. High tension suspension structure, detail of conductor wires, long-rod insulators, and associated hardware, facing west.

Photo No. 27. High tension suspension structure, detail of base with modern fiber optic box, facing west.

APPENDIX B

Engineering Drawings

Drawing 1. Plan of the 138 kV transmission system after its completion in 1966, Drawing No. AUX-PAA-0115 (Pan American World Airways Inc. 1966)

Drawing 2. Master Electrical Utility Map: 138 kV power transmission system in 1971, Drawing No. AS-BLT NV-71-03-06, Sheet 303 (Holmes and Narver 1971)

Drawing 3. Master Electrical Utility Maps: Frenchman Flat Substation after its completion in 1966, Drawing No. AS-BLT NV-71-03-06, Sheet 294.I (Stearns-Roger 1966)

Drawing 4. Frenchman Flat electrical and grounding details, Drawing No. NV-71-03-09-E19.1 (Stearns-Roger 1967)

Drawing 5. 138 kV three-pole dead-end structure, Drawing No. NV-71-03-08-E56 (Stearns-Roger 1966)

Drawing 6. 138 kV five-pole high-tension suspension structure, Drawing No. JS-090-080-E307 (Bechtel 1960)

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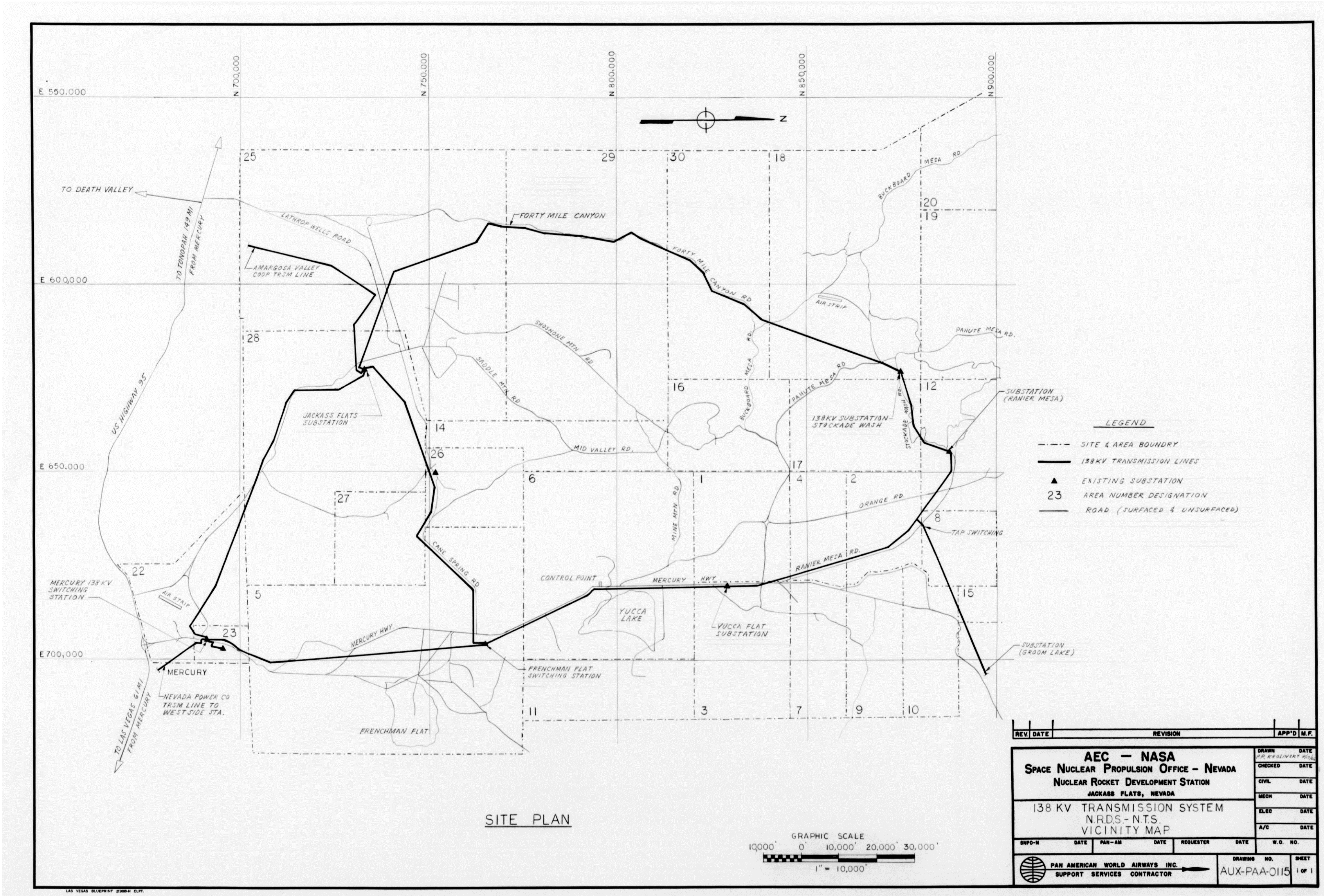

Drawing 1. Plan of the 138 kV power transmission system after its completion in 1966 (Pan American World Airways Inc. 1966).

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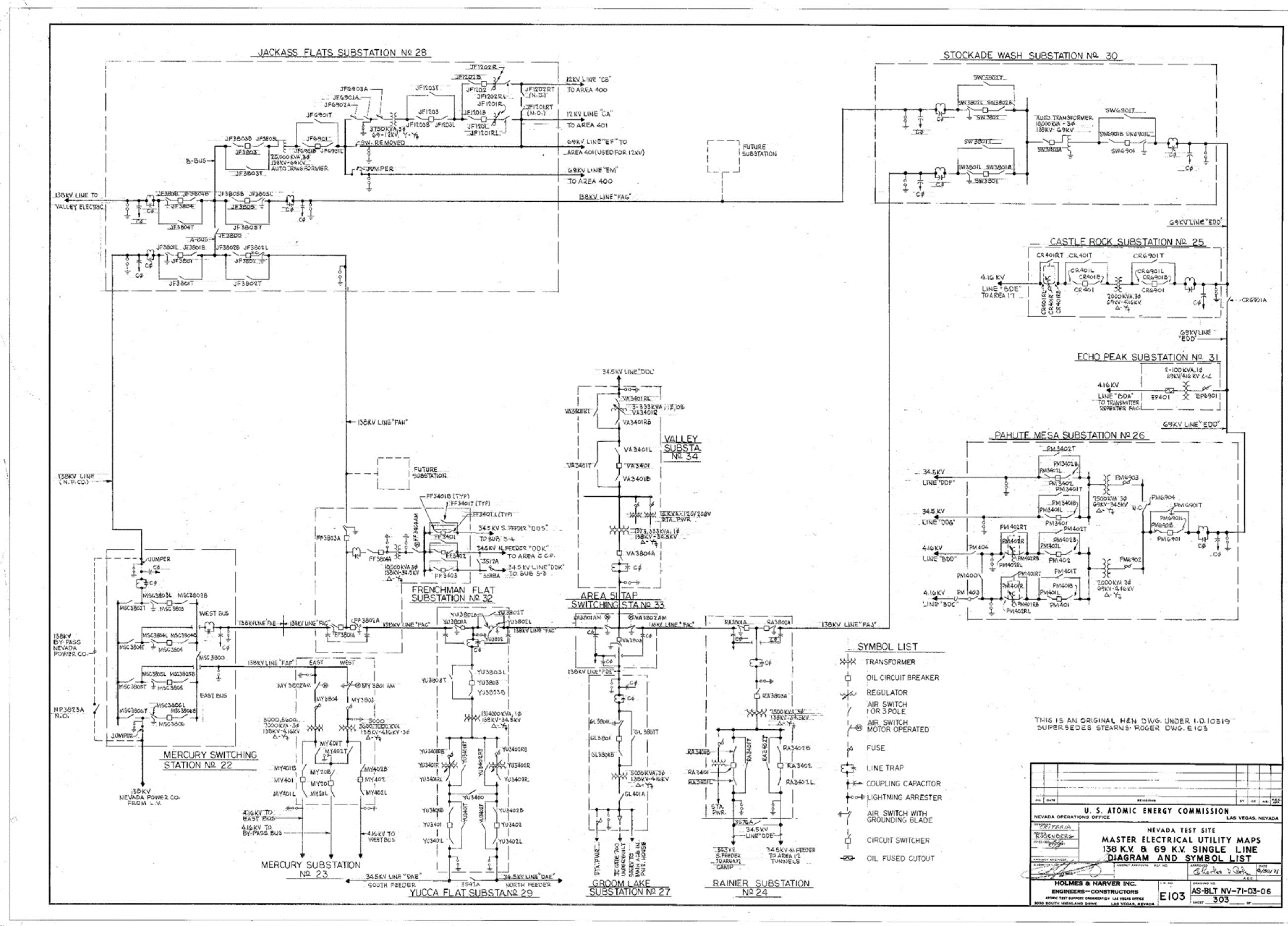

Drawing 2. Master Electrical Utility Map: 138 kV power transmission system in 1971 (Holmes and Narver 1971).

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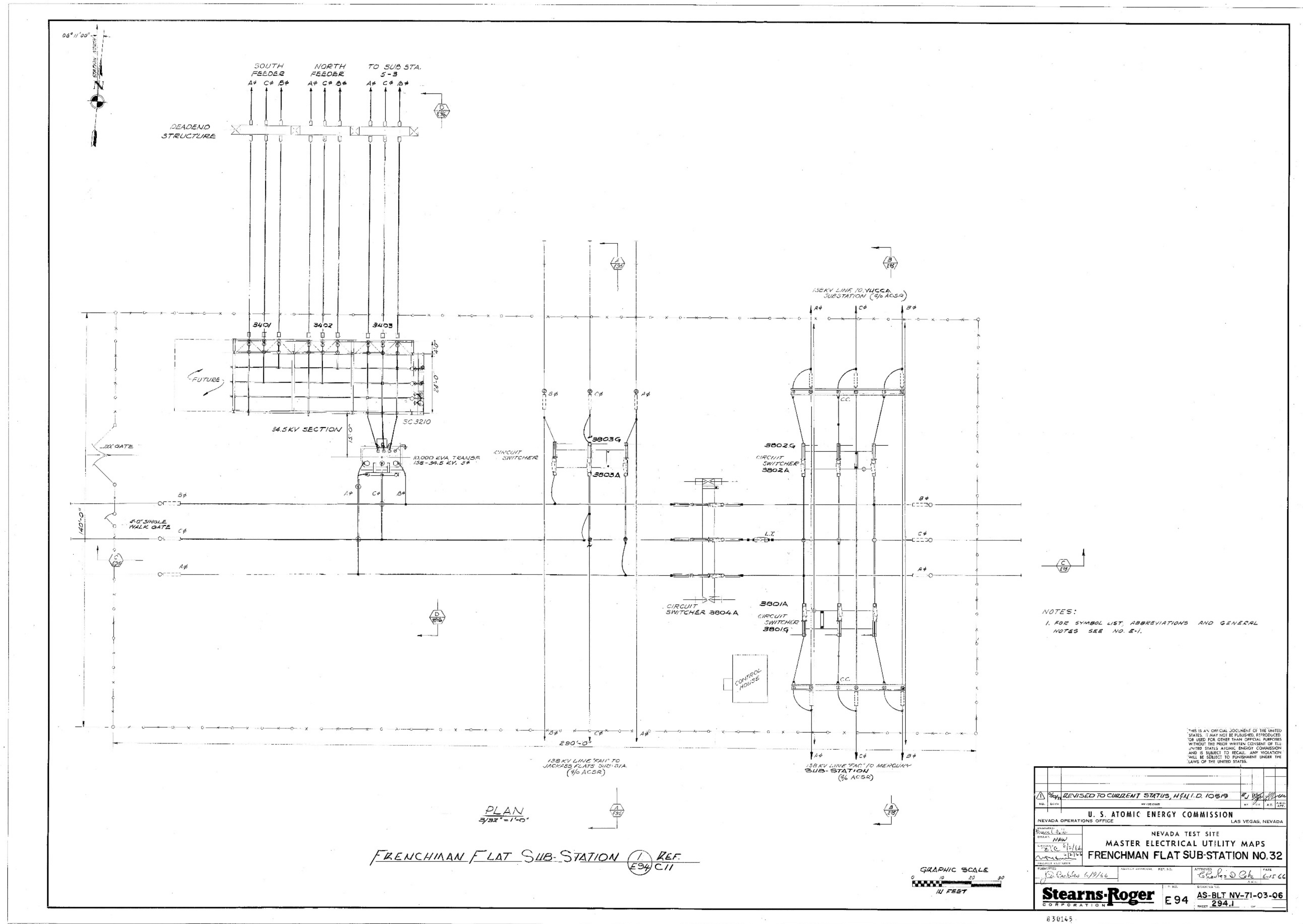

Drawing 3. Master Electrical Utility Maps: Frenchman Flat Substation after completion in 1966 (Stearns-Roger 1966).

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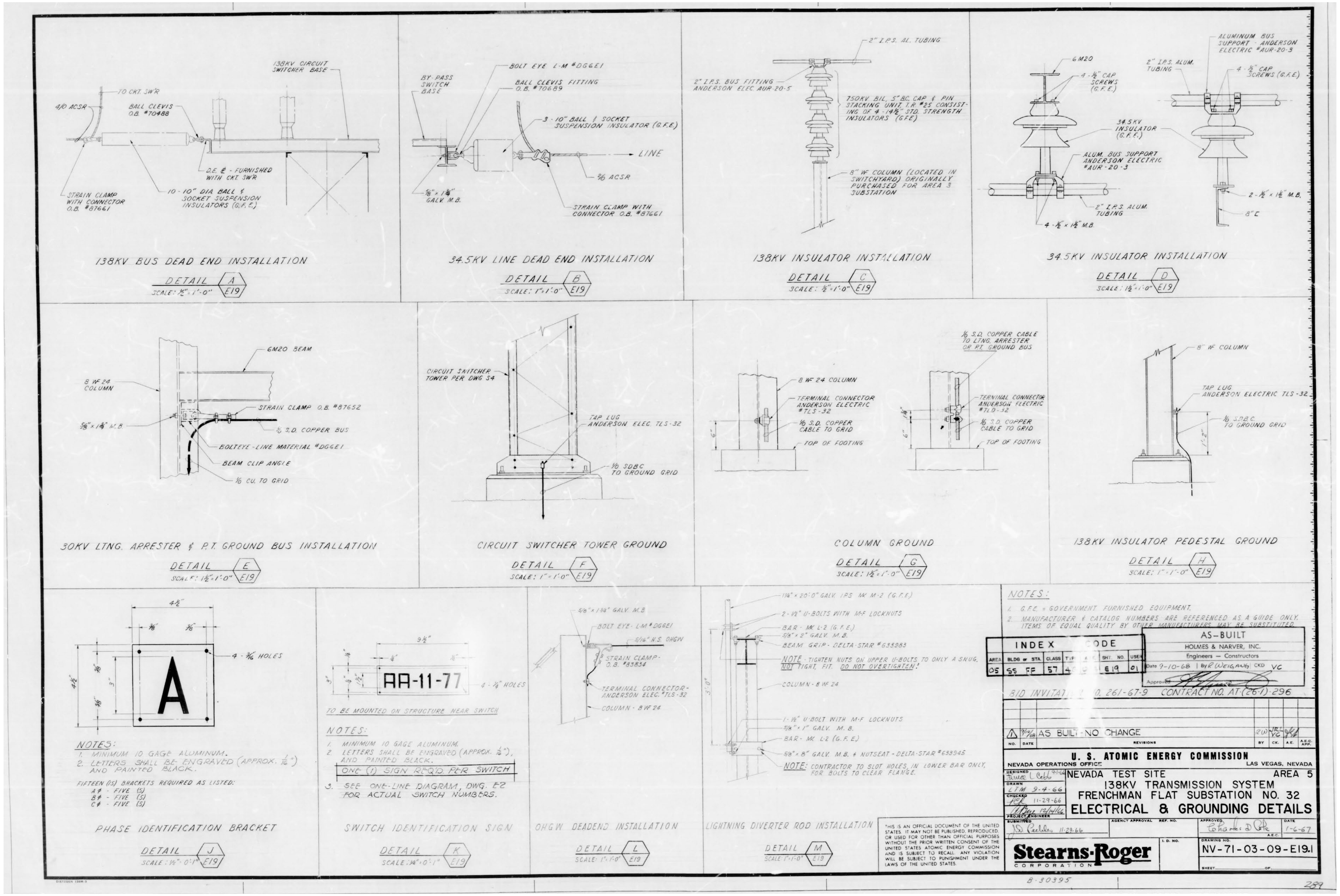

Drawing 4. Frenchman Flat Substation electrical and grounding details (Sterns-Roger 1967).

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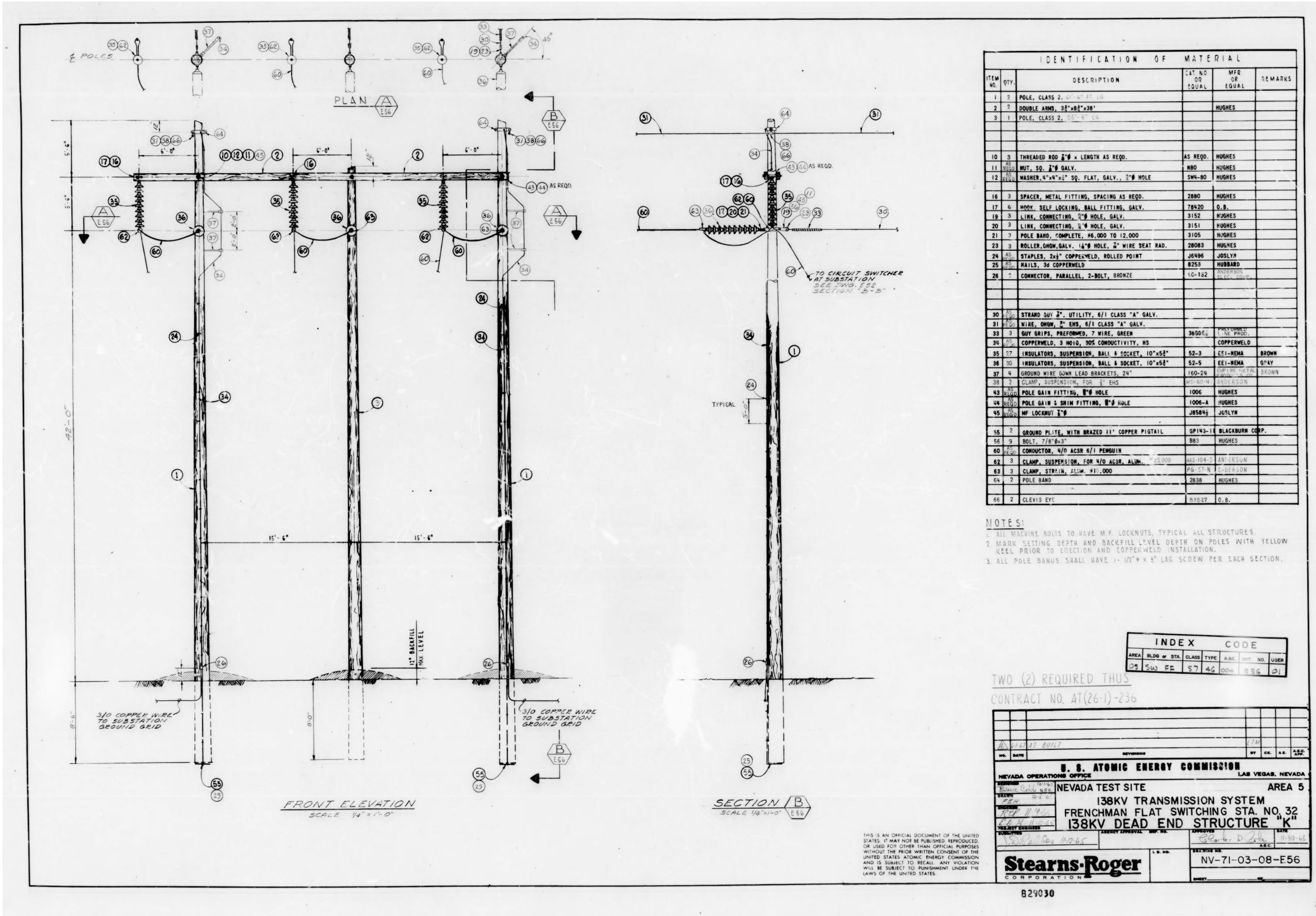

Drawing 5. 138 kV three-pole dead-end structure (Stearns-Roger 1966).

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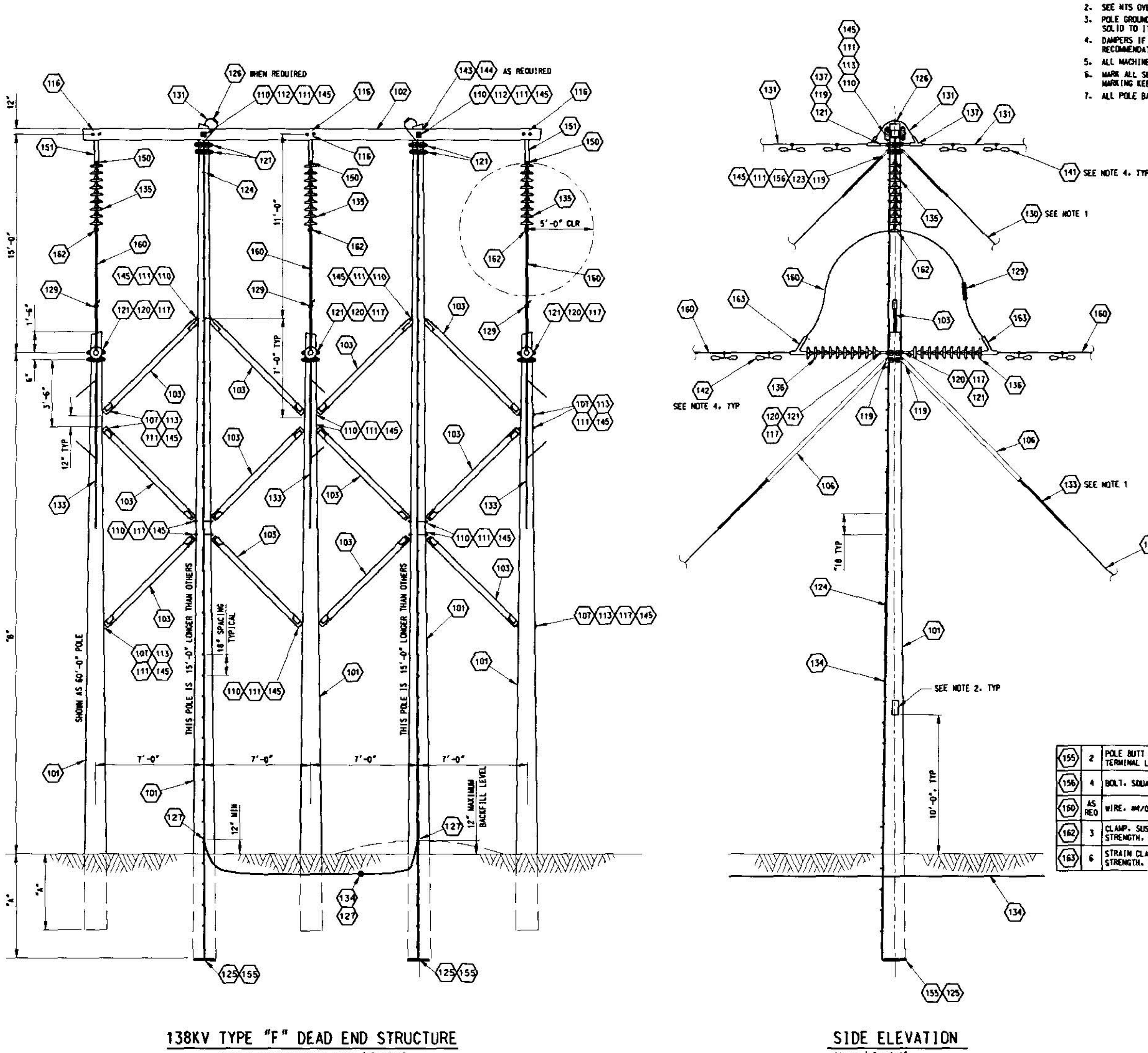

NOTES

1. SEE NTS OVERHEAD POWER LINE STANDARD 80408 FOR GUY DETAILS.
2. SEE NTS OVERHEAD POWER LINE STANDARD 80406 FOR POLE MARKER DETAILS.
3. POLE GROUND WIRES ARE TO CLEAR ALL LINE HARDWARE BY 2" OR BE BONDED SOLID TO IT. BOND GROUND WIRE TO STATIC WIRE POLE BAND.
4. DAMPERS IF USED. SHALL BE USED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS.
5. ALL MACHINE BOLTS WILL HAVE MF LOCKNUTS: TYPICAL ALL STRUCTURES.
6. MARK ALL SETTING AND BACKFILL LEVEL DEPTHS ON POLES WITH YELLOW MARKING KEEL. PRIOR TO ERECTION AND COPPERWELD INSTALLATION.
7. ALL POLE BANDS WILL HAVE ONE (1) 1/2" x 4" LAG SCREW PER EACH SECTION.

BILL OF MATERIAL

ITEM NO	QUAN	DESCRIPTION	CAT NO OR EQUAL	MANUFACTURER OR EQUAL
101	5	POLE. CLASS 1. WESTERN RED CEDAR. SEE TABLE FOR REQUIRED LENGTH.		
102	2	DOUBLE CROSSARM. SIZE AS REQUIRED		HUGHES BROTHERS
103	12	BRACE VEE. 3 3/8'x 4 3/8 x 5'-10" DROP. SPACING. AS REQUIRED	2025	HUGHES BROTHERS
106	6	GUY STRAIN INSULATOR. FIBERGLASS. 35.000 LB. 13/16" DIA ROD. 96" LENGTH	CF696-96	HUGHES BROTHERS
107	6	SQUARE HEAD MACHINE BOLT. 7/8" DIA.. GALVANIZED. LENGTH AS REQUIRED	B8XX-6	HUGHES BROTHERS
108	2	BENT BOLT. 7/8" DIA x 6" LENGTH	2722.18-8	HUGHES BROTHERS
109	AS REQ	BENT STUD. 7/8" DIA x 8" LENGTH	2722.10-8	HUGHES BROTHERS
110	11	FULL THREADED ROD. 7/8" DIA. GALVANIZED. LENGTH AS REQUIRED	TR8XX-FNN	HUGHES BROTHERS
111	AS REQ	SQUARE NUT. MACHINE BOLT. 7/8" DIA GALVANIZED	N80	HUGHES BROTHERS
112	4	WASHER. 4" x 4" x 1/4" FLAT GALVANIZED 15/16" DIA HOLE	SW4-80	HUGHES BROTHERS
113	6	WASHER. 4" x 4" x 1/4". CURVED. GALVANIZED 15/16" DIA HOLE	CW-80	HUGHES BROTHERS
116	3	SPACER. FITTING. ADJUSTABLE FOR H-FRAME. DOUBLE ARM. 8 1/2"-12 1/2" RANGE	3414.6FL -100	HUGHES BROTHERS
117	6	HOOK. SELF LOCKING. BALL FITTING. GALVANIZED	HB-30	ANDERSON
119	14	LINK. CONNECTING. OFFSET. 1/4" x 2" x 9 1/2". 15/16" DIA HOLE. 24.000 LBS	3152	HUGHES BROTHERS
120	6	LINK. CONNECTING. OFFSET. 1/4" x 2" x 9 1/2". 15/16" & 1 1/4" DIA HOLE. 24.000 LBS	3151	HUGHES BROTHERS
121	10	POLE BAND. HEAVY DUTY. WITH 7/8" THRU BOLT AND BONDING CLIPS. GALV.	3108.5 2718.55	HUGHES BROTHERS
123	4	ROLLER. GUY. GALVANIZED. 1 1/16" DIA HOLE. 7/16" WIRE SEAT RADIUS	28083	HUGHES BROTHERS
124	AS REQ	STAPLES. HOT DIPPED GALVANIZED. ROLLED POINT 1 3/4" x 3/8" SPREAD	J173	JOSLYN
125	AS REQ	NAILS. STEEL. COPPER COATED. 3d. 1 1/4	J7253	JOSLYN
126	AS REQ	CONNECTOR. PARALLEL. 2-BOLT. FOR 3/8" SHLD WIRE. DUCTILE IRON. GALV.	C-3/8	MACLEAN POWER SYS
127	3	NICOPRESS. SLICE. COPPER. FOR #6 SOLID	YDS6W	BURNDY
129	AS REQ	CONNECTOR. SPLICE. ALUMINUM. FOR #4/0 ACSR	FTR-4/0	ANDERSON
130	AS REQ	STRAIN GUY. 7/16". UTILITY. 6/1 CLASS "A" GALVANIZED		
131	AS REQ	WIRE. GUY. GALVANIZED STEEL. 3/8" EHS		
133	20	GUY GRIPS. PREFORMED. T WIRE. GREEN	38GDE 7/16	PREFORMED LINE PROD.
134	AS REQ	WIRE. #6 AWG BARE COPPER. SOFT DRAWN		
135	27	INSULATOR. SUSPENSION. BALL & SOCKET. 20000 LBS. 10" x 5 3/4". ANSI CLASS 52-3. CHOCOLATE	8200	LAPP
136	60	INSULATOR. SUSPENSION. BALL & SOCKET. 30000 LBS. 10" x 5 3/4". ANSI CLASS 52-5. GRAY	5960A-70	LAPP
137	4	STRAIN CLAMP. MALLEABLE IRON. 20000 LB ULTIMATE STRENGTH	SWDE-55-S SA-04	ANDERSON
141	AS REQ	VIBRATION DAMPER. SUSPENSION. FOR 3/8" EHS STEEL	DB109	DULMISON
142	AS REQ	VIBRATION DAMPER. SUSPENSION. FOR 4/0 ACSR	DB0512	DULMISON
143	AS REQ	POLE GRID GAIN FITTING. 4" x 6 3/4". GALVANIZED STEEL. W/ 31/32" HOLE AND BONDING CLIP	1262-AB	HUGHES BROTHERS
145	AS REQ	LOCKNUT. SQUARE. 7/8" DIA	MF80	HUGHES BROTHERS
150	3	BALL CLEVIS. 30.000 LBS. 2 7/8" LENGTH	BT3055	JOSLYN
151	3	LINK. EXTENSION. 1'-8" LENGTH	J6659	JOSLYN

155	2	POLE BUTT GROUND PLATE. 7"x 7 1/2". W/SET SCREW TERMINAL LUGS. (W/12'. #6 SOLID CU PIGTAIL)	J9196	JOSLYN
156	4	BOLT. SQUARE. MACHINE 7/8" DIA x 4" LENGTH	884-2	HUGHES BROTHERS
160	AS REQ	WIRE. #4/0 ACSR. CODE NAME PENGUIN		
162	3	CLAMP. SUSPENSION. ALUM. 18.000 LBS ULTIMATE STRENGTH. W/SOCKET CONNECTOR	HAS-35-S SA-06	ANDERSON
163	6	STRAIN CLAMP. ALUMINUM. 30000 LB ULTIMATE STRENGTH. WITH SOCKET CONNECTOR	SD-112-S SA-10-13	ANDERSON

TYPE F DEAD END		
POLE	DIM "A"	DIM "B"
45'	6'-6"	37'-0"
50'	7'-0"	41'-6"
55'	7'-6"	46'-0"
60'	8'-0"	50'-6"
65'	8'-6"	55'-0"
70'	9'-0"	59'-6"
75'	9'-6"	64'-0"
80'	10'-0"	69'-6"
85'	10'-6"	74'-0"

NO	DATE	REVISIONS	DESIGN	DRAWN	CHECK	PE/ENG	USER	DOE
0		OVERHEAD POWER STANDARDS UPDATE 09/28/00						

U.S. DEPARTMENT OF ENERGY

NEVADA OPERATIONS OFFICE — LAS VEGAS. NEVADA

DESIGNED: RAH

ENGINEERING STANDARDS
OVERHEAD POWER LINES
TYPE F
5 POLE DEAD END STRUCTURE 138KV

SUBMITTED: BECHTEL NEVADA — USER — APPROVAL BLOCK: DEPT OF ENERGY PROJ ENGR — DATE 10/00

Bechtel Nevada
P.O. BOX 98521 LAS VEGAS. NV 89193-8521

STANDARD NUMBER 80606 — DRAWING NUMBER JS-090-080-E307 — SHEET OF — CAD FILE LOCATION e:/detbook/ohpl/ — REVISION 0

Drawing 6. 138 kV five-pole high-tension suspension structure (Bechtel 1960).

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