Husky Pup

Husky Pup was the third nuclear test in the U12t Tunnel and it was located in the U12t.03 drift at a vertical depth of 1,142 ft (348 m) below the surface (Brady et al. 1989:69). The Husky Pup nuclear test was conducted on October 24, 1975. LANL supplied the nuclear device and the yield was less than 20 kilotons (DOE/NV 2000). Husky Pup was a horizontal line-of-sight test (Figures 161-164). Six horizontal exploratory holes were drilled for the U12t.03 drift (Fuhriman 1978:2). This data was added to the tunnel geology database. Typical for U12t Tunnel, an abundance of ground water was encountered during the exploratory drilling and subsequent mining. The water, continuously drained from the tunnel, totaled about 62 million gallons over the duration of the test.

Mining of the line-of-sight drift began in July 1974 and was completed in September (Brady et al. 1989:73). The line-of-sight drift turned to the right in the U12t Tunnel main drift at 3,575 ft (1,090 m) from the portal and was 1,163 ft (354 m) long (Fuhriman 1978:1). At the beginning of the drift, it was 16 ft (4.9 m) wide and high and became intermittently smaller over the course of the drift to where it was only 5 ft (1.5 m) wide and 7 ft (2.1 m) high at the entrance to the zero room. The line-of-sight pipe was 975 ft (297 m) long and was installed from April to June 1975 (Brady et al. 1989:73). The pipe was relatively shorter than the preceding two tests due to improvements in the closure system (Ristvet et al. 2007). The pipe contained a muffler, two DNA Auxiliary Closures, a Tunnel and Pipe Seal, two intermediate scientific stations, one bellows decoupler, two test chambers, and three pipe stubs (Fuhriman 1978:1). The two test chambers and five sections of pipe were refurbished from the Husky Ace test conducted in 1973 in the U12n Tunnel (Brady et al. 1989:71; Wilson 1976:8). The vacuum pumping system was located in an alcove next to the line-of-sight drift (Wilson 1976:24). The alcove measured 27 ft (8.2 m) long, 14 ft (4.3 m) wide, and 16 ft (4.9 m) high.

A bypass drift, parallel to the line-of-sight drift, turned to the right in the U12t Tunnel main drift at 3,675 ft (1,120 m) from the portal (Fuhriman 1978:1).The bypass drift and associated alcoves were started in October, 1974 and completed in December (Brady et al. 1989:73). The drift was 920 ft (280 m) long, and 13 ft (4 m) wide and 13.5 ft (4.1 m) high where it started. About a third of the way, it became 9.5 ft (2.9 m) wide and 10 ft (3 m) high. Near its end, the bypass drift curved to the right and joined the line-of-sight drift at the zero room. This last section at the end before the zero room was 11 ft (3.4 m) wide, 10 ft high, and about 100 ft long (30 m). At the curve in the bypass drift, a straight extension was mined 142 ft (43 m) long, 8 ft (2.4 m) wide, and 8.5 ft (2.6 m) high. An experiment alcove was located at the end of the extension and a 12 inch (30 cm) horizontal drill hole connected the alcove with the zero room. Also at this location where the bypass drift began to return to the line-of-sight drift, but away from the zero room, were three horizontal drill holes in the left rib of the bypass drift to house different types of cable to be tested (Wilkinson and Abrahamson 1976). The holes were 12 inches in diameter and had depths of 208 ft (63 m), 198 ft (60 m), and 180 ft (55 m), respectively. The bypass drift also accommodated a pipe extending 297 ft (91 m) from the zero room for an Alpha experiment. Four crosscuts were mined between the line-of-sight drift and the bypass drift. Two crosscuts were used to install the two DNA Auxiliary Closures and two crosscuts provided access to the two test chambers. Experiment alcoves were also located in the two

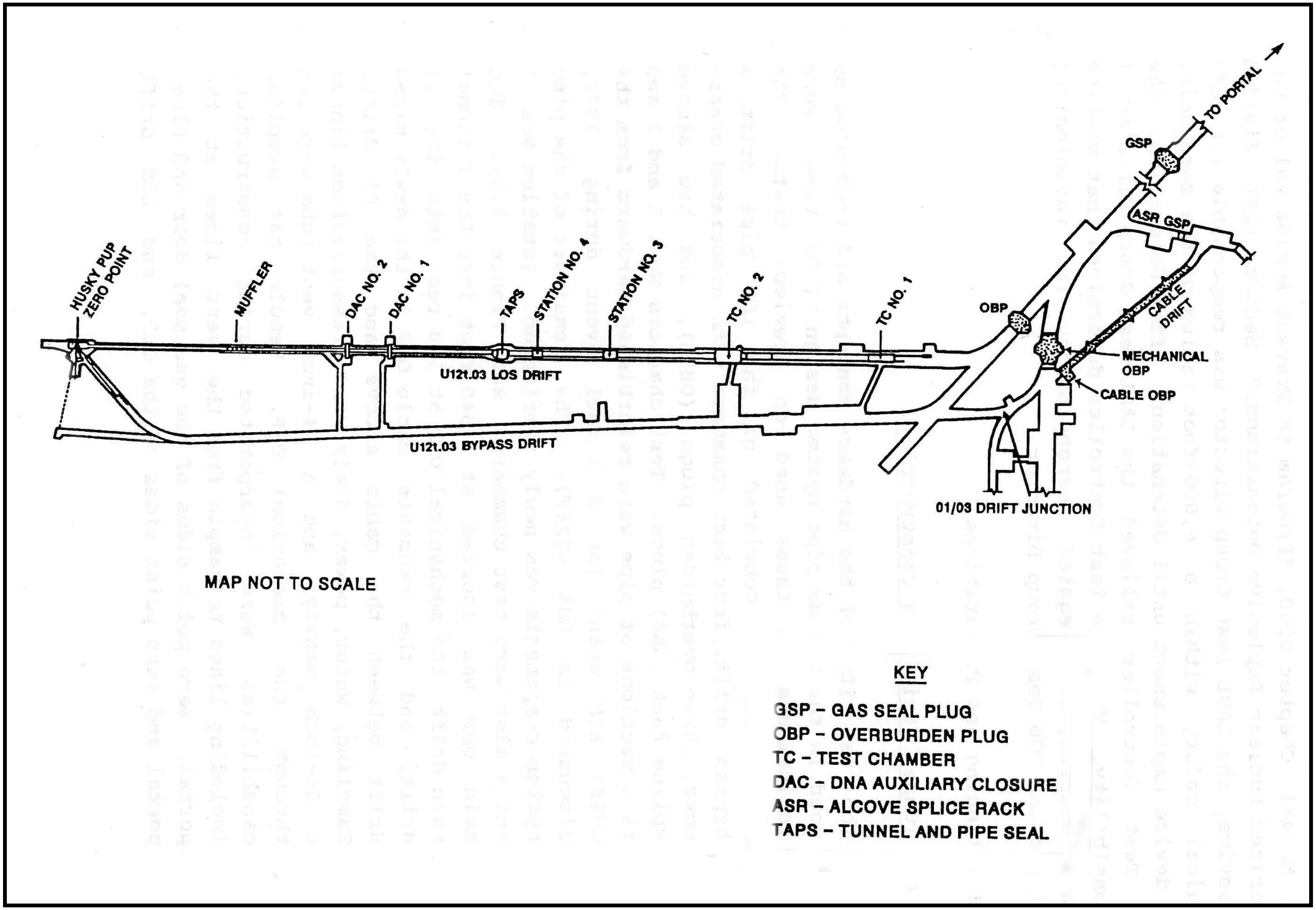

Figure 161. Plan of the U12t.03 drift for the Husky Pup nuclear weapons effects test (Brady et al. 1989:72).

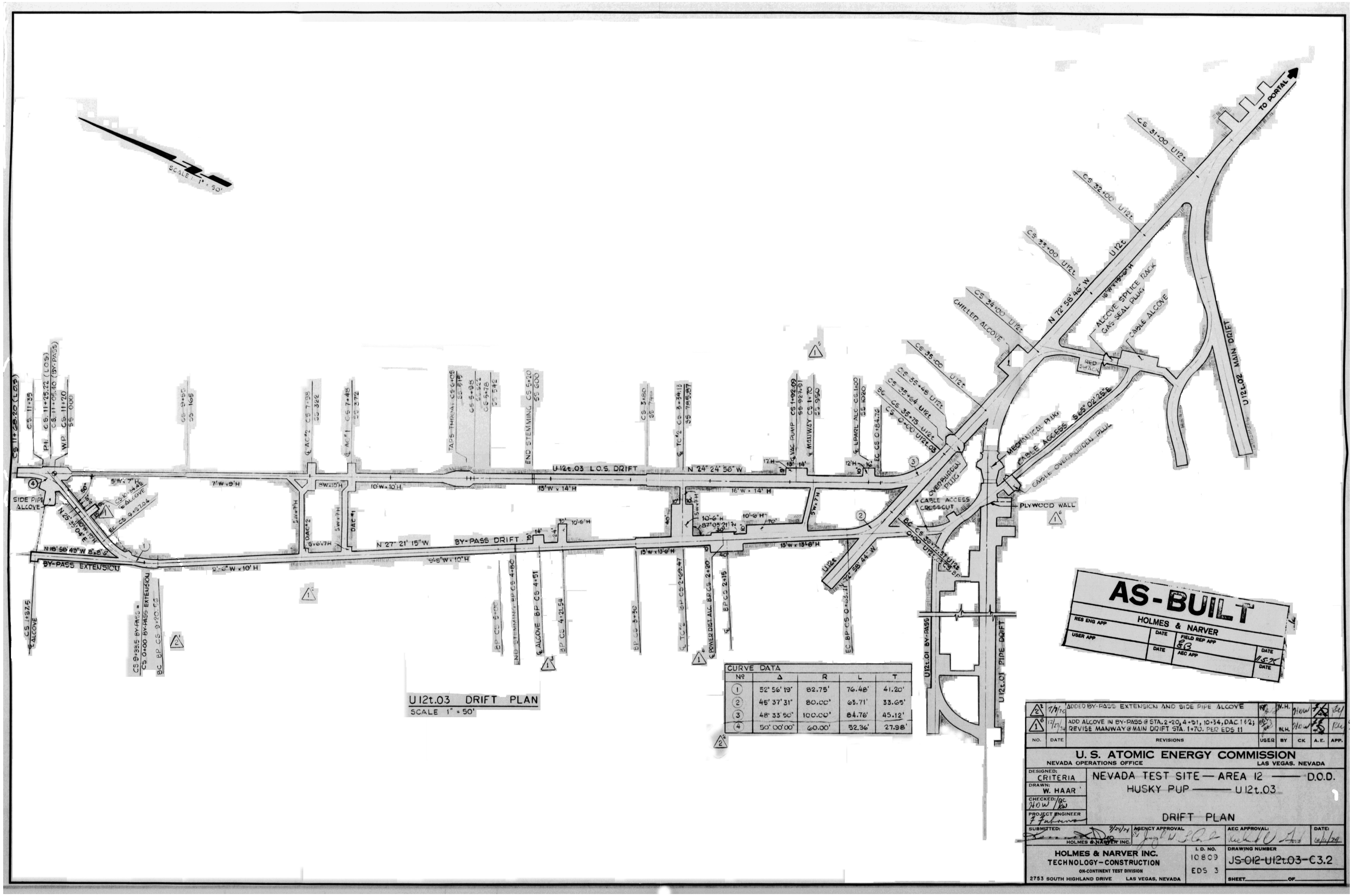

Figure 162. Construction plan of the U12t.03 drift, 1975 (drawing JS-012-U12t.03-C3, on file at the Archives and Records Center, Mercury).

Figure 163. A-box for the Husky Pup test being moved into U12t Tunnel, 1975 (photograph on file, Defense Threat Reduction Information Analysis Center, Albuquerque).

Figure 164. Test Chamber No. 1 for the Husky Pup test in the U12t.03 drift, 1975 (photograph on file, Defense Threat Reduction Information Analysis Center, Albuquerque).

test chamber crosscuts. Experiments were installed from July to September 1975 (Brady et al. 1989:73).

Permanent U12t Tunnel facilities, such as the Cable Plant, Gas Seal Plug, and Gas Seal Door, were reused for this test. Three overburden plugs were employed. The Main Overburden Plug was located in the U12t Tunnel main drift at 3,540 ft (1,079 m) from the portal, the Mechanical Overburden Plug was 140 ft (43 m) into the U12t.01 drift, and the Reusable Cable Overburden Plug in the drift between the Cable Alcove and the U12t.01 Drift (Brady et al. 1989:71). As with the previous tests, the standard Remote Area Monitoring System was used for Husky Pup with units located on the mesa, at the portal, and throughout the underground (Mullen and Eubank 1977:5-6).

All recording was done in the existing mesa trailer park (Fuhriman 1978:1). The ROSES were not used in this test. A Close-In Recording System (CIRS), employing video transmission to record the faster signals generated during a nuclear test was installed in the Lockheed Palo Alto Research Laboratory alcove next to the line-of-sight drift. It was the first time this data recording system was tried out in an actual test environment (Smith and Kaiser 1977). CIRS was located adjacent to close-in experiments in contrast to recording systems linked to the experiments by a long coaxial cable that took longer to record the signals (Smith and Kaiser 1977:4, 33). Moreover, video transmissions used by CIRS did not degrade the original input pulse from the test despite the distance from the experiments in the tunnel to the recording trailer. According to Smith and Kaiser (1977:5), the overall feasibility and performance of the system was demonstrated during this initial trial.

A 10 ft sq (3 m sq) granite block, weighing 43 tons, was placed near the nuclear device in the zero room in order to, among other things, measure shock wave closest to the device as part of an energy coupling experiment (Kratz 1976:41; Ristvet et al. 2007; Wilson 1976:36). The granite block was obtained from Westerly, California (Ristvet et al. 2007). It was transported into the tunnel and aligned with a transportation dolly customarily used to transport the auxiliary closures for the line-of-site pipe (Kratz 1976:41). The dolly had four screw-jack legs by which to adjust the block into final position in the zero room. An 8 inch (20 cm) diameter horizontal hole was drilled into the back of the block at a radial angle to the device. An 8 inch diameter manufactured cylindrical core, consisting of a field coil wrapped around an aluminum disc, a cylindrical spacer, and three pickup coils wrapped around three different granite cylinders, was inserted into the hole. Voids in the core between the cylinders were filled with an epoxy that matched the granite (Kratz 1976:55). Power to the field coil was supplied by thirty 12-volt J.C. Penny Company Lifetime 78 automobile batteries connected in a series in a nearby alcove (Kratz 1976:61). The data from the experiment were to be recorded on oscilloscopes in a trailer at the portal (Kratz 1976:65). During stemming of the bypass drift, the battery alcove was flooded and discharged the batteries, burning out the field coil (Kratz 1976:15, 72). Consequently, velocity data were not obtained from the field coil. The pickup coils were not damaged, however, and the shock wave from the nuclear explosion was recorded and measured. The experiment was considered to be a success despite the water problem.

The device was detonated around 10:00 in the morning of October 24, 1975 (Brady et al. 1989:80). The Remote Area Monitoring System detected no unexpected radiation and reentry teams were dispatched within an hour to the portal and mesa areas (Mullen and Eubank 1977:7). The reentry teams found no radiation levels above normal background. Recovery of data from these two areas began around 12:30 in the afternoon and lasted until just after 3:00 pm (Brady et al. 1989:80). The expected subsurface cavity collapse occurred at 3:15 pm. Remote readings in the tunnel showed no high levels of toxic or explosive gases and the tunnel ventilation system was started. No radioactive releases were detected (Schoengold et al. 1996).

Tunnel reentry started the next day (D+1) through the Gas Seal Door, Gas Seal Plug, and Overburden Plugs and no excessive levels of radiation or toxic and explosive gases were encountered (Brady et al. 1989:82; Mullen and Eubank 1977:7). Elevated levels of radiation, however, were encountered in the line-of-site drift (Brady et al. 1989:83). In addition, elevated levels of radiation and trace gases were found at the test chambers. Some film was recovered from one of the alcoves. It was not until the D+4 day, when the exposure rates had dropped to safer levels, that recovery of experiments began in the test chambers (Brady et al. 1989:84). The Gas Seal Plug and the Overburden Plug train ways were mined out, allowing train traffic to be reestablished (Brady et al. 1989:84; Mullen and Eubank 1977:7). The ventilation system was repaired where necessary. All experiments were recovered by November 7, 1975 (Brady et al. 1989:86), and it was determined that all experiments had been properly exposed to the radiation during the test (Wilson 1976:37).

Postshot containment evaluations continued after the experiments were removed and ventilation was established to the working point side of the Tunnel and Pipe Seal (Brady et al. 1989:84; Mullen and Eubank 1977:7). Water was found on the working point side of the Tunnel and Pipe Seal after opening the door slightly and it was drained through a hole drilled into the bottom of the line-of-sight pipe. The door was fully opened the following day and the line-of-sight pipe between the Tunnel and Pipe Seal and the first DNA Auxiliary Closure, about 100 ft (30 m), was inspected and found to have been extremely damaged. Photographs were taken of this area and work in the line-of-sight drift was terminated November 19, 1975.

About seven months later, on July 12, 1976, a reentry drift was started from the bypass drift heading toward the DNA Auxiliary Closures to assess their performance (Brady et al. 1989:87). Conventional drill and blast mining techniques were used to mine the reentry drift. A horizontal probe hole was always drilled 18 to 22 ft (5.5 to 6.7 m) in length ahead of each round of mining to check for radiation and toxic gases. No radiation was found in any of the probes. Mining of the reentry drift continued until July 30, 1976, reaching a length of 135 ft (41 m) when it was terminated because the miners were needed at the U12n Tunnel. No additional containment-related Husky Pup reentry work was conducted (Brady et al. 1989:88). Except for occasional tours, U12t Tunnel was inactive until 1982.

Midas Myth/Milagro

Midas Myth/Milagro was the fourth nuclear test in the U12t Tunnel and was conducted in the U12t.04 drift on February 15, 1984 at a vertical depth of 1,185 ft (361 m) below the surface (Stinson et al. 1993:132). Midas Myth was a horizontal line-of-sight pipe test, while Milagro was a series of add on experiments conducted by LANL. LANL also supplied the nuclear device and was in charge of all device operations. Yield of the device was less than 20 kilotons (DOE/NV 2000).

Prior to mining of the U12t.04 drift complex, one exploratory hole was drilled to supplement the existing tunnel geology database. The U12t.04 line-of-sight drift was turned to the right in the U12t Tunnel main drift 4,749 ft (1,447 m) from the portal and was 1,125 ft (343 m) long (Figures 165-167). Mining of the U12t.04 drift complex began in May 1982 and was completed in February 1983. It included the main line-of-sight drift, a bypass drift, a zero room, a ballroom, and a vacuum pumping and monitoring station (Richey 1991; Stinson et al. 1993:134). The Midas Myth line-of-sight pipe was 8 inches (20 cm) in diameter at the end closest to the nuclear device and 13 ft (4 m) in diameter in Test Chamber No. 1 at the other end. It was approximately 923 ft (281 m) long (Richey 1991). The pipe system included a muffler, two auxiliary closures, a Tunnel and Pipe Seal, three test chambers, and four diagnostic pipe stubs (Stinson et al. 1993:134). A significant feature used for the first time during the Midas Myth test was a very large alcove referred to as the ballroom. The ballroom was approximately 200 ft (61 m) long, 38 ft (11.6 m) wide, and 12 ft (3.7 m) high and was mined with a flat back, or ceiling. It was designed to house 20 Recorder and Oscilloscope Sealed Environmental System (ROSES) units. The ballroom was the largest open space created in any of the tunnels (Ristvet et al. 2007). There were five crosscuts mined between the ballroom and the U12t.04 line-of-sight drift to provide for cable runs and access to experiments mounted in the test chambers. The Milagro experiments were located in a short line-of-sight pipe drift extending from the zero room and perpendicular to the Midas Myth line-of-sight pipe drift. The experiments were exposed to the same nuclear device as Midas Myth. Permanent U12t Tunnel facilities, such as the Cable Plant, Gas Seal Plug, and Gas Seal Door, were reused for this test.

Installation of the line-of-sight pipe began in February 1983 and was completed in August. By the end of the year, the LANL Milagro area located near ground zero at the end of the bypass drift was grouted, the LANL ROSES units were installed in the bypass drift, and the fiber optic cables were set in place (Stinson et al. 1993:135). ROSES units were also placed in the ROSES drift next to the main line-of-sight drift, in the U12t.03 bypass drift, and in the main access tunnel (see Figure 165). Additional recording equipment for the Milagro experiments was put in an alcove and along the bypass drift (Richey 1991). Installation of experiments began in September 1983 and was completed by January 1984 (Stinson et al. 1993:135). The vacuum system was also completed by January 1984 (Kissinger and Long 1984). Stemming of the line-of-sight drift began in July 1983 from ground zero outward to 550 ft (168 m). Following insertion of the device, the bypass drift was stemmed outward to 500 ft (152 m).

New construction at the portal area consisted of a trailer pad nearer the portal for Sandia Laboratories, three dry storage buildings, two office buildings, a craft shop, a Health Physics trailer, a Portal Recording Facility, an Experimenter's Dry Storage and Handling Building, a Reentry and Monitor Control Building, and a LN2 pumping area (Richey 1991; see Figure 21). Also, to create more space at the portal, the bunker pad below the tailings pile was raised to accommodate additional trailers. The existing road was upgraded for sedan traffic. The New Recording Facility, Building 12-890, was located along the west face of the portal area and northwest of the portal. The

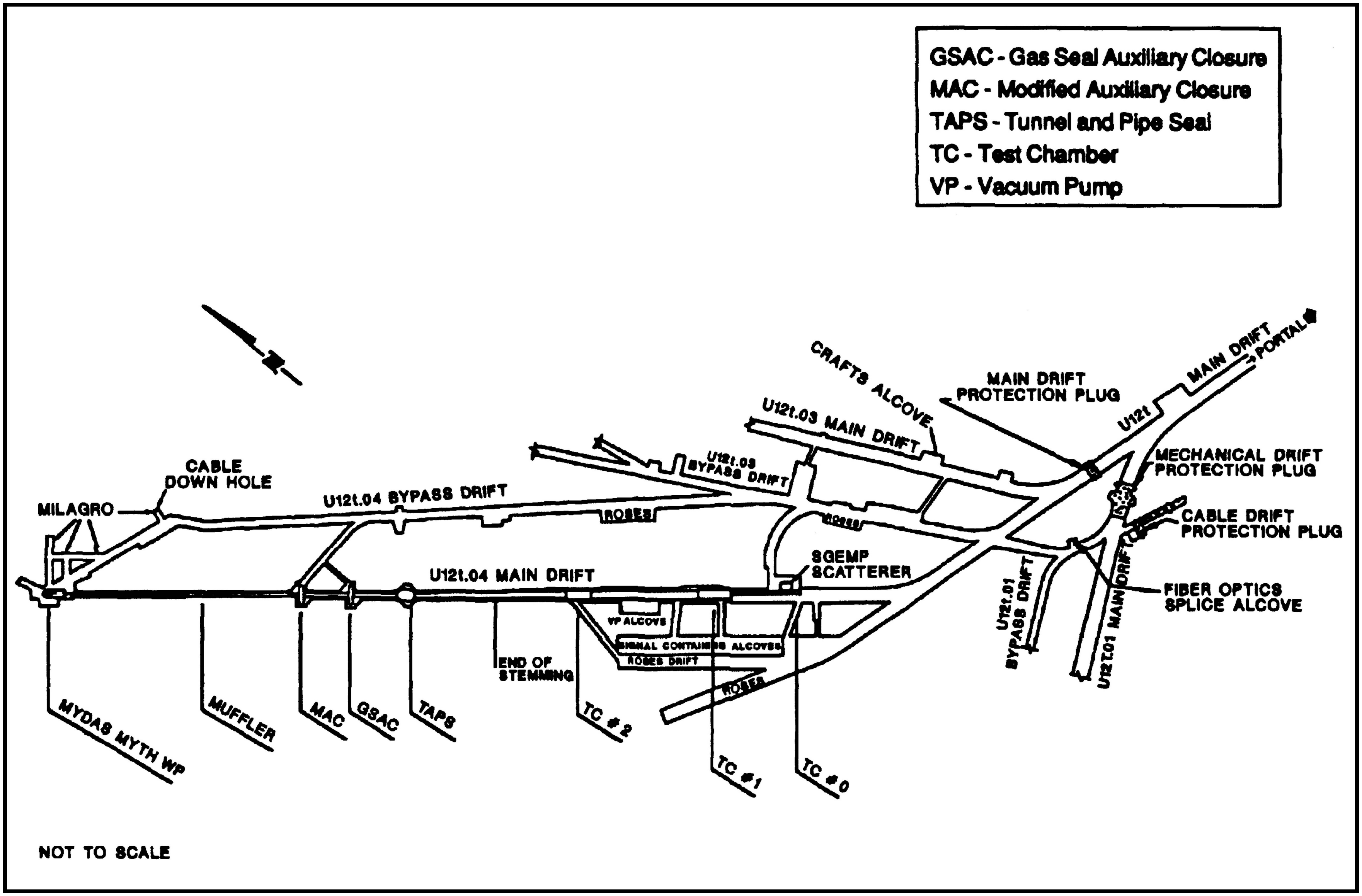

Figure 165. Plan of the U12t.04 drift for the Midas Myth/Milagro test (Stinson et al. 1993:136).

Figure 166. Plan of the U12t.03 drift (upper) and the U12t.04 drift (lower), ca 1984 (drawing SK-C12-84-C1, on file at the Archives and Records Center, Mercury).

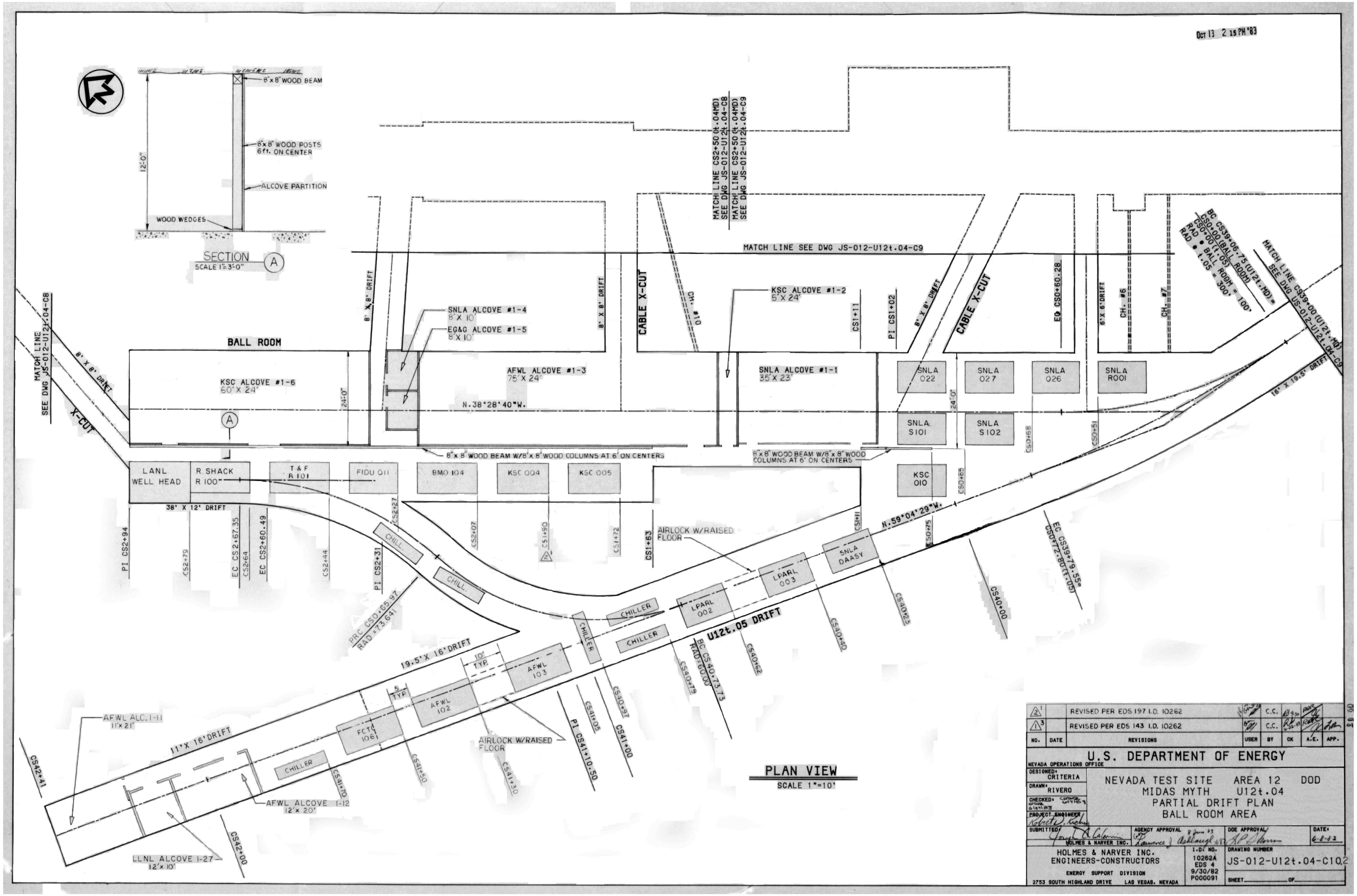

Figure 167. Plan of the Ballroom in U12t.04 drift, 1983 (drawing JS-012-U12t.04-C10.2, on file at the Archives and Records Center, Mercury).

two office buildings, Buildings 12-889 and 12-897, replaced older and substandard trailers, and were located toward the southern edge of the portal area. These buildings measured 20 x 60 ft (6 x 18 m) and were insulated. Building 12-889 housed the DNA and architectural and engineering staff and Building 12-897 was the construction office for Reynolds Electrical and Engineering Company. The three dry storage structures, Buildings 12-888, 12-895, and 12-896, were built along rail spurs in the eastern part of the portal area. The craft shop, Building 12-887, was placed near the old office trailer complex and was used to repair mining equipment. The reentry and monitor control structure, Building 12-894, was located adjacent to the portal. A new Health Physics trailer was placed next to the control structure. A microwave tower was also located near the control structure in order to beam signals to the Control Point. A passive billboard repeater station was placed on the I J K tunnel access road because there was no direct-line-of-sight between the tower and the Control Point. The Experimenter's Dry Storage and Handling building was constructed along a rail spur next to the existing electrical warehouse. The electrical warehouse was to be replaced with a new building, but it did not get accomplished during this test. The Halliburton Yard was moved to the southern part of the portal area where two dewar tanks and three chilled water storage tanks were erected. Two sections of scrap line-of-sight pipe were made into water storage tanks that more than doubled the capacity of the water distribution system to 78,000 gallons of non-potable water. This water was for mining and construction. Potable water was delivered to the site in five gallon bottles.

The cooling water system at the portal area consisted of two 150 ton water to air cooling towers that were able to circulate 600 gallons per minute through a 6-inch pipe to a 13,100 gallon capacity storage reservoir located at the head of the U12t.03 drift (Richey 1991). Two portable pumps on a skid then moved the water to the underground distribution system and supplied condensed water to various size chillers in order to cool recording equipment situated throughout the test drift. Ventilation of the drift was accomplished by drawing air through the drift branches to a 26 inch (66 cm) vent line that passed through the Main Drift Protection Plug. The line then connected to two 36 inch (91 cm) vent lines for suction from the portal by two Buffalo blowers and one Sutorbilt blower.

The Milagro experiments had a requirement to record very high speed data and to do so required shorter cable runs between the experiments and the recording equipment. To support this requirement, a second trailer park near surface ground zero was constructed on Aqueduct Mesa (Richey 1991). It was located northeast of the existing U12t Tunnel trailer park, which was not used for this test. A vertical cable hole was designed and drilled from the new trailer park to intersect the curve in the U12t.04 bypass drift near the working point. The cable hole was of similar diameter (36 inches; 91 cm) as ones in the main trailer park. Depth of the hole was 1,187 ft (362 m), ending about 30 ft (9 m) below the drift. The first 60 ft (18 m) was fitted with 48 inch (122 cm) casing, while the remaining length was not cased. The drill hole accommodated 120 cables provided by LANL. Most of the Milagro data was recorded in the new trailer park. The remaining faster Milagro data was recorded in a ROSES unit positioned at the end of stemming in the bypass drift.

Signal dry runs began in January 1984 and a final mandatory full participation dry run was successfully executed on January 31, whereupon final device preparation and stemming commenced (Stinson et al. 1993:138). Remote Area Monitoring System units were installed outside the tunnel at and around the portal, on the mesa top, and inside the tunnel (Mullen and Eubank 1985:14-15; Stinson et al. 1993:141). A final dry run was conducted on February 14 and the next day in the early hours of February 15 final arming and button up procedures started. A faulty power supply for a fiber optics decoder needed to be replaced before the test, delaying it for two hours. The Midas Myth device was detonated at 9:00 on the morning of February 15, 1984. All instrumentation and containment systems functioned as designed.

All but one of the Remote Area Monitoring System units still operating after the detonation read normal background levels of radiation (Stinson et al. 1993:147). After one hour, this one unit also began reading normal background. Initial reentry survey teams departed for the portal and mesa areas one hour after detonation, and one hour later, the initial survey was completed (Mullen and Eubank 1985:15; Stinson et al. 1993:147). No radiation above background levels was detected. The portal area was entered again later in the day around 5:00 in the afternoon for remote gas sampling. No toxic or explosive gases were detected in the tunnel at this time.

The mesa reentry team, accompanied by a Milagro data recovery team, was working at the Milagro recording trailer park when a subsidence of the mesa cap rock suddenly occurred beneath the trailer park about three hours after detonation (DTRA 2002:388; NTS News Bulletin 1984; Stinson et al. 1993:132, 148; U.S. Congress 1989:50). It was the first ever such occurrence as a result of undergound testing on either Aqueduct or Rainier Mesas. The subsidence was 120 ft (37 m) long, 60 ft (18 m) wide, 18 ft (5.5 m) deep on one end, and 4 ft (1.2 m) deep on the opposite end. The trailers were damaged and 10 members of the mesa reentry and Milagro data recovery teams were injured and evacuated to hospitals in Las Vegas.

Tunnel reentry through the Gas Seal Door and the Gas Seal Plug started on the second day after detonation or D+2 and normal conditions were encountered (Mullen and Eubank 1985:16; Stinson et al. 1993:148, 150). At the main Overburden Plug, slightly elevated radiation and gas levels were detected and ventilation was reestablished. Shortly afterward, the reentry team proceeded to the U12t.05 drift and the U12t.04 ballroom and found a large amount of damage to the line-of-site pipe, the ballroom, the alcoves, and the ROSES units. The tunnel had collapsed in both places as a result of ground shock, crushed all the ROSES units, and destroyed most of the recording equipment. Further inspection into the line-of-sight drift found extensive damage to the line-of-sight pipe and the vacuum system pumps (Kissinger and Long 1984). Elevated radiation and toxic and explosive gases were detected at the thermal shield wall in the line-of-sight drift. It was later determined that greater than normal ground shock occurred due to the closeness of the working point to underlying hard rock. This increased the reflective ground shock normally associated with a tunnel test and resulted in the increased damage.

Extensive rehabilitation was started February 18, 1984 in the main U12t Tunnel and side drifts and was completed up to the U12t.04 ballroom by February 28 (Mullen and Eubank 1985:17; Stinson et al. 1993:151). The rehabilitation included installation of rock bolts and wire mesh, cribbing, removing debris, and reinstalling railroad track. On February 29, Test Chamber No. 1 was entered to inspect the line-of-sight pipe and tunnel. The line-of-sight pipe was collapsed, but access was possible to the test chambers and test alcoves. An elevated radiation level was detected at the door of Test Chamber No. 1. Mining through the thermal shield wall in the U12t.04 line-of-sight drift began on March 14. These tasks were completed by March 22, 1984. Most of the experiments were also recovered by mid March.

On April 12, 1984 a mining of a reentry drift toward the detonation point was started with an Alpine miner. A probe hole was drilled ahead of the mining for early detection of radiation or gases that may be present. Mining was terminated in late June when radioactively-contaminated water began seeping through the face of the reentry drift.

Drilling towards the blast cavity was initiated from the U12t.04 reentry drift on April 24, 1984 to define the size of the cavity. Three holes were drilled and samples collected. Radiation, toxic gases, and explosive gases were detected in the first two holes and both were sealed with grout to contain the contamination. In the third drill hole, a glassy material was found in the core samples and sent for analysis (Stinson et al. 1993:152). Elevated radiation levels and contaminated steam and water were also present. As a result, drilling operations were ended on June 29, 1984 due to the severity of the radiation and potential harm to the workers and to U12t Tunnel. Containment procedures were subsequently initiated for the U12t.04 drift complex. The reentry drift was plugged with grout and all reentry and recovery operations were completed by March 1985. No post test drilling from the mesa was conducted. Although low concentrations of radioactive gases were detected in the tunnel after the test, no radioactive effluents escaped to the atmosphere (Schoengold et al. 1996; Stinson et al. 1993:132; U.S. Congress 1989:50).

Mighty Oak

Mighty Oak was the fifth nuclear test conducted in U12t Tunnel and it was detonated on the morning of April 10, 1986 (Schoengold 1999:115). It had a yield of less than 20 kilotons (DOE/NV 2000:83; Schoengold et al. 1996:218). The nuclear device, supplied by LLNL, was located in the U12t.08 drift at a vertical depth of 1,294 ft (394 m) below the surface. LLNL also supplied the device systems services. The Mighty Oak test was slated at different times for the U12t.05, U12t.06, and U12t.07 drifts, but the drifts were rejected and never fully developed (see Figure 14). One reason for selecting the U12t.08 drift over these other drifts was because of ground shock complications from the Midas Myth/Milagro test causing the Mighty Oak test to be positioned further away from the Midas Myth detonation point (Schoengold 1999:118).

Mining of the U12t.08 drift began in late November 1983 and was completed one year later (Schoengold 1999:118). The U12t.08 drift was one of the most complex test layouts designed by DTRA. It consisted of a typical straight main drift for the line-of-sight pipe, a bypass drift, a crosscut between them at the auxiliary closures, a zero room, a test chamber for experiments, experimenters alcoves, and a ROSES drift and a recording alcove for data recording equipment

(Figures 168-169). A total of 97 holes were drilled for the test: 2 exploratory, 60 for experiments, 15 for cables, and 20 for the geology (Williams 1985). The ROSES drift was 25 ft (7.6 m) wide, 12 ft (3.7 m) high, and 295 ft (90 m) long, while the recording alcove was 25 ft wide, 12 ft high, and 325 ft (99 m) long. The Mighty Oak test also included eight structures experiments located in two drifts on the right side of the bypass drift. These two drifts, designated B and C, were 106 ft (32 m) and 212 ft (6.4 m) long, respectively. The structures were made of reinforced concrete. The annulus of the structures were filled with light weight concrete which served as packing to absorb ground shock transmitted from the surrounding rock to the structures. The structures varied in diameter and were located in the center of the drifts at two different range stations from the working point to assess their ability to survive different shock levels.

The U12t.08 line-of-sight drift was started off the right rib of the U12t.02 bypass drift, crossed the U12t.01 line-of-sight drift, and was 1,292 ft (394 m) long. It was 20 ft (6.1 m) wide and 22 ft (6.7 m) high at the start and decreased incrementally to a final dimension of 8.5 ft (2.6 m) high and wide from the most forward DNA Auxiliary Closure to the zero room (Schoengold 1999:117). The U12t.08 bypass drift was mined from the right rib of the U12t.01 bypass drift. The bypass drift was 12 ft (3.7 m) wide and 11 ft (3.4 m) high for the first half at the start and decreased to 11 ft wide and high the second half. It was enlarged to 14 ft (4.3 m) wide where it curved or angled to accommodate the transfer of large size experiments.

Installation of the line-of-sight pipe was started in January 1985. The line-of-sight pipe was 911 ft (278 m) long and contained a muffler, two DNA Auxiliary Closures, and a Tunnel and Pipe Seal. The test chamber at the portal end of the pipe was 14 ft (4.3 m) in diameter and 51 ft (15.5 m) long (DOE/NV 1987:15). The steel shell of the chamber was supported by inner rings on which experiments were mounted. Two scatterer stations were deployed just beyond the end of the pipe (Williams 1985). The scatterer station belonging to the Ballistic Missile Office was 942 ft (287 m) from ground zero and the other one for the Sandia National Laboratory was 970 (296 m) from ground zero. The zero room consisted of a rectangular steel box, 30 ft (9 m) long and 10 ft (3 m) wide and high (Williams 1985). LANL used stub pipes extending from the A-box for a front end experiment named EMZY, and LLNL used two of the stub pipes for a front end prompt diagnostic experiment. By the end of October 1985, the pipe, the closures, the Tunnel and Pipe Seal, cables, instrument and experimenter alcoves, vacuum pump modules, and scatterer stations were installed or completed. The line-of-sight drift was stemmed to a distance of 764 ft (233 m) from ground zero, while stemming, after the device was installed, reached 552 ft (168 m) for the bypass drift (Schoengold 1999:121).

The cooling water system at the portal consisted of two 150 ton water-to-air cooling towers and was connected through a 6-inch line to two storage reservoirs within the tunnel (Williams 1985). The water was then circulated to various size chillers in the different alcoves, which was typical for each test. Tunnel ventilation, by drawing air from the drift branches, was provided by 2 ft (61 cm) and a 3 ft (91 cm) vent pipes connected to two Buffalo blowers and one Sutorbilt blower at the portal (Williams 1985).

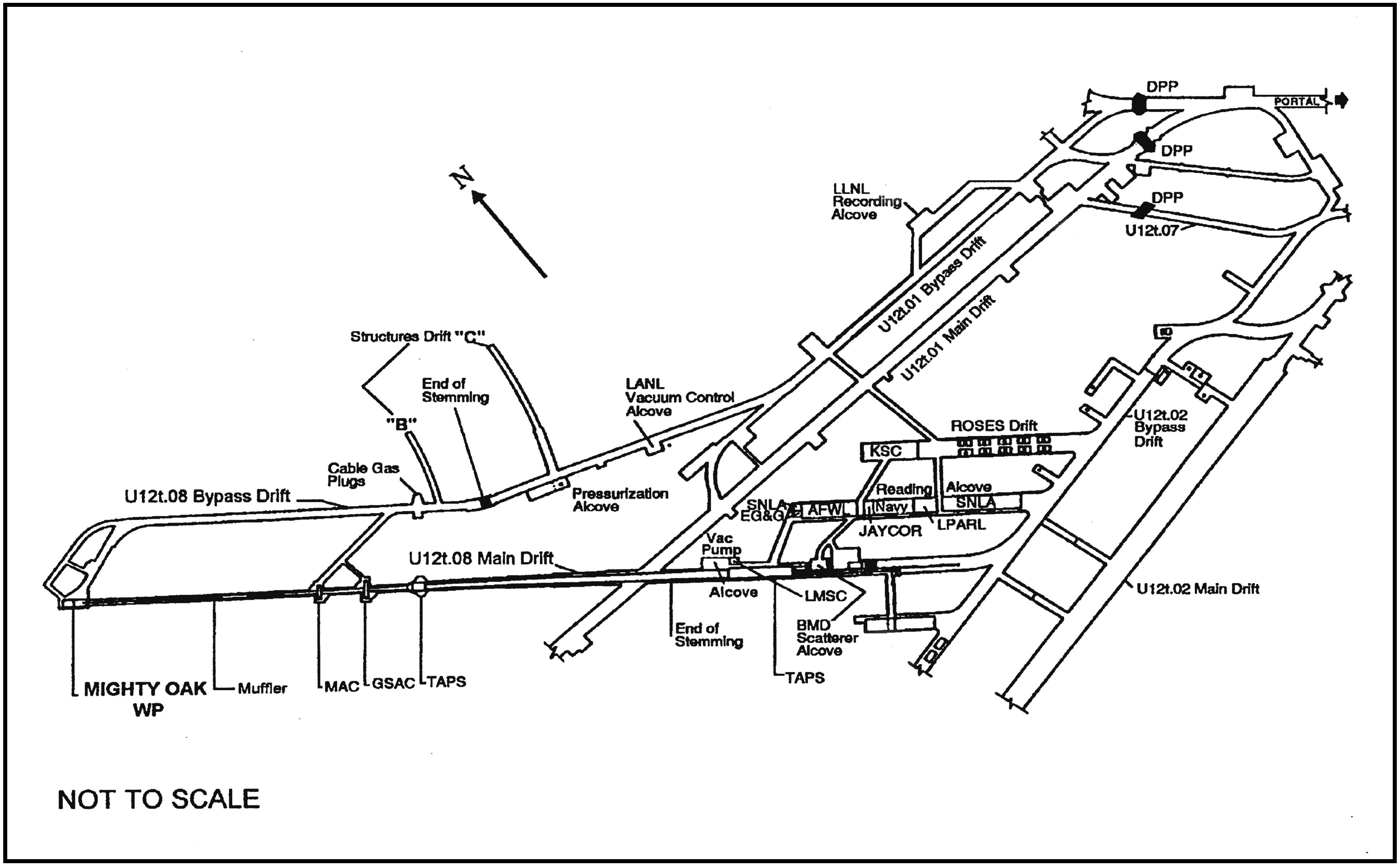

Figure 168. Plan of the U12t.08 drift for the Mighty Oak test (Schoengold 1999:119).

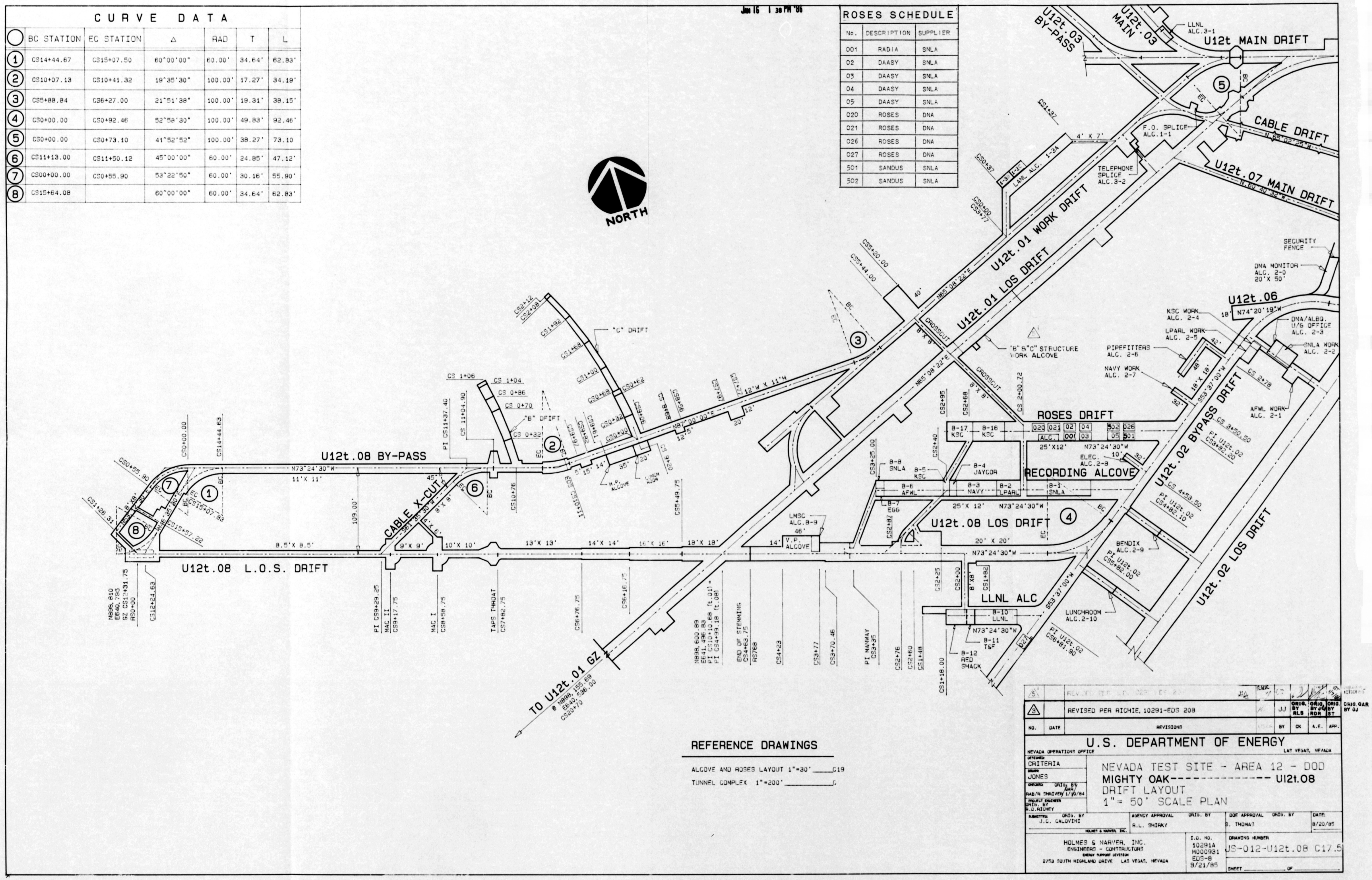

Figure 169. Construction plan of the U12t.08 drift for the Mighty Oak test, 1985 (drawing JS-012-U12t.08-C17.5, on file at the Archives and Records Center, Mercury).

Between November 1985 and March 1986 all experiments and recording equipment were installed. A total of 2,638 cables were used: 80 for arming and firing, 74 for timing and monitors, and 2,484 for experiments (Williams 1985). Most of the experiments (85 percent) in the Mighty Oak test were active, that is, connected to various detectors and sensors which provided data before, during, and after exposure to radiation (DOE/NV 1987:17). A smaller portion (15 percent) of the experiments were passive and had to be recovered after the test in order to retrieve any data. DTRA experimenters used a new high speed fiber optic cable system to transmit data to the portal recording station, while the National Laboratories used copper cables to transmit data to the underground recording alcoves. The copper cables transmitted data at a slower rate than fiber optic cables. No recording was done on the mesa for the Mighty Oak test.

The Mighty Oak test was scheduled for April 8, 1986, but detonation was postponed two days because of unfavorable wind conditions (DOE/NV 1987:30; Schoengold 1999:130). The device was detonated at 6:08 in the morning of April 10. All Remote Area Monitoring System units outside the Gas Seal Plug indicated background radiation levels. Almost immediately, however, units inside the Drift Protection Plug were off scale, which indicated a failure of Containment Vessel I. Radioactive gas then compromised Containment Vessel II by leaking through the Mechanical Drift Protection Plug and migrating to the working point side of the Gas Seal Plug where it was contained. After a few hours, the radiation levels peaked and began to decay (DOE/NV 1987:31). Reentry teams were dispatched to the portal about three hours after detonation to conduct an overall condition inspection and to begin preparation for a hot tunnel reentry beyond the Gas Seal Plug. Inspection of the portal area was completed by noon with no radiation levels above normal detected (Mullen and Eubank 1988a:44; Schoengold 1999:131). At this time, it was also verified that no radiation had leaked past the Gas Seal Plug to the Gas Seal Door. The Gas Seal Door was opened and the railroad track reinstalled. A number of attempts were made over the next several days to reenter the Gas Seal Plug, but radiation levels were too elevated. The DOE Test Controller would eventually approve eight controlled releases of radioactive effluents to the atmosphere (Black et al. 1986:4; Mullen and Eubank 1988a:45; Schoengold 1999:115). The first controlled release was on April 22 or D+12 for about 8 hours from the working point side of the Gas Seal Plug. On April 23 or D+13, reentry was finally made through the Gas Seal Plug to the portal side of the Mechanical Drift Protection Plug. Very little physical damage was observed to that point in the tunnel, but elevated levels of radiation and toxic gases remained on the working point side of the Drift Protection Plug (Mullen and Eubank 1988a:44). The last controlled release of radioactive effluents to the atmosphere was continuous from May 5 to May 19 in order to ventilate the tunnel on the working point side of the Drift Protection Plug. Following the controlled releases, low levels of radioactivity were detected beyond the boundaries of the NTS (Black et al. 1986; DOE/NV 1987:34; Schoengold et al. 1996:219). No radioactivity, however, was detected offsite after May 5 (Black et al. 1986:12). To complicate matters, airborne radioactivity from the Chernobyl nuclear reactor disaster in the former Soviet Union that occurred on April 26, 1986 was also detected in the NTS off-site monitoring (DOE/NV 1987:34). Normal ventilation of the tunnel was established by May 22 (Schoengold 1999:133).

Mining through the Gas Seal Plug and cleanup to the U12t.02 Drift Protection Plug began on May 7 and was completed by the end of May (Schoengold 1999:133, 138). Cleanup consisted of applying two coats of white latex paint to the tunnel ribs and back to fix or seal alpha contamination to the surface to prevent inhalation; washing the train rails; and removing dirt from the invert or floor and replacing it with pea gravel. These actions were taken for worker safety.

Mining of several reentry drifts was attempted into the line-of-sight drift, but all were discontinued for worker safety after encountering elevated levels of radiation. Eventually, a successful reentry drift was mined starting on the right side of the U12t.02 line-of-sight drift, continuing up and over the Overburden Plug in the U12t.01 drift, then down, around, and over to the U12t.08 drift where it crossed the U12 t.01 drift. A viewing port was mined into the Mighty Oak pipe drift at the U12t.01 crossing where one could, with the aid of a mirror, see the devastation created by the blast that came down the Mighty Oak line-of-sight drift. The reentry drift continued on around and then parallel to the left side of the Mighty Oak line-of-sight drift. Crosscuts were mined from the reentry drift to the Mighty Oak line-of-sight drift at several locations to assess the damage. The reentry drift mining continued to where it entered the LLNL alcoves for inspection. Physically, the alcoves were intact, but highly contaminated. Several other reentry drifts were mined off the main reentry drift and they included crosscuts to alcoves in the U12t.01 bypass drift, a crosscut to the back side of the Structures No. 2 drift, a reentry drift between the Mighty Oak line-of-sight drift and the bypass drift to assess the condition of the pipe in the vicinity of the DNA Auxiliary Closures, a crosscut to the front of Structures No. 1 drift, and numerous crosscuts to recording alcoves. The physical damage and contamination present in the recording alcoves allowed only minimal reentry and recovery efforts. The most important equipment recovered were some of the memory units that were installed inside the equipment racks and ROSES units. Otherwise, nearly all experiments, diagnostics, and construction equipment staged underground were lost as a result of high radiation, excessive temperature, and destruction (DOE/NV 1987:1, 48; Hunt et al. 1987; Leistner 1991; Schoengold 1999:135). Most of the recovery work was completed by April 1987, with all work in the U12t.08 drift ending June 15, 1988 (Schoengold 1999:139). In spite of the overall devastation, data recovery was quite good. DTRA experimenters recovered about 95 percent of their data because the new fiber optic system transmitted data to the portal before it could be impacted by radiation, heat, and destruction forces. The total data recovery for the test was estimated at around 70 percent.

In summary, the test met the DOE mandate that no uncontrolled radiation leave the tunnel because DTRA employed the three nested vessel concept. From a containment perspective, however, Vessels I and II failed. The test was contained by Vessel III at the Gas Seal Plug. The total failure of Vessel I resulted in all material in the main drift being ejected against the portal end of the line-of-sight drift. Vessel II was breached as significant radiation migrated all the way to the working point side of the Vessel III plug. Despite these circumstances, a majority of the data was recovered. DTRA data was transmitted by way of the fiber optic system and all the signals were recorded at the portal before the failure occurred underground.

A series of postshot reviews were conducted and the findings were implemented in all following tests. It was determined that the line-of-sight pipe was too short for the amount of taper, causing the auxiliary closures to be fitted in the pipe closer to ground zero (Ristvet et al. 2007). This created a situation where the closures where not strong enough to adequately contain the explosion. The closure nearest the explosion was over-pressured and failed, leaving the tunnel open to where higher than normal temperatures and pressures moving down the tunnel overwhelmed the Mechanical Auxiliary Closure, the Gas Seal Auxiliary Closure, and the Tunnel and Pipe Seal (U.S. Congress 1989:51). At the Tunnel and Pipe Seal, temperatures reached 2,000 degrees Fahrenheit and pressure was 1,400 psi, both being much more than it was designed. As a result of the failure of the mechanical closures, radiation escaped into the tunnel.

Mission Ghost

Mission Ghost was the sixth and final test in the U12t Tunnel and it was located in the U12t.09 drift (Figures 170-172). The test was conducted on June 20, 1987 and had a yield of less than 20 kilotons (DOE/NV 2000). The nuclear device and device systems services were supplied by LANL. The device was installed in a 25 ft (7.6 m) diameter hemispherical cavity at a vertical depth of 1,054 ft (321 m) below the surface (Schoengold 1999:163). The objective of the test was to prove existing electro-magnetic pulse models based on the 1962 Small Boy test were indeed correct (Ristvet et al. 2007). It was also considered a containment experiment, being a smaller-scaled version of the upcoming Misty Echo test to be conducted in the U12n Tunnel in 1989 (Ristvet et al. 2007).

Mining for the U12t.09 drift began in December 1986 and turned right off the main U12t Tunnel drift 3,298 ft (1,005 m) from the portal. The U12t.09 drift was 530 ft (162 m) long, 10 ft (3 m) wide, 10.5 ft (3.2 m) high, and had no bypass drift (Schoengold 1999:165). It contained four small alcoves. To mine the hemispherical cavity at the end of the drift, a vertical raise was drilled and blasted in the back or roof of the U12t.09 drift up to the designed top edge of the cavity. The top edge of the cavity was approximately 28 ft (8.5 m) above the invert or floor of the U12t.09 drift. The remainder of the cavity was then carefully mined out to a radius 12.5 ft (3.8 m) by drilling and blasting from the raise outward to the designed cavity wall. Mining continued downward until it reached the invert of the U12t.09 drift. Muck, created during mining of the cavity, fell down to the bottom of the drift, was loaded into mine cars, hauled outside by train, and dumped.

By taking advantage of existing alcoves in the tunnel, only one alcove for experimenters and the Red Shack had to be mined for the Mission Ghost test. This alcove was off the main U12t Tunnel drift 3,128 ft (953 m) from the portal, was 220 ft (67 m) long, and housed four experimenter agencies plus the Red Shack. Mining of the Experimenter and Red Shack alcove and an accompanying runaround or access drift were completed by the end of March 1987 (Schoengold 1999:167). All experiments and recording equipment were installed by June. The Mandatory Full-Power Signal Dry Run was conducted on June 10 and some equipment had to be replaced (Schoengold 1999:169). The device was installed in the cavity and the cavity was filled with high strength grout to a depth of 15.4 ft (4.7 m) above the invert or floor of the U12t.09 drift. The drift was then stemmed with grout outward 213 ft (65 m). The final Signal Dry Run was completed on June 19 and the test was conducted the next day on June 20, 1987 at 9:00 in the morning.

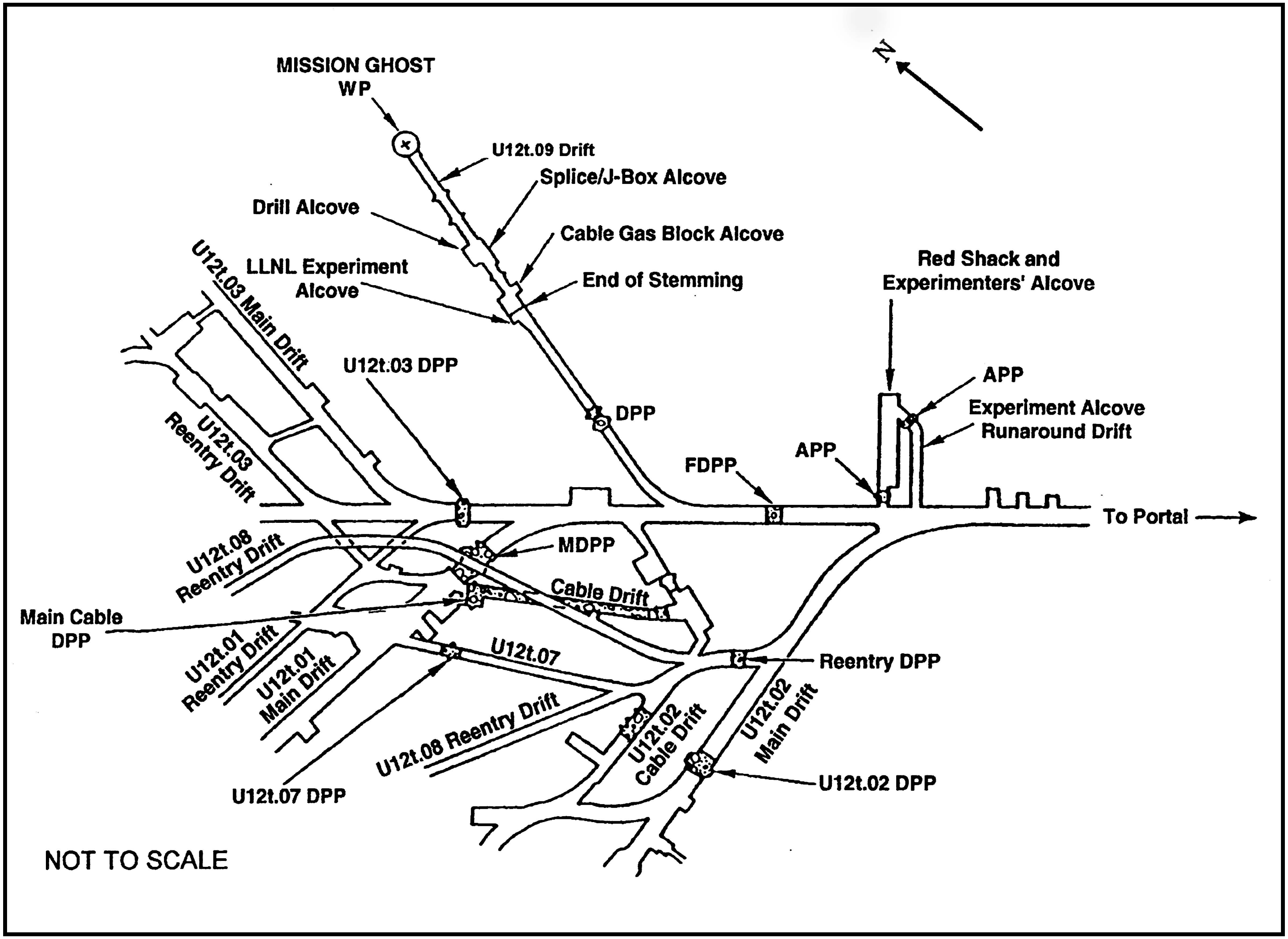

Figure 170. Plan of the U12t.09 drift for the Mission Ghost test (Schoengold 1999:166).

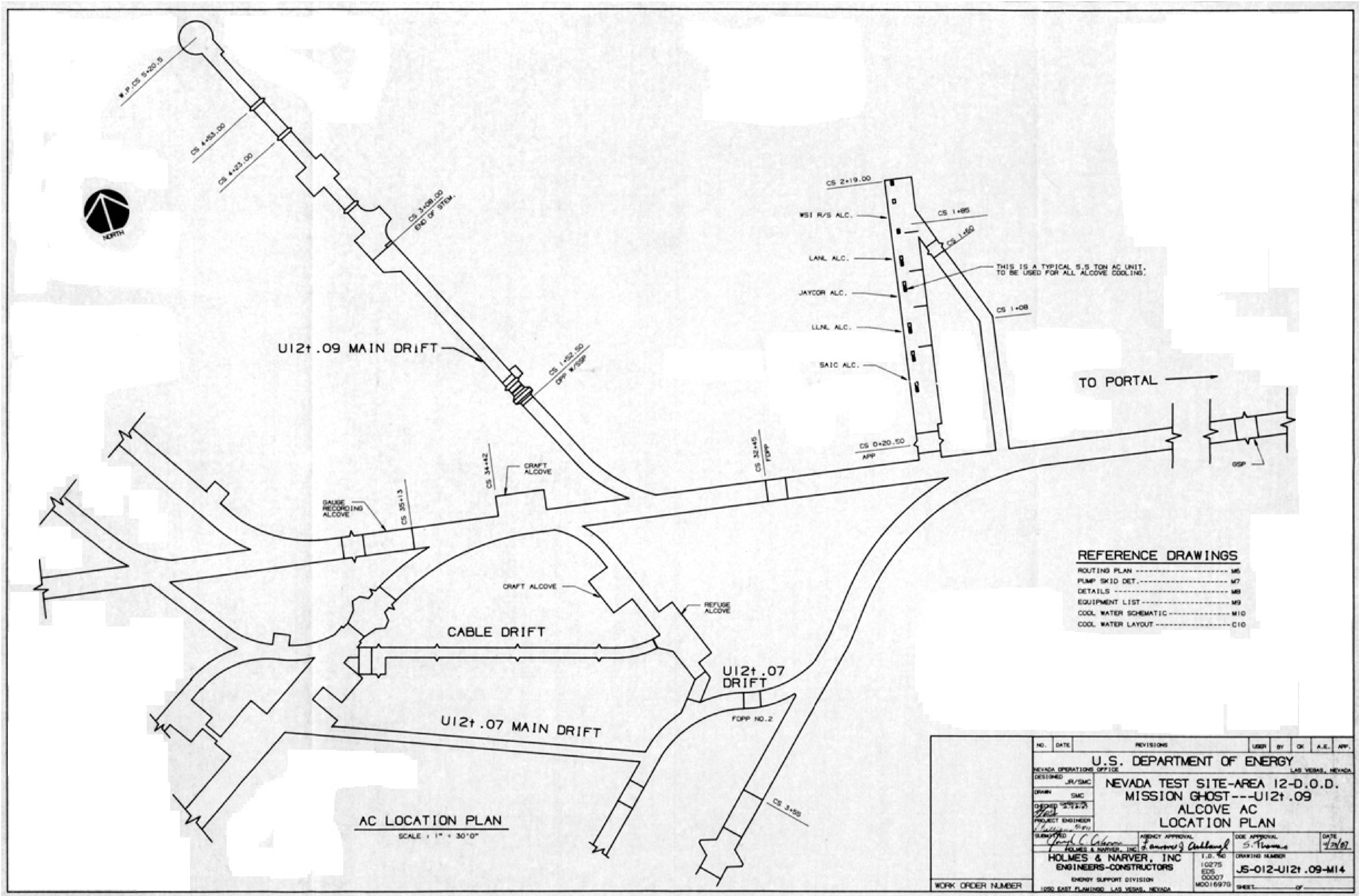

Figure 171. Plan of the U12t.09 drift for the Mission Ghost test, 1987 (drawing JS-012-U12t.09-M14, on file at the Archives and Records Center, Mercury).

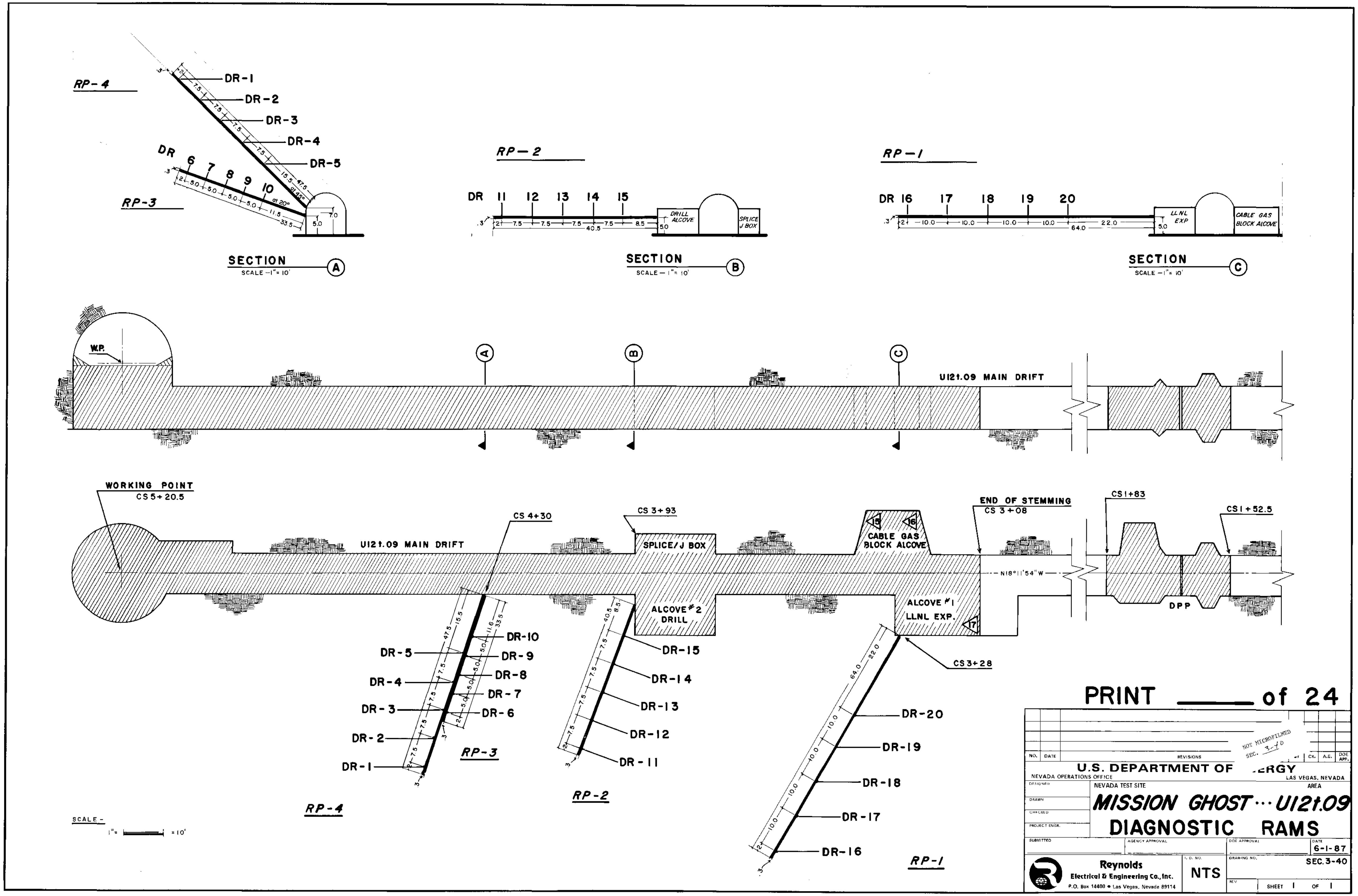

Figure 172. Plan (lower sketch) and profile (upper sketch) of the U12t.09 drift, 1987 (drawing SEC. 3-40, on file at the Archives and Records Center, Mercury).

Remote Area Monitoring System units located inside the tunnel, at the portal, and on top of the mesa did not register any radiation levels above background (Mullen and Eubank 1988b:85; Schoengold 1999:177). Reentry to the portal area began shortly after detonation and was completed within an hour. No elevated radiation levels were detected. Remote sampling within the tunnel also did not detect elevated levels of radiation or any toxic and explosive gases. Tunnel reentry began the next day or D+1 to the Gas Seal Plug in the main access drift and the railroad tracks were reinstalled through the Gas Seal Door (Mullen and Eubank 1988b:86). The Reentry Team then prodeeded to the Experimenter's Alcove Protection Plug and to the Facilities Drift Protection Plug. No elevated levels of radiation or toxic gases were found in either place. The Experimenter's Alcove was inspected and no damage was found. Mining of the Gas Seal Plug was started on D+2 and completed by D+3. The test was a containment success and most of the experiments and equipment were recovered by June 26 or D+6.

On July 10, 1987, the first postshot drill hole was started. The purpose for drilling the drill holes was to determine the dimensions of the blast cavity which were required for use in the calculation effort. The drill holes were equipped with a blowout preventer to keep pressure that may be in the cavity from escaping into the tunnel or to the atmosphere. The first hole was drilled horizontally from the Experimenter's Alcove toward the blast cavity (Schoengold 1999:179). A second drill hole was started on July 23 from the mesa into the cavity through a pre-test hole drilled to within 60.5 ft (18.4 m) of the cavity and then grouted for containment. It was re-drilled through the grout in the original hole and the blast cavity was reached at a depth of 1,134 ft (346 m) below the surface on July 31 (Schoengold 1999:180). On August 6, 1987 the first drill hole was stopped at 494.4 ft (150.7 m). The cavity then underwent a controlled release of pressure until there was no chance of pressure release through the first drill hole. Beginning on December 16, 1987 when ventilation was established to the mesa, radioactive effluents, contained in the blast cavity for about six months, were released intermittently over a three week period (Schoengold 1999:163; Schoengold et al. 1996:225). The released effluents did not go beyond the boundary of the NTS. Drilling was started again on January 7, 1988 and the near cavity wall was reached at 495.5 ft (151 m). Drilling of the first hole finally ended at 585 ft (178 m) on January 12, 1988 when the far wall was located (Schoengold 1999:180).

Mining of a reentry drift to the left of the U12t.09 drift was started on August 7, 1987 and entered the U12t.09 main drift at the end of stemming and the LLNL alcove on August 14 (Schoengold 1999:179). The reentry drift was rock bolted and the access into the main drift widened. Survey work continued from September through December and work on the reentry drift toward the cavity continued into March 1988. Additional probe holes were started in the reentry drift to the cavity. In addition, four crosscuts were mined from the right rib of the reentry drift between April and July 1988. The purpose for three of the crosscuts was to examine and record hydrofrac holes, while the remaining crosscut was to facilitate experiment recovery. The reentry mining was completed by July 1988. This concluded the last nuclear test in the U12t Tunnel.

Dipole Knight

The Dipole Knight 2 and 3 conventional weapons tests were conducted in the U12t Tunnel portal area on January 23 and February 12, 1997, respectively, by the Defense Special Weapons Agency (Thompson and Goodfellow 1997). These tests were part of a program to assess the effectiveness of conventional munitions on light steel structures and on weapons of mass destruction equipment housed within these types of buildings (Thompson and Goodfellow 1997:1). Specifically, the tests provided information on the vulnerabilities of light steel structures to airblast and irregular fragments from the weapons. It also helped determine the amount of protection these structures provide against such weapons. Additionally, the tests provided information on the storage containers and production equipment for weapons of mass destruction. The containers and equipment were simulated by using metal drums and salvaged equipment strategically positioned inside and outside the structures (Thompson and Goodfellow 1997:2).

Weapons used in the test consisted of general purpose bombs, placed vertically with the nose down and touching the ground surface (Thompson and Goodfellow 1997:4). The bombs were detonated electronically. The bomb for the Dipole Knight 2 test was located in the open and 77 ft (23.5 m) south of Building 12-896. The Dipole Knight 3 bomb was also placed in the open, 25 ft (7.6 m) from Building 12-895. Metal drums that simulated storage containers were placed inside and outside both buildings. Salvaged equipment that simulated production equipment were placed around the test bed (Thompson and Goodfellow 1997:12). The salvaged equipment also served as protective barriers for other buildings in the area.

Both tests were successfully executed and useful data on air blast and fragment dispersion were gathered (Thompson and Goodfellow 1997:37). Results of the tests compared favorably to the pre-test models. Buildings 12-895 and 12-896 were damaged by the tests.

Divine Eagle

The purpose of the Divine Eagle test program was to develop a small diameter conventional warhead that was capable of penetrating concrete structures (Oxtoby 1998; Thompson 2008, personal communication). The U12t Portal was selected for the Divine Eagle field tests because the data recording equipment was already in place following the Dipole Knight tests. There were four phases of tests for Divine Eagle, conducted on December 9-11, 1997 and February 3-5, February 9-11, and April 13-16, 1998.

The testing was done in two parts. First, a series of concrete discs (cakes) were used to test the penetration capability of the explosive to be employed in the warhead. Second, the warhead was tested on concrete cakes using explosives with BBs to increase its penetration capabilities. The concrete cakes were 4 inches (10 cm) thick and had diameters of 8 inches (20 cm), 48 inches (1.2m), and 60 inches (1.5 m). The concrete mix had a compressive strength of 3,000 psi (21 mpa) and contained up to 3/8 inch (1 cm) diameter aggregate.

The two smaller diameter concrete cakes were used with explosives only. A small void was formed in the top of each cake to hold the explosive. As the cakes were stacked one upon another for each successive test, the stack of cakes was held rigidly together using two half sections of heavy walled steel pipe that were bolted together. The 60 inch diameter cakes were stacked the same way; however, there was no void in the top of each cake for the explosive as the warhead was simply placed on top of the stack of cakes.

Stacking the cakes, installing the explosive, bolting the half sections together, attaching firing lines, and firing the explosive sequence was repeated until the stack reached ten cakes in the first phase of the test program. The second phase used the 60 inch diameter cakes and a warhead loaded with BBs. The warhead was positioned vertically on top of the stacks, armed, and fired. Rapid repeated firings caused the BBs to penetrate the stack of cakes. The Divine Eagle tests were deemed successful.

SUMMARY AND RECOMMENDATIONS

The U12t Tunnel was one of a series of tunnels on the east side of Rainier and Aqueduct Mesas used for underground nuclear weapons effects tests. In contrast to the other tunnels, U12t Tunnel was started by DTRA, rather than the National Laboratories, in order to meet its testing program requirements for DoD. The U12t Tunnel complex consists of a main access drift and nine designated primary side drifts, a substantial tailings pile fronting the tunnel portal, a series of discharge ponds downslope of the tailings pile, and two instrumentation trailer parks and 16 drill holes on top of Aqueduct Mesa. Total exposed surface area for the tunnel complex, including the portal area and the top of the mesa, is 184.9 acres (74.8 hectares). The amount of underground mining for U12t Tunnel totaled 6.61 miles (10.64 km). Preparation for the site was started in late 1967, with mining of the main access drift beginning on April 30, 1968.

Six nuclear weapons effects tests and one high explosive test were conducted within the U12t Tunnel and two series of conventional weapons tests were conducted outside the tunnel in the portal area. The nuclear tests were Mint Leaf, Diamond Sculls, Husky Pup, Midas Myth/Milagro, Mighty Oak, and Mission Ghost. LLNL provided four of the nuclear devices and LANL provided two and all had a yield of less than 20 kilotons. The first nuclear test was conducted in 1970 and the last in 1987. The nitromethane high explosive test was conducted in 1973. It was a Stemming Plan Test, designated SPLAT, and was a scaled model of a line-of-sight pipe configuration. The Dipole Knight 2 and 3 conventional weapons tests in the portal area in 1997 were part of a program to assess the effectiveness of light steel structures and equipment for weapons of mass destruction. The purpose of the Divine Eagle conventional weapons tests in the portal area in 1997 and 1998 was to develop a small diameter conventional warhead capable of penetrating concrete structures.

The objective of the first five nuclear tests in the U12t Tunnel was to determine the vulnerability or survivability of various military hardware, structures, and electronic equipment when exposed to the radiation field of a nuclear explosion. In these tests, missile systems of the U.S. Army and Navy were evaluated. The tests also required high altitude simulation. The sixth nuclear test, Mission Ghost, was designed to study the shock induced effects of a near surface nuclear detonation and was located in a hemispherical cavity underground.

The Diamond Sculls test had the largest diameter and longest horizontal line-of-sight pipe ever used at the NTS. The test chamber attached to the end of the pipe also has the distinction of being the biggest. An Assembly Area was constructed underground specifically to weld sections of the pipe together before moving them into place. The test chamber was also constructed in this manner. In the Husky Pup test, a Close-In Recording System (CIRS) using video transmission was first employed to record the faster signals generated during a nuclear test. A 10 ft sq (3 m sq) granite block, weighing 43 tons, was placed near the Husky Pup nuclear device in the zero room as part of an energy coupling experiment.

In the Midas Myth/Milagro test, a large open space, called the ballroom, was used for the first time. The ballroom was the largest open space created in any of the tunnels and housed recording instruments. Most of the upgrades to the portal area, such as new buildings and equipment, occurred during preparation for the Midas Myth/Milagro test. A second trailer park located near surface ground zero was constructed on Aqueduct Mesa for the Milagro experiments in the test. About three hours after detonation, a subsidence crater suddenly occurred beneath this trailer park where reentry and data recovery teams were working at the time. The trailers were damaged and 10 people were evacuated to hospitals in Las Vegas. Moreover, greater than normal ground shock caused sections of the tunnel to collapse and most of the recording equipment was destroyed.

The Mighty Oak drift was one of the most complex test layouts designed by DTRA. It included two large rooms for recording instruments nearly in size to the ballroom in the Midas Myth/Milagro test and two drifts for structures experiments extended from the bypass drift. Most of the experiments in the Mighty Oak test were connected to various detectors and sensors that provided constant transfer of data, while a small portion of the experiments had to be recovered after the test to retrieve their data. In addition, DTRA experimenters used a high speed fiber optic cable system to transmit data to the portal recording station. In contrast, the National Laboratories used copper cables to transmit data to the underground recording alcoves. Shortly after detonation, a failure of Containment Vessels I and II occurred. The escaped radioactive gas was contained in Vessel III at the Gas Seal Plug. It was later determined that the auxiliary closures in the line-of-sight pipe were positioned too close to ground zero and were not strong enough to adequately contain the explosion. Nearly all experiments, diagnostics, and construction equipment staged underground were lost as a result. Most of the data was recovered, however, with total data recovery estimated at around 70 percent for all agencies. The data recovery rate for DTRA, transmitted by way of the fiber optic system to the portal, was about 95 percent. The other agencies did not use the fiber optic system for this test.

Modifications to the landscape associated with the U12t Tunnel in the Portal Area resulted from four principal activities: road construction and maintenance; mining activities related to tunnel development and the disposal of mine tailings; site preparation, such as mine tailings in construction fill for buildings and staging areas; and construction of retention ponds. On the mesa, primary landscape modifications included road construction, trailer park pads, drill hole pads, local quarry and bedrock excavation for building the pads and roads, and electrical transmission lines and generating stations.

In the Portal Area, four activity areas with cultural features were defined: the Portal Terrace, the Ventilation Terrace, the Water Supply Terrace, and the Pond Area. The Portal Terrace is a large dirt and gravel platform created from mine tailings. It is in front of the portal and was used primarily as a staging area for construction and testing activities within the tunnel. Above the Portal Terrace is the smaller Ventilation Terrace, cut into the face of Aqueduct Mesa. On this terrace was equipment that regulated air to the tunnel during construction and testing activities. Above the Ventilation Terrace is the small Water Supply Terrace on which four water tanks are located. Below the Portal Terrace is the Pond Area with six sediment ponds to contain runoff from the tunnel.

On top of Aqueduct Mesa are the U12t Tunnel Mesa Trailer Park, the Midas Myth/Milagro Trailer Park, and Drill Hole Locations. Multiple instrumentation trailers were located at the U12t Tunnel Mesa Trailer Park during testing to record data from experiments located underground in the tunnel. The trailers were linked to the experiments by numerous cables inserted in 3 ft diameter holes drilled from the mesa into the tunnel interior. The U12t Tunnel Mesa Trailer Park was used only for the first three nuclear tests for recording data in instrumentation trailers. For the last three tests, this data recording was done underground in the tunnel and not at the Mesa Trailer Park. The second, smaller trailer park, referred to as the Midas Myth/Milagro Trailer Park, was northwest of the U12t Tunnel Mesa Trailer Park and used only in the fourth nuclear test just to record data from the LANL Milagro experiments during the Midas Myth test. The drill holes are generally on dirt pads and include exploratory, cable, and postshot. Exploratory holes are drilled to test the subsurface geology. Cable holes are drilled to insert cables to the tunnel interior. Postshot drill holes are for after the test to sample the subsurface environment.

A total of 89 cultural features were recorded: 54 at the portal and 35 on the mesa. Cultural features at the portal are mostly concrete pads and building foundations; other features include the portal, rail lines, the camel back, ventilation and cooling system components, communication equipment, and electrical equipment. On the mesa, cultural features are drill holes, a few small concrete pads, a loading ramp, and electrical equipment.

National Register Eligibility

Nuclear testing is one of the study units stated in the Nevada Comprehensive Preservation Plan provided by the Nevada State Historic Preservation Office (White et al. 1991). Accordingly, the major sites and structures associated with nuclear testing are considered to have intrinsic significance in the history of Nevada and the nation and are eligible to the National Register of Historic Places. The U12t Tunnel served from 1967 to 1988 for underground nuclear weapons effects tests by DTRA and is eligible to the National Register of Historic Places under criteria a and c, consideration g of 36 CFR Part 60.4 as a historic landscape. It does not qualify under criteria b and d.

Criterion a refers to events that have made significant contributions to the broad patterns of our history. Research at the U12t Tunnel was conducted in the defense of the United States during the Cold War, a war characterized by competing social, economic, and political ideologies between two superpowers - the former Soviet Union and the United States. Atomic weaponry was central to this on-going struggle in order to gain military advantage and deter aggression from the other side. The purpose of the U12t Tunnel was to provide an underground testing environment for the development of nuclear weapons and to assess the effects of a nuclear explosion on materials and equipment.

Criterion b applies to properties associated with individuals whose specific contributions to history can be identified and documented. No such person has been identified with the U12t Tunnel.

Criterion c applies to properties significant for their physical design or construction, including architecture, landscape architecture, and engineering. The U12t Tunnel embodies a distinctive characteristics of a type and method of construction and engineering for conducting underground nuclear weapons effects tests. It also provided a context for improving the technology and engineering for the containment of undergound nuclear tests. Furthermore, a number of technological and engineering innovations for underground nuclear weapons effects testing were first implemented in the U12t Tunnel.

Criterion d refers to important research questions about human history or prehistory that can only be answered by the actual physical material of a cultural resource. The U12t Tunnel does not meet this criterion.

Consideration g refers to properties less than fifty years old, of exceptional importance, and have achieved significance. The U12t Tunnel is less than fifty years old, considered to be of exceptional importance, and has achieved significance.

Management Recommendations

As a historic landscape eligible to the National Register of Historic Places, the Desert Research Institute recommends that the U12t Tunnel area be left in place in its current condition and that it be included in the NTS monitoring program and monitored for disturbances or alterations on a regular basis. It is further recommended that signage be placed at the entrance to the U12t Tunnel area describing it as a historic property recognized by DOE and NNSA/NSO.

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APPENDIX A

BEDROCK DESCRIPTIONS FOR OLDER GEOLOGIC UNITS IN RAINIER AND AQUEDUCT MESAS

INDIAN TRAIL FORMATION, GROUSE CANYON MEMBER (TIG)

The Grouse Canyon Member of the Indian Trail Formation (Tertiary) is a simple cooling unit with an underlying ash-fall tuff.

Lower Part (Tertiary)

Tertiary ash-fall tuff. About 46 to 121 ft (14 to 37 m) of ash-fall tuff; probably genetically related to an overlying welded tuff; greenish-yellow and bluish-gray; conspicuous fragments of black glass; zeolitic alteration is locally intense. This unit overlies the Lower member of the Indian Trail Formation.

INDIAN TRAIL FORMATION, LOWER (TIL) - TERTIARY

The Lower Member of the Indian Trail Formation consists of 131 to 590 ft (40 to 180 m) of bedded tuff, pale-gray, fine to lapilli-size; zeolitic; locally divided into Tunnel Beds and informal units at Grouse Canyon, Captain Jack Spring, and Whiterock Spring areas.

Tunnel Bed 4 ($Tilt_4$)

This is the uppermost unit of the Lower Member of the Indian Trail Formation. It consists of about 262 to 377 ft (80 to 115 m) of pale-gray and red bedded tuff; red beds are continuous for several miles; several thin but conspicuous dark-gray beds of lithic tuff; zeolitic; forms resistant round ledges. Sargent and Orkild (1973) included this unit and Tunnel Bed 3 within the Upper Bedded Tuff (Miocene) unit (Tabu) of their Bedded Tuff, which is described as white to pale-brown thin- to thick-bedded commonly zeolitized tuffaceous sediments and ash-fall tuff; locally may include nonwelded to partially welded ash-flow tuffs; in places the ash-fall tuffs contain abundant pumice averaging 1 cm in length; some beds are reworked and conglomeratic; locally they are rich in dacite lithic fragments; intercalated with units from the Grouse Canyon Member of the Belted Range Tuff down to the Monotony Tuff; thickness 0 to greater than 4,265 ft (1,300 m). Tunnel Bed 4 and Tunnel Bed 3 are roughly equivalent to the Ash-Fall Tuff (Tba; Miocene) of Frizzell of the Belted Range Tuff, Grouse Canyon Formation. Tba is described as massive to well-bedded ash-fall and tuffaceous sandstone; tuff partially to completely zeolitized; cogenetic with the Belted Range Tuff, as much as 1,640 ft (500 m) thick.

Tunnel Bed 3 ($Tilt_3$)

This unit consists of about 100 to 200 ft (30 to 60 m) of pink and pale-gray tuff; beds and color are discontinuous; prominent red beds at top and bottom; zeolitized. Tunnel Bed 3 as included in the Upper Bedded Tuff of Sargent and Orkild (1973) is described in the Tunnel Bed 4 description above. Tunnel Bed 3 as included in the Belted Range Tuff, Grouse Canyon Formation of Frizzell and Shulters (1990) is described in the Tunnel Bed 4 description above.

Tunnel Bed 2 ($Tilt_2$)

This unit consists of about 100ft (30 m) of pale-gray with subordinate red and purple tuff; two zones with pisolite beds, one about 40 ft (12 m) and the other about 80 feet (24 m) above the base; zeolitic; thin welded tuff is found locally at the top of the unit. Sargent and Orkild (1973) included this unit and Tunnel Bed 1 within the Lower Bedded Tuff (Miocene to Oligocene) unit (Tabl) of their Bedded Tuff, which is described as white to pale-brown thin- to thick-bedded commonly zeolitized tuffaceous sediments and ash-fall tuff; locally may include nonwelded to partially welded ash-flow tuffs; in places the ash-fall tuffs contain abundant pumice averaging 1 cm in length; some beds are reworked and conglomeratic; locally they are rich in dacite lithic fragments; intercalated with units from the Grouse Canyon Member of the Belted Range Tuff down to the Monotony Tuff; thickness 0 to greater than 4,265 ft (1,300 m). Tunnel Bed 2 and Tunnel Bed 1 are roughly equivalent to the Ash-Fall Tuff (Ta1; Miocene) of the Belted Range Tuff, Grouse Canyon Formation of Frizzell and Shulters (1990) and is described as laminated to thick-bedded ash-fall tuff, reworked tuffaceous sandstone and conglomerate, and nonwelded ash-flow tuff; locally zeolitized; local quartzofeldspathic sandstone is argillic and zeolitized; as much as 2,297 ft (700 m) thick.

Tunnel Bed 1 ($Tilt_1$)

This is the basal unit of the Lower Member of the Indian Trail Formation. It consists of about 200 ft (60 m) of purplish- to pinkish-red and minor gray bedded tuff; prominent red beds at top and about 50 feet below top; zeolitic. Tunnel Bed 1 as included in the Bedded Tuff of Sargent and Orkild (1973) is described in the Tunnel Bed 2 description above. Tunnel Bed 1 as included in the Ash-Fall Tuff of Frizzell and Shulters (1990) is described in the Tunnel Bed 2 description above. Tunnel Bed 1 is unconformable on the Paleozoic Dolomite – Unit C.

Dolomite – Unit C (Ddc)

This unit is described as Devonian in age, gray and very dark gray finely crystalline dolomite interbedded with thinner light-gray dolomite; beds of rounded masses of white breccia in a matrix of dark-gray dolomite. The beds pinch and swell and weather to pit and point surfaces. Thickness of the unit is greater than 1,476 ft (450 m). Sargent and Orkild (1973) map this same unit as Devonian dolomite and limestone (Ddl) that consists of interbedded light-to dark-gray dolomite and limestone, laminated to thick bedded; locally includes sandy dolomite and zones rich in silt, chert, and clay, and is largely equivalent to the Devils Gate Limestone and Nevada Formation, thickness about 2,297 ft (700 m). Frizzell and Shulters (1990) map the same unit as Carbonate rock, undivided Devonian, Silurian, and Ordovician (Doc) and describe the unit as predominantly dolomite in the Specter and Spotted Ranges, generally light colored, thickness about 1,706 ft (520 m); interbedded dolomite and fossiliferous dolomitic limestone along the west margin of Yucca Flat, thickness about 2,165 ft (660 m); and crinoidal limestone and dolomite in the Calico Hills, thickness about 100 ft (30 m).

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APPENDIX B

CONTRACTORS AND OTHER GOVERNMENT AGENCIES

Contractors and other Government Agencies

U.S. Department of Energy Contractors

The DOE employed many contractors and several other government agencies to conduct nuclear tests at the NTS. DTRA, through a memorandum of understanding with DOE, was obligated to use the DOE contractors for engineering design, construction, mining and drilling, operation, and maintenance of the facilities it used to conduct its test programs at the NTS. DTRA employed their own contractors to design, assemble, install, and recover experiments fielded on each of their tests. The National Laboratories, under contract to the DOE, provided the nuclear devices for all tests including those sponsored by DTRA.

The following identifies the principle DOE contractors and government agencies employed at the NTS:

Lawrence Livermore National Laboratory (LLNL), Livermore, California - provided nuclear device design and testing

Los Alamos National Laboratory (LANL), Los Alamos, New Mexico - provided nuclear device design and testing

Sandia National Laboratory (SNL), Albuquerque, New Mexico - provided nuclear device design, line-of-sight pipe closure systems design and operation oversight, rock mechanics research, and health physics support

Reynolds Electrical and Engineering Co., Inc. (REECo), Las Vegas, Nevada - responsible for NTS operations and maintenance; mining, drilling, and construction; environmental, safety, and health services; housing and cafeterias; motor pool; and medical services

Holmes and Narver Inc. (H&N), Los Angeles, California and Las Vegas, Nevada - provided architectural and engineering (A&E) support for civil, mechanical, and electrical design services; construction quality control and materials testing

Fenix and Scisson Inc. (F&S), Tulsa, Oklahoma - provided architectural and engineering support for mining and drilling services; geological support services; and contract administration for cementing services contractors

Raytheon Services Nevada (RSN), Waltham, Massachusetts - contractor for A&E services formerly provided by H&N and F&S

Edgerton, Germerhausen, and Grier (EG&G) Inc., Las Vegas, Nevada and Cambridge, Massachusetts - provided electronic measurements and high speed photography; instrumentation support for DOE laboratories (i.e., LLNL, LANL, and SNL); operated the monitor room at the

Control Point for all DTRA tests, including the monitoring of real time health and welfare of all experiments on a test and provided command and control for all non-device related mechanical and electrical systems in the tunnel complex; and designed the instrumentation cable plant and provided oversight during installation of cables and connectors

Dowell Corp., Tulsa, Oklahoma, Halliburton Co., Tulsa, Oklahoma, and B.J. Titan Services Co. - provided cementing services, including bulk storage, blending, hauling, and pumping of all cementitious materials used on the NTS

Bell Telephone Co. and Central Telephone Co. - provided telephonic communication services throughout the NTS

Wackenhut Security Inc. (WSI) - provided site-wide security services

Other Government Agencies

Nye County Sheriff - provided traffic and law enforcement services throughout the NTS

United States Post Office - operated a full service post office in Mercury and a satellite post office in Area 12 of the NTS

United States Geological Survey, Denver Office - provided geological mapping and logging services and containment support for the NTS

National Oceanic and Atmospheric Administration, Air Resources Laboratory, Special Operations and Research Division, Las Vegas, Nevada - provided complete weather research, air dispersion, atmospheric sciences, and forecast support for all NTS operations

U.S. Environmental Protection Agency, Nuclear Radiation Assessment Division, Las Vegas, Nevada - provided downwind and cloud tracking services

U.S. Air Force, Nellis Air Force Base, Nevada - provided helicopters for aerial photography and downwind cloud tracking support

Defense Threat Reduction Agency Contractors

Lockheed Missile and Space Co. (LMSC) Sunnyvale, California - provided horizontal line-of-site (HLOS) pipe and vacuum systems design, manufacturing, installation, and operational oversight

Bendix Corporation (BC) Las Vegas, Nevada - provided instrumentation services including inventory, maintenance and repair, configuration, and assembly of recording equipment and racks of equipment for agencies that fielded experiments on DTRA tests

Pan American World Airways (PanAm), Cocoa Beach, Florida - provided still, motion, and video photography and archive documentation services

Los Alamos National Laboratory (LANL), Los Alamos, New Mexico - provided the design, procurement, and installation support for vertical line-of-site (VLOS) pipe systems

U.S. Army Corps of Engineers, Waterways Experiment Station (WES), Vicksburg, MS - provided rock mechanics, rock core testing and analysis, concrete and grout mix design, development, quality control, and placement oversight

Terra Tech Corporation, Salt Lake City, UT - provided rock mechanics, rock core testing, and containment design support.

Systems, Science, and Software, Inc. (S-Cubed), La Jolla, California - provided containment calculations, predictions, and design support.

Pacifica Technology (PacTec), La Jolla, California - provided containment calculation support

Agencies and Organizations that Fielded Experiments on DTRA Tunnel Tests:

Air Force Weapons Laboratory
Ballistic Missile Office
Bell Telephone Laboratories
Boeing Technical and Management Services, Inc.
Effects Technology, Inc.
General Atomic Corporation
General Electric
General Research Corporation
J.A. Young Corporation
Kaman Science Corporation
Lockheed Palo Alto Research Laboratory
Massachusetts Institute of Technology
McDonnell Douglas Aircraft Corporation
McDonnell Douglas Astronautics Corporation
Navy Strategic Systems Project Office
Physics International
Science Applications International Corporation
Science and Engineering Associates
S-Cubed
Stanford Research Institute
TRW Systems