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BANEBERRY SUMMARY REPORT

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SUMMARY

The BANEBERRY underground nuclear device development test of less than 20 kilotons was detonated near the northern border of Yucca Flat on the Nevada Test Site (NTS) at 7:30 a.m., PST, on December 18, 1970. All programmed operations proceeded normally until 3.5 minutes after detonation when a release of radioactivity commenced from a fissure which opened up after detonation at a distance of about 300 feet and in a southwesterly direction from the emplacement hole. This release continued over an extended period even after commonly experienced surface collapse occurred at 16.5 minutes after detonation. This collapse was a normal and expected phenomenon. The effluent venting rate steadily decreased with time but visible vapor continued to emanate from the fissure for 24 hours after detonation.

Because the phenomena which led to release of radioactivity from the BANEBERRY test were not immediately evident, the Commission suspended weapons tests at the NTS until it had reviewed BANEBERRY in detail and was convinced that every reasonable precaution was initiated to minimize the probability of a similar future occurrence. This report is a summary of the events surrounding the BANEBERRY release and postshot investigative findings and conclusions.

The BANEBERRY venting can be attributed basically to stronger coupling of energy into the ground than is normal for tests buried at this depth in Yucca Flat. This stronger coupling was due to a high water content at shallow depth which resulted from a geologic environment unique in test experience and limited to a relatively small area around the BANEBERRY site. The emplacement geometry and other geologic characteristics of the surrounding media may have contributed in a lesser degree to the release.

Radioactivity released as a result of the BANEBERRY detonation produced some exposures to personnel both onsite and offsite. However, operational safety procedures instituted following the detonation were successful in ensuring that radiation exposures to test site workers or the offsite population were below currently established Federal Radiation Council standards for normal peacetime operations. Section 3 of this report reviews radiological safety activities associated with BANEBERRY.

On the basis of the BANEBERRY experience and investigation, the Commission has taken action to strengthen technical and administrative procedures to substantially reduce the probability of a similar future occurrence. These actions include but are not limited to: more extensive geologic and geophysical investigations; the institution of more conservative area controls and restriction of forward area personnel and facilities to minimum requirements; and a more vigorous analytical program so as to better understand the behavior of nuclear detonations in the various environments which may be encountered in emplacing underground tests, with special emphasis on more conservative burial depth for low yield experiments.

1. DESCRIPTION AND LOCATION OF THE EXPERIMENT

BANEBERRY was an underground nuclear test of less than 20 kilotons designed by the Lawrence Radiation Laboratory-Livermore, California, in support of requirements established by the Department of Defense. The test was conducted in Area 8, drill hole U8d, of the Nevada Test Site. The nuclear device was emplaced in an 86-inch-diameter hole at a depth of 910 feet. The emplacement geometry of this test was that of an evacuated line-of-sight (LOS) pipe equipped with fast closure systems and running vertically from near the explosive device to the surface. The hole outside the LOS pipe was backfilled to the surface with sand, gravel, and plastic stemming materials.

2. CONTAINMENT ANALYSIS

2.1 Shot-Time Phenomena

All programmed operations were performed in a normal and anticipated manner until the release of radioactivity commenced. Signals from instruments near the explosion indicated that containment features functioned as planned.

At 3.5 minutes after detonation, a release of radioactivity began from a location estimated to be 300 feet S60° W of surface zero. The initial point of release rapidly elongated until radioactivity was issuing from a fissure oriented radially to surface zero and bearing S60° W. The release occurred over a distance of 315 feet, extending from 375 feet to a distance of 60 feet from surface zero. After surface collapse, 16.5 minutes after detonation, release continued with diminished velocity from that portion of the fissure outside the collapse crater. Fairly rapid venting of steam continued until about H plus 2 hours, after which only a lazy cloud of vapor could be seen drifting up from the portion of the fissure outside the crater. This continued for nearly 24 hours.

Previous ventings through emplacement holes or fissures were reduced to seepage or were stopped entirely upon surface collapse. The BANEBERRY test is in marked contrast to this behavior, supplying the evidence that a large portion of the release path was external to the chimney* region and therefore not disrupted by chimney growth and surface collapse.

* Chimney: The chimney is that structure formed by collapse of the underground cavity created by an underground nuclear detonation. As the overlying rock falls into the cavity, a rubble-filled region progresses upward forming a generally cylindrical outline. The ultimate chimney height depends on yield and rock properties and frequently, as it did in BANEBERRY, reaches the surface and causes a subsidence crater.

The final surface crater, formed by chimney growth to the surface, is 78 feet deep. The crater outline is slightly oval with an average diameter of 455 feet. The depth to diameter ratio is somewhat greater than normally experienced for a test at this yield and depth in the central portions of Yucca Flat.

2.2 Yield and Energy Coupling

2.2.1 Radiochemical Analysis

Radiochemical yield determination presently available on the BANEBERRY device indicates the yield was about as expected.

2.2.2 Seismic Measurements

Initial yield estimates for BANEBERRY were developed from ground motion amplitudes measured at distant seismic stations. Three different organizations estimated yield values independently and all of these estimates were considerably greater than the yield as determined by radiochemical analysis.

Yield determination for an experiment by seismic measurements relies on comparison with a test of known yield detonated nearby and in the same geologic environment. Only two other tests had been conducted near BANEBERRY. DISCUS THROWER, located 2,100 feet north-northeast, was detonated in tuff at a depth nearer to the subsurface Paleozoic carbonate bedrock than BANEBERRY. CYATHUS, located 2,000 feet east, was detonated in tuff at a depth more remote from the carbonate rocks. The yield determinations for BANEBERRY were established assuming that one or the other of the nearby tests represented the BANEBERRY environment. The facts indicate that much stronger ground motion coupling occurred for BANEBERRY than for these two nearby tests and can be explained by the geologic differences which are now known to exist for these tests.

Enhanced coupling factors of the required magnitude can easily be attained by the existence of a water content near saturation in the test medium. Physical properties determined for samples obtained postshot from the detonation medium (600 feet horizontally from the shot point) reveal the water content is indeed very high. The DISCUS THROWER and CYATHUS shot media were not saturated and consequently it is not proper to establish a yield based on seismic measurements for BANEBERRY by comparison with these two events. Had seismic amplitude curves established for saturated media been applied to BANEBERRY, a seismic yield consistent with the radiochemical yield would have resulted.

2.3 Hole History

Drill hole U8d, the uncased BANEBERRY emplacement hole, was drilled 126 feet northwest of the U8a10 satellite hole.* Drilling commenced October 25, 1970, and was completed December 8, 1970. The 86-inch hole was drilled to a depth of 980 feet. A caliper log showed filling to 891 feet with significantly enlarged zones below 700 feet. Cleanout operations resulted in continued filling and sloughing of the hole below 700 feet. Eight successive cementing and redrilling sequences were necessary to complete the hole to a final depth of 942 feet. Completion of the hole required 38,000 cubic feet of cement with an estimated 8,300 cubic feet of cement remaining in the 700- to 928-foot interval after all redrilling operations had been completed.

The cement used in the hole was a basic oil-well-type cement with nylon fibers added to reduce its brittleness. This cement is commonly used in NTS holes. The mix used contained very little carbonate (less than 4 percent) and consisted of 44 percent water by weight.

The problems in completing the hole are attributed to the high montmorillonite clay content of the tuff below 700 feet. Montmorillonite may swell 50 percent in volume when exposed to water and tends to slough when wet so that as the hole is drilled sloughing of the walls will occur. The drilling technique used on this hole required a 200- to 400-foot head of water in the hole at all times, therefore more than enough water was available to account for flowing of the clay. Similar problems were encountered with some of the DISCUS THROWER satellite holes, especially U8a9, U8a10, and U8a11 which bracket the BANEBERRY site. A downhole television survey two days after hole U8d completion indicated no water inflow had occurred during this period, and the foot of water left in the hole after completion was still present. Considering the natural state water content of the shot medium, it is unlikely that significant amounts of water could have been added to the formation during drilling operations.

The amount of difficulty encountered in drilling this hole is not unique in the NTS experience. Several holes have required extensive cementing to permit hole completion and some of these were used in an uncased condition. Neither is the diameter unusual for an uncased hole and, indeed, several this size and larger have been successfully utilized.

The cause of the hole completion problems on U8d appears almost unique because such high montmorillonite clay content is now known to exist only at U8d and some of the U8a satellite holes.

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* U8a10 satellite hole was drilled prior to the detonation of the DISCUS THROWER test to determine subsurface geology at the test area.

2.4 Stemming Emplacement

Several modifications of the original stemming design were made. These modifications involved differences in the final location of the various stemming materials. The stemming of the emplacement hole did fill the hole around and above the device canister, and there is no evidence that the stemming deviations contributed in any substantial manner to the venting.

2.5 Geology of the BANEBERRY Site

Preshot knowledge of subsurface geology in the BANEBERRY area was based on information obtained from the DISCUS THROWER satellite holes, the closest of these, U8a10, being 126 feet southeast of the BANEBERRY site.

The site was intentionally selected to provide high seismic velocities in the first 200 feet above the detonation point. Calculations show that this is advantageous in assuring closure of the LOS pipe. The average velocity from 910 feet to the surface, based on signals from BANEBERRY itself, was 6,400 feet per second. Even higher velocities were indicated preshot by sonic logs in the U8a10 hole. Density of the material above the shot point is also high, averaging about 2.15 g/cm^3 as calculated from density logs in U8a10. Only one estimate of porosity and water content was available preshot from near the shot point environment. A core from U8a10, taken between 977 and 985 feet in the same geologic unit as the BANEBERRY working point, had a porosity of 40.6 percent, and 98 percent of the pore space was filled with water. During drilling, this core was in contact with drilling fluid, however, and it was not believed possible to establish the true in situ water content from this information. Carbonate content estimated for this same core was about 15 percent. Postshot analysis of cuttings from the BANEBERRY emplacement hole shows lower values ($\sim$5 percent) for CO_2 content.

As mentioned earlier, a feature peculiar to the BANEBERRY site and some of the DISCUS THROWER satellite holes is the presence of very large amounts of montmorillonite clay. This clay, when present in large quantities, will form a relatively impermeable barrier to water flow. Downward-moving water would be held back by these clay zones permitting the saturated or nearly saturated regions to exist in the BANEBERRY shot zone. Also the fact that BANEBERRY is located on the axis of a subsurface trough would serve to concentrate and localize water around the BANEBERRY site. In addition, there is a change in character of the Paleozoic bedrock just to the east of the BANEBERRY site from carbonate rock on the east to quartzite and argillite on the west. The quartzite and argillite being less permeable would drain away water at depth less rapidly, thus contributing to the existence of regions of high water content. Post-BANEBERRY drilling at a location (Ue8f) 600 feet southeast of U8d obtained samples from the shot horizon which show the tuff to be nearly saturated and to contain very large amounts of water.

In addition to these unusual features, it should also be pointed out that the alluvium in the upper 700 feet is a relatively well-cemented material with densities and sonic velocities much higher than normally associated with alluvium found nearer the center of Yucca Flat. It is not representative of those areas of the NTS where most of testing experience has been gained and where extensive containment guidelines have been developed.

BANEBERRY caused surface faulting and cracking to occur. Similar faulting occurred on DISCUS THROWER but the magnitude of the BANEBERRY faulting is unusual for a shot of this low yield. These faults indicate that considerable in situ tectonic stress exists in this area. The motion and attitude of the faults are consistent with the regional stress pattern known to exist in Pahute and Rainier Mesas. These faults are indicative of a minimum principal stress axis oriented northwest-southeast. The alignment of faults and the venting fissure along the direction of maximum principal stress and the normal fault type of displacement on the faults implies a low stress in the northwest-southeast direction.

The nature of the BANEBERRY faults and fissures implies that a preshot weakness did exist and controlled shot-time response of these features. The fissure through which the venting occurred may be traced to the northeast beyond its release path but shows no fault-type movement--only separation perpendicular to the fissure. Its radial nature indicates it may have been generated by the ground shock and doming of the ground above the cavity with its azimuth being determined by the minimum principal stress orientation.

2.6 BANEBERRY LOS Containment Diagnostics

To prevent release of radioactive material through the LOS pipe, various closure mechanisms were employed. Performance of the closure mechanisms was monitored by instrument stations placed at various locations in the LOS pipe. The sensors located at these points measure temperature, pressure, velocity, acceleration, and radiation.

Analysis of the data received from these sensors shows that the behavior of the LOS pipe at, and subsequent to, shot time was within the range of experience on contained vertical LOS tests and in some respects was better. Pressure in the LOS pipe above 250 feet, at times of seconds until after venting began, was at less pressure than is normally experienced at similar times on other LOS tests. At late time, 9 minutes after zero time or 5.5 minutes after venting commenced, this same measurement indicated higher pressures than are normally experienced for LOS pipe tests emplaced in a drier media at comparable times.

Data from the sensors indicate that the LOS pipe and stemming (above 250 feet and 350 feet, respectively, from the detonation point) were not a part of the initial vent path and did not contribute to the eventual release. Since the diagnostic data for the lower portion of the LOS pipe are consistent with previous experience for contained tests, the pipe in that range is not viewed as a primary cause of the release.

2.7 Conclusions

The primary cause of venting of the BANEBERRY test was an unexpected and unrecognized abnormally high water content in the medium surrounding the detonation point. (This high water content is believed to be in no way associated with the drilling operations.) This increased the coupling of energy into the earth and also extended the duration of high pressures in the cavity. The end result was the experiment's behaving as if it were of higher effective yield and therefore emplaced at too shallow a depth. Had the same test occurred in the more usual test environment, without the high water content, it is believed that it would have been satisfactorily contained underground.

The geology at the BANEBERRY site is significantly different than that which is known or inferred to represent the bulk of underground test experience at the NTS. Depth of burial necessary for containment developed empirically from this test experience is medium dependent and should not be routinely applied to tests in new geologic situations.

Present containment criteria for vertically emplaced tests are adequate for those areas of the NTS where the geologic environment is the same as that where the bulk of testing experience has been acquired. These criteria are conservative for high yield tests, many of which are below the water table, but less so for low yield detonations. For low yields, an unusual environment may result in phenomena sufficiently different from experience to lead to release of radioactivity. Both detailed geologic information and a more conservative burial criteria would help avoid unexpected developments when testing in new areas. For high yield tests, the large absolute depths involved prevent propagation of fissures to the surface, so that there is less sensitivity to geologic variations.

3. RADIOLOGICAL SAFETY ACTIVITIES

3.1 Control Point Operations

For each underground nuclear test, briefings are held in the hours preceding the test to discuss meteorological conditions and to assess the predicted conditions at shot time and during the immediate postshot hours. The first BANEBERRY readiness briefing was held at 2:30 p.m., PST, on December 17, 1970 (D minus 1). It was noted that all actions were on schedule to assure technical readiness for a zero time of 7:30 a.m., PST, on December 18, 1970.

At the D-day morning readiness briefing, weather predictions for shot time and fallout predictions based upon predicted winds and an assumption of an inadvertent and extensive release of radioactivity were presented to the Test Manager and his Advisory Panel. It is a safety evaluation procedure for every experiment to assume such a hypothetical incident in order to determine that an underground test can be conducted safely. Based upon the foregoing information, the Test Manager and his Advisory Panel concluded that the onsite exclusion area and the offsite monitors and control procedures were adequate for safe conduct of the test.

The detonation proceeded on schedule. Subsequent to the release of radioactivity, action was taken to expand the Test Site exclusion areas. All northbound traffic into forward areas from Mercury was halted. Evacuation of personnel from the exclusion areas was completed at approximately 9:15 a.m., PST.

3.2 Onsite Radiological Safety Activities

3.2.1 Personnel Radiological Surveys

During the evacuation of personnel, preparations were made at Control Point 2 and the decontamination pad to survey these personnel, their personal effects, and vehicles. A personnel decontamination station was set up inside building CP-2. All contaminated clothing and personal effects were monitored, inventoried, and bagged. Individuals whose clothing exceeded 0.3 mR/hr were provided with white paper or cloth overalls and rubber boots and their personal effects were collected.

Approximately 900 personnel were surveyed. Of these, 86 personnel were decontaminated at CP-2 and 66 of these were sent to Mercury for thyroid activity measurements. Of those counted at Mercury, 18 were sent to the Southwestern Radiological Health Laboratory (SWRHL) whole-body counter in Las Vegas for additional measurements. Dose data for those personnel having measured thyroid activity are given in Figure 1.

3.2.2 Onsite Doses to Persons

The highest radiation doses to persons onsite occurred on the day of the test and resulted from cloud passage over Area 12. Based on initial film badge readings and thyroid monitoring, no exposure of onsite personnel was in excess of the occupational standards in AEC or Federal Radiation Council occupational guides for normal peacetime operations. The highest exposures (see Table 1) were received by two security guards and were about 30 percent of the Federal Radiation Council's quarterly guide for whole body and about 37 percent of the guide for thyroid exposure. The exposure to the lens of the eye was almost equal to the exposure limit.

3.2.3 Equipment Decontamination

More than 500 privately owned vehicles were surveyed following the Area 12 evacuation and more than 400 were found to be contaminated. All the vehicles

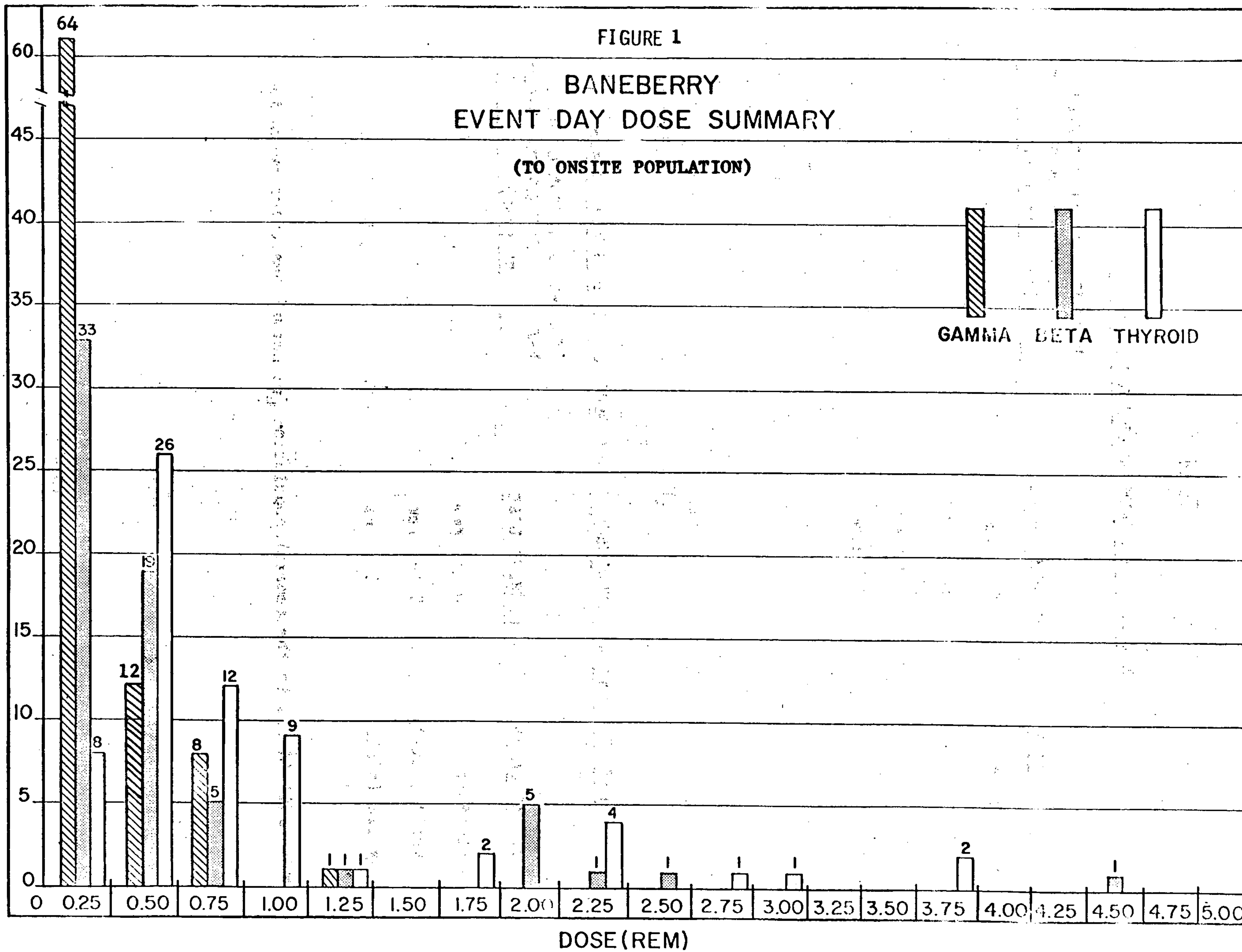


FIGURE 1
BANEBERRY
EVENT DAY DOSE SUMMARY
(TO ONSITE POPULATION)
GAMMA
BETA
THYROID
NO. PERSONNEL EXPOSED
DOSE (REM)
0
5
10
15
20
25
30
35
40
45
60
64
33
8
12
19
26
8
5
12
9
1
1
1
2
5
1
4
1
1
1
2
1
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
3.75
4.00
4.25
4.50
4.75
5.00

TABLE 1

BANEBERRY - MAXIMUM OCCUPATIONAL EXPOSURES

CRITICAL ORGAN	HIGHEST DOSE	FEDERAL RADIATION COUNCIL RADIATION PROTECTION GUIDE (rems/quarter)
Whole Body	1.0 rems	3
Lens of Eye	2.4 rems	3
Skin	4.6 rems	10
Thyroid	3.7 rems	10

TABLE 2

BANEBERRY - MAXIMUM EXPOSURES TO THE GENERAL PUBLIC (INDIVIDUALS)

CRITICAL ORGAN	HIGHEST DOSE	FEDERAL RADIATION COUNCIL RADIATION PROTECTION GUIDE* (rems/year)
Whole Body	0.036 rem	0.5
Thyroid (child)	0.13 rem	1.5
Thyroid (adult)	0.5 rem	1.5

*For individuals in the general population for normal peacetime operations.

except 86 were decontaminated utilizing water spray and vacuum cleaners and returned to their owners.

The 86 remaining vehicles had higher levels of contamination and were kept until they could be more thoroughly decontaminated. The procedure was delayed because of freezing weather, so many of the owners were provided with rental automobiles. All the vehicles have been returned to their owners.

3.2.4 Areal Radiation Surveys and Decontamination

Radiation surveys were subsequently conducted in Area 12 Camp on December 20, December 21, and December 22, 1970, using portable survey instruments. Exposure rates at three feet above the snow- and ice-covered ground varied from 5 to 9 mR/hr on the 20th; 2 to 3 mR/hr on the 21st; and 1.5 to 2.5 mR/hr on the 22nd.

Decontamination of Area 12 Camp commenced on January 22, 1971. The initial phase began with decontamination of the roads in Area 12 using high pressure fire trucks and water trucks. The second phase began with decontamination of the interiors of housing trailers. The Camp cleanup was completed for reopening on February 1, 1971.

3.3 Offsite Radiological Safety Activities

The surveillance and dosimetry networks, as well as the techniques used in special surveillance and monitoring for the BANEBERRY test, are discussed in the report NVO-40 (Second Edition). All of the routine stations in the Air Sampling Network west of the Mississippi River were operational and the Standby Milk Network was activated in California, Idaho, Wyoming, Colorado, and Utah. Additional environmental sampling was performed in Nevada, Utah, California, Minnesota, South Dakota, North Dakota, Arizona, Colorado, Idaho, Montana and Wyoming.

All exposures and doses in the offsite area were well within the FRC and AEC guidelines for normal peacetime situations. The maximum exposures to the general public are summarized in Table 2 and discussed in the following paragraphs.

3.3.1 External Exposure

Twenty-six monitors were in the field on December 18 (D-day) to obtain measurements of exposure rates during cloud passage. The maximum exposure rate recorded at a populated location was 0.5 mR/hr at Blue Jay Maintenance Station (2 adults, 3 children). The maximum measured offsite exposure rate was 1.2 mR/hr at an unpopulated area near Queen City Summit, Nevada. Remonitoring on December 19 showed a maximum residual 0.3 mR/hr 17 miles east of Tonopah on Highway 6. The maximum residual exposure rate at a populated location was 0.1 mR/hr at Diablo Maintenance Station (3 people), Blue Jay Maintenance Station (5 people), and Clark Station (1 person). The total offsite population residing at Tonopah and other small communities, as well as at ranches and highway maintenance stations which were within the area of positive D-day ground monitoring, was about 4,000 to 5,000 persons.

External gamma exposures to infinity in the offsite area were estimated from data using hand-held survey meters, recording rate-meters, and thermoluminescent dosimeters. The line of maximum deposition appears to have passed almost due north of the test point, crossing Highway 6 between Warm Springs and Tonopah. The highest estimated infinity external exposure* at a populated location was 0.036 rem which occurred at Clark Station as a result of cloud passage and subsequent ground deposition. There was only one resident in the immediate vicinity where this level was observed. This level of external, whole-body gamma radiation is about one-fifth of the Federal Radiation Council Radiation Protection Guide for the general population or about one-fifteenth of the Radiation Protection Guide for an individual in the population. The Radiation Protection Guide is defined as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to maintain radiation doses as far below this guide as practicable. A few persons (less than 10) entering the general vicinity on the following day received exposures of about 0.02 rem from deposition.

3.3.2 Ingestion Doses

The Federal Radiation Council has provided Radiation Protection Guides for evaluating situations where there are potential exposures to iodine-131. The Radiation Protection Guides applicable to the general public assume radioiodine intake by children and three ranges of daily intake are defined:

Range I: 0 to 10 micromicrocuries (picocuries) per day

Range II: 10 to 100 picocuries per day

Range III: 100 to 1,000 picocuries per day

Continuous daily intake of about 100 picocuries of iodine-131 (the top of Range II) per day for one year would lead to exposures not exceeding the Radiation Protection Guide value of 0.5 rem per year for a suitable sample of the population.

*"Infinity external exposure" is the cumulative exposure which one might experience from radioactive material deposited in the area if he were to remain in that location for the rest of his life. Depending on the nature of the radioactive material, the majority of the exposure could be delivered over a time period varying from minutes to years.

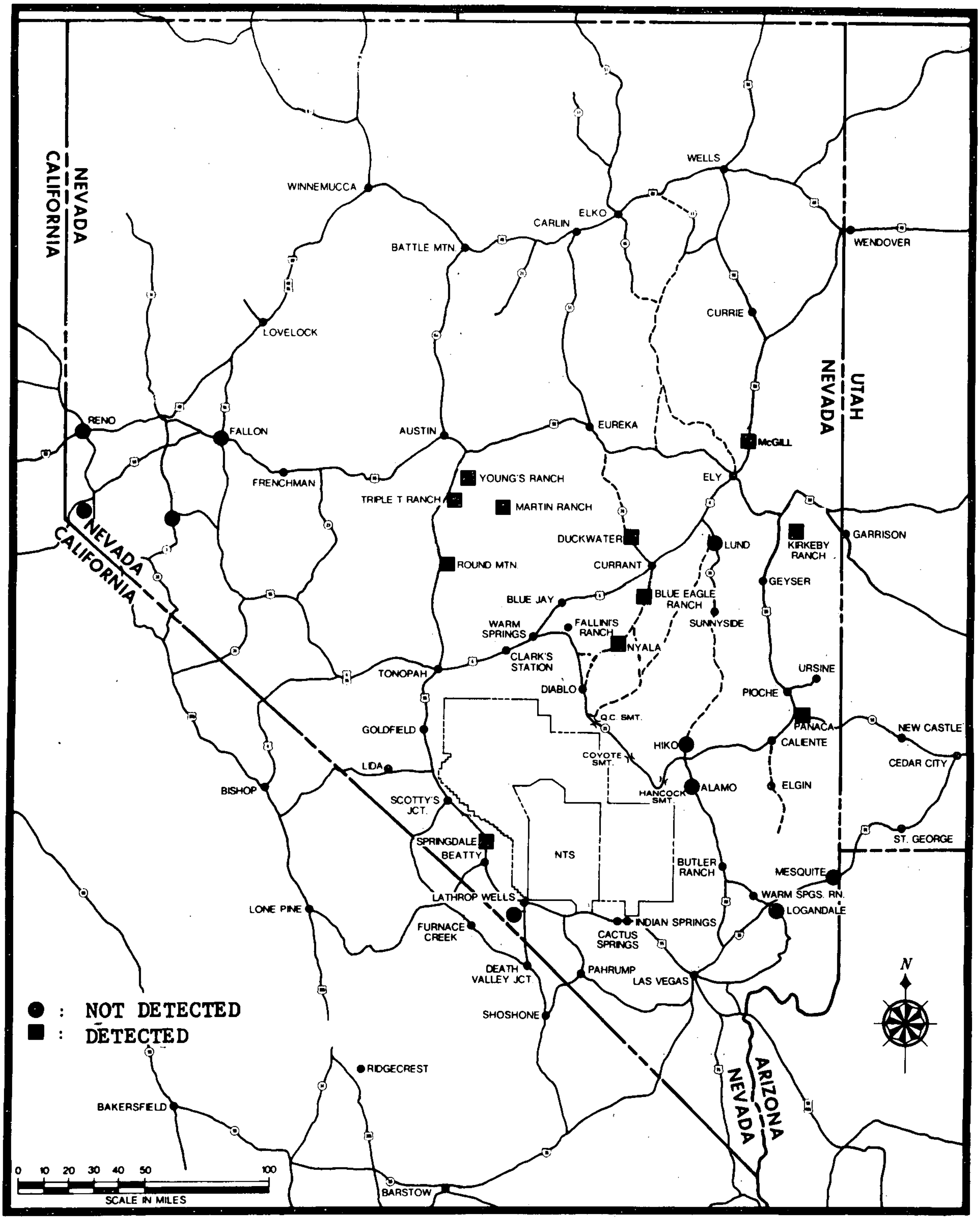
The Federal Radiation Council Protective Action Guide is the projected dose to individuals in the general population which warrants protective action following a single contaminating event. The Protective Action Guide will not be exceeded if the average projected dose to the thyroids of a suitable sample of the population does not exceed.10 rems.

Ingestion of radioiodine can occur through use of contaminated food or water. One important route is the milk-thyroid pathway, another is the drinking water-thyroid pathway. Projected ingestion doses from the only other radionuclides (tritium and cesium-137) found in milk are orders of magnitude lower than thyroid doses from radioiodine. Figure 2 shows those locations in Nevada where radioiodine was detected in milk samples.

The highest radioiodine levels in milk occurred at a ranch near Springdale, a few miles north of Beatty, Nevada. The milk supply at the ranch with the highest concentration was sampled daily since this milk was being used by other families in the Beatty area. The highest level of iodine-131 observed was 810 picocuries per liter (pCi/l) of milk on December 26 and December 27, 1970. These two samples were in Range III of the Federal Radiation Council's guide for daily intake of iodine-131. Since the milk concentrations resulted from a single short-term contaminating event which ceased on actual milk sampling and assuming continued use of milk by the children, would be about 14,000 picocuries. This represents approximately 40 percent of the annual Radiation Protection Guide and is well within Range II. Although the highest milk concentration represented a very small fraction of the Federal Radiation Council Protective Action Guide value, from December 31, 1970, through January 10, 1971, distribution of the milk was terminated as a precautionary measure. The children (ages 13 years and 15 years) at the ranch near Springdale continued to drink the milk. The highest estimated thyroid exposure from inhalation and milk ingestion was 130 mrem (0.13 rem) to a two-year-old child in the Beatty, Nevada, area.

Radioiodine was also detected in milk samples from five locations outside Nevada: Bakersfield, California; Jerome, Idaho; Powell and Laramie, Wyoming; and Mt. Pleasant, Utah. The highest levels found at these five locations were at Bakersfield, California, and Mt. Pleasant, Utah, where the peak iodine-131 concentration was 60 pCi/l, corresponding to a projected infant thyroid dose of less than 10 mrem. As indicated above, 60 pCi/l of milk is within Range II of the Federal Radiation Council's guide for a single day's intake of iodine-131.

After the environmental sampling program following the BANEBERRY venting was ended, it was learned that sheepherders in the area north of the NTS where radioactivity had been measured, were using melted snow as a source of drinking water and cooking water. During the weeks following BANEBERRY, the sheepherders were in an area from about 30 miles east of Eureka, Nevada on Highway 50, south to Duckwater, Nevada, Based on sampling results in the general area, on information obtained from the eight sheepherders about their location and water consumption, and on snowfall records, it was estimated that the dose to their thyroids from radioactive iodine



RADIOIODINE IN MILK - NEVADA
BANEBERRY

FIGURE 2

was about 0.5 rad, plus or minus a factor of three. The large uncertainty in the estimate results from the fact that there is no detailed information on radioactive contamination levels at the exact locations where the sheepherders were; the old snowpack was diluted by new and uncontaminated snow; and there is no information about distribution of the radioactivity at any depth in the snowpack.

3.3.3 Inhalation Doses

Fresh fission products, including radioiodine, were detected in air samples collected in the Air Surveillance Network. The highest estimated inhalation dose in the offsite area was 90 mrem to a hypothetical infant thyroid, based on the level of radioiodine detected in the air filter sample collected at Stone Cabin Ranch, Nevada (which was unpopulated during cloud passage). As noted previously, the Federal Radiation Council Radiation Protection Guide for thyroid is 1,500 mrem per year. The highest estimated inhalation dose outside Nevada was 5 mrem at Garrison, Utah, and Idaho Falls, Idaho. The estimated dose at Salt Lake City, Utah, was 4 mrem.

3.3.4 Cooperative LRL-University of Utah Radioecological Studies

Dr. R. C. Pendleton of the University of Utah and the Biomedical Division of the Lawrence Radiation Laboratory are cooperatively conducting radioecological studies of the decay of fallout radionuclides in Utah. Unrelated to BANEBERRY, the joint effort had just completed a 7-week period of air sampling from 16 stations throughout the State of Utah just before the BANEBERRY test. Dr. Pendleton was apprised of the BANEBERRY test in time to activate the statewide air sampling network before radioactivity reached Utah.

Inhalation doses estimated from preliminary radionuclide concentrations measured by Dr. Pendleton's group at stations with complete data agree very well with doses estimated from concentrations observed by the Air Surveillance Network discussed above. Estimated inhalation doses to an infant receptor at 3 of Dr. Pendleton's stations within 20 miles of Salt Lake City were 8 mrem, 5 mrem, and 2 mrem, compared to the Air Surveillance Network Salt Lake City dose estimate of 4 mrem. The inhalation dose at Cedar City, Utah, estimated from Dr. Pendleton's data, was 0.08 mrem, compared to 0.07 mrem estimated from the Air Surveillance Network Cedar City station results.

3.4 Conclusions

Action was taken by the AEC at one farm close to the Test Site to discontinue public distribution of milk for a few days. This action was not required by the Federal Radiation Council Protective Action Guide but was in keeping with the AEC's policy to reduce exposures to the lowest extent practicable. Potential thyroid exposures to the few individuals in the nearby offsite areas were reduced by this action.

In assessing the overall radiological consequences of this accidental release, the data indicate the radiation exposures to workers on the Test Site and to individuals within the general population outside the Test Site did not exceed the radiation protection guidelines recommended by the Federal Radiation Council for the protection of workers and the public for normal peacetime operations.