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REPORT
NPS-1

DEPARTMENT OF HEALTH
NEW ZEALAND

REPORT ON RADIOACTIVITY MONITORING DURING THE VISITS OF NUCLEAR POWERED SHIPS

22 FEBRUARY 1977

NATIONAL RADIATION LABORATORY
P. O. BOX 25-099, CHRISTCHURCH
NEW ZEALAND

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REPORT ON RADIOACTIVITY MONITORING DURING THE VISITS OF NUCLEAR POWERED SHIPS TO NEW ZEALAND.

1. GENERAL

1.1 Introduction

The National Radiation Laboratory of the Department of Health is required under NZAEC Report 500 "New Zealand Code for Nuclear Powered Shipping" (June 1976) to monitor for release of radioactivity during the stay of such a ship in a New Zealand port and to provide technical assistance to Civil Defence organisations charged with dealing with any emergency arising from an accidental release of radioactive materials.

This report outlines the activities undertaken for the two visits which took place in 1976.

1.2 Responsibilities

The Laboratory's responsibilities for monitoring are set out in Section 9 of Annex III of NZAEC-500. In brief they consist of:

(a) undertaking the measurement of suitable samples to detect the degree of any contamination arising from the routine operation of the nuclear powered ship during its visit.

(b) arranging the continuous operation of an alarm for the local detection of a nuclear incident.

(c) arranging, in conformity with the Public Safety Plan for the Port issued by the Ministry of Civil Defence, for emergency monitoring. This largely consists of training the mobile teams provided by the Ministry of Defence, the crews of tugs which may be used to shift the ship and the health inspectors and others who would operate decontamination centres.

(d) the provision for radiation officers to be continuously available at the Operations Room during the visit.

1.3 Initial Preparations

(a) In view of the short interval between the issue of NZAEC-500 and the proposed visit of the nuclear powered ship to Wellington a first priority was the obtaining of suitable monitoring equipment.

While for the routine monitoring programme the Environmental

Radioactivity section of the Laboratory was equipped to evaluate the considerable numbers of samples planned for, it was necessary to import 25 air samplers and develop a prototype and manufacture at the Laboratory several hundred air sampling cartridges capable of differentiating between radio iodines and other radioisotopes.

In addition, to prepare for any emergency it was necessary to import sets of radiological and sampling instruments for the mobile monitoring teams and to use Services and adapted Laboratory equipment to act as gamma-alarm or personnel contamination detection instruments. (See Annex A).

When the instruments were received or modified they were all checked for efficiency, sensitivity and consistency of operation under the expected conditions of service.

(b) Also of high priority was the establishment of guidance levels of radiation exposure. These "emergency reference levels" are similar to those adopted by a number of overseas countries and would give doses of the order of the maximum permissible annual exposure for a person occupationally exposed. They therefore give a readily understood measure of relative hazard and while not leading to mandatory counter-measures, indicate the level at which consideration should be given to the advisability in the particular situation of taking more than simple protective measures.

Analyses of potential emergency situations were then used to ensure that the equipment had adequate sensitivity under adverse conditions and to convert Emergency Reference Levels into readings of the instruments on particular samples or in practical situations.

(c) A group of seven Laboratory officers collaborated in the above work and prepared for undertaking the work specified in the Code. This group then developed the required training programmes.

(d) Other preparatory work involved:

(i) Development and manufacture of special air filters for use with the "Staplex" high volume air samplers operated by the mobile monitoring teams.

(ii) Arranging with the Air Pollution Section of the Department of Health for the selection of suitable sites, for the installation of the routine air-sampling network and for the daily collection of samples during the operation. Also making up at the Laboratory the extension power-leads and weather-proof filter holders and hoses required for the air pumps used in the network.

(iii) Arranging with Ministry of Defence and the Public Health Bureau of the Department of Health for the collection and despatch of all samples required for the routine monitoring programme.

(iv) Liaising with the Civil Defence authorities for the production of Public Safety Plans and for the collaboration required during the visits.

2. WELLINGTON VISIT

The USS TRUXTUN visited Wellington from 0700 hours on 27 August to 1000 hours 2 September 1976, and anchored in the harbour at a distance of 1500 metres and a bearing of 010° from Point Jerningham. Allowing for swing around the anchorage the nearest land was always greater than 1200 metres from the ship.

2.1 Training

The Ministry of Defence supplied eight two-man teams, four from the Army (Royal Engineers Corps) and four from the Navy, each team having one member of sergeant or NCO rank. Their instruction took three days and included:-

(a) General introduction to the type of radiation measuring instruments to be used and a simple explanation of how they worked. This involved an elementary description of the types of radioactive emission expected and of the operation of a nuclear reactor and how it fitted into a ship's propulsion system.

(b) Detailed instruction on each dosemeter, exposure ratemeter and the scintillation counters. This included instruction on the care of the instrument, checking for its serviceability, changing batteries where necessary and taking measurements. (See Plate 1 Annex D).

(c) Instruction on the daily checks on equipment and how to record them, the measurements required in the event of an alarm, where and when to make them, recording and reporting measurements and other data required.

(d) The effect of radiation from radioactive materials on living matter. Doses necessary to produce detectable physical effects, minor ailments and serious health hazards. The existence and magnitude of background radiation and the derivation of maximum permitted doses and dose limits.

(e) On the third day the defence teams were joined by ten health inspectors from the Department of Health and the procedures to be followed if contamination of the public were suspected were outlined.

These included the use of special dose-rate meters to monitor clothing and the monitoring of thyroid activity with scintillation probes, the issue of potassium iodate tablets and disposal of contaminated clothing.

(f) On the afternoon of the third day the communications equipment was issued and the network outlined by the Army officer in charge of the base station. Instruction on the radio transceivers was given by the Army teams to the Navy teams and Laboratory officers and a trial run carried out using the Army vehicles supplied for the operation. Opportunity was also taken to check the operation in the vehicles of the high volume air sampling pumps.

The morning of the fourth day was spent in issuing all equipment, log books, film badges, etc., to the teams and reviewing the operational orders and general procedures for implementing the Public Safety Plan. The operation commenced on that day, 26 August 1976.

2.2 Civil Defence Operations

Organisation

A Public Safety Operations Headquarters was established in the National Civil Defence Centre in the sub-basement area of the new Parliament Buildings (Beehive sub-basement). This was manned from 1800 hours 26 August for the duration of the visit by the following personnel:-

The Regional Commissioner of Civil Defence for the Central Region, an observer and three scientists from the National Radiation Laboratory (technical advisors), duty Naval staff from the Defence Department (Defence Command Post and communications), and members of the monitoring teams provided by the Defence Department. Plate 2 Annex D shows the Operations Room.

The Director of Naval Operations was the Defence Officer in Charge. The naval vessels involved were the motor launches PAEA and MANGA.

Monitoring Teams

The eight two-man monitoring teams referred to in Section 2.1, viz. four Navy teams to man the motor launches and tugs and four Army teams for the operations on shore, were under the command of the Defence Officer in Charge but were instructed to act as directed by the Laboratory duty officer in the event of an emergency.

The two water-borne navy teams maintained constant watch in the motor launches which patrolled the TRUXTUN on a rostered duty basis at a speed of

three knots at a distance of 200 metres from the ship. The monitoring instruments on board the launches included the early warning gamma alarm meters. These teams were responsible for collecting sea-water samples in each tidal cycle downstream from the nuclear powered ship. Constant watch was maintained on the monitoring signal net. (See Plate 3 Annex D).

The duty tug monitoring team and the two duty shore monitoring teams were based at the Civil Defence Operations Headquarters on 30-minute standby. The standby teams at two hours notice, were stationed at Shelly Bay.

All shore based teams assisted with watch keeping duties at the CD Operations HQ and changed duties every 24 hours.

A practice deployment to test communications was conducted at least once in every 24 hour period. (See Plate 4 Annex D). Areas of poor radio communication were recorded on large scale maps of the Wellington district.

Monitoring instruments were checked daily for correct operation and measurements of background radiation levels were recorded in log books by the respective monitoring teams (See Annex A for a description of the instruments used for the operation).

Defence Command Post and Communications

A Defence Command Post was set up at CD Operations HQ and manned on a continuous basis as required by the Defence Officer in Charge by the signaller in control of the monitoring signals net, assisted by monitoring personnel. During working hours the Defence Officer in Charge was available either in Defence HQ or in the CD Operations HQ. Out of working hours the duty Naval staff officer was available in CD Operations HQ. The duty Naval staff officer, with the assistance of the duty radiation officer supervised the daily practice monitoring deployment and kept the Defence Officer in Charge fully informed.

Protective Equipment

A stock of protective clothing and potassium iodate tablets was available at the CD Operations HQ for issue to members of the tug crew and others who might have been required to enter an area of significant health hazard. Plate 5 Annex D shows the protective equipment and instrumentation provided.

Meteorological Service

Meteorological data and weather forecasts were forwarded by telex to the CD Operations HQ at 6 hourly intervals and the areas of greatest risk within a 30° sector down-wind from the ship were continuously recorded on large scale

maps of the district.

Southerly winds (160°-210°) averaging 30 knots on the surface were experienced throughout the visit. Winds of such velocity would rapidly disperse airborne material in the event of an accident and reduce the potential hazard to the local population.

Decontamination Centres

Emergency plans were made to set up decontamination centres with facilities to measure individual contamination and radioactive iodine uptake by the thyroid gland, to decontaminate affected persons, and to provide medical facilities including the issue of potassium iodate tablets.

Four two-man decontamination teams (health inspectors) equipped with monitoring instruments were provided by the Department of Health. The teams were rotated on a daily basis with one team available at 2 hours notice. Plate 6 Annex D demonstrates the use of a contamination monitor.

2.3 Routine Monitoring

Regular Water Sampling

Regular sea water sampling was undertaken on the monitoring launch which circled the nuclear ship continuously while in harbour. A composite 2-litre sample was taken twice daily, one litre one hour before and the second litre one hour after high tide. Samples were collected from within the top metre of water 300 metres downstream of the vessel.

In addition a pre-visit background sea water sample was taken from the harbour on the evening before the arrival of the nuclear powered ship.

Bottom Sediment Sampling

Four grab samples of mud were collected before the ship arrived and again after it had left the area. The samples were taken within the swinging distance of the ship's anchorage.

Filter-Feeding Molluscs - Large Size Blue Mussel

Mussels from six selected sites in Wellington Harbour were collected before the ship's arrival and again from the same sites after its departure.

Air Sampling

Air sampling was conducted continuously during the nuclear ship's visit at 17 of the 22 preselected sites around the Wellington harbour foreshore. The sites are indicated on the chart Annex B.

Sampling was by means of air pumps each drawing 17 cubic metres of air per day through a special cartridge. The cartridges were made at the Laboratory from 22 mm diameter plastic cylinders containing a glass-fibre pre-filter for trapping particulates followed by a 35 mm bed of activated charcoal for trapping radioiodines. During routine monitoring the cartridges were changed each day.

2.4 Results

(a) Routine monitoring

Immediately on collection all samples were airfreighted to the Laboratory where they were analysed by gamma spectroscopy. (See Plate 7 Annex D). Measurements on the pre-visit samples were used to establish the background levels of any natural or artificial radioactivity present. Results of measurements on all such samples collected during and after the nuclear ship's visit showed only those traces of natural radioactivity, and at the same levels, as were measured in the pre-visit samples.

The air sampling cartridges were measured for radioiodine and total gamma activity by gamma spectroscopy. Counts in the photopeak of iodine-131, and total counts, were compared with those from background cartridges measured under identical conditions. The limit of detection for the initial screening measurements was 0.7 picocuries of iodine-131 per cubic metre. This value is less than 1% of the dose limit for continuous exposure over one year, for critical groups in the population, as set by the International Commission on Radiological Protection. All cartridges measured showed iodine-131 levels below this limit of detection and no detectable increase in total gamma activity was observed to be present in any cartridge. As an additional refinement the air cartridge samples from selected sites 8, 9, 10, which were downwind from the ship during its entire stay at the port were reassessed with extended measurement periods which gave a limit of detection one-tenth that described above. These measurements showed levels below this lower detectable limit.

The above results indicate that had the ship remained in port under the same conditions for a full year the resulting exposure to the local people would have been less than 1% of the dose limit for members of the public as set by the International Commission on Radiological Protection.

(b) Emergency monitoring

Under section 3.1 of Annex 1 of the Code the Commanding Officer or Master of a nuclear powered ship is required to notify local authorities of any unexpected event involving a nuclear reactor which may result in possible public hazard or of any circumstances known to him which might increase the likelihood of any such event. No such incident was reported by the Master of the TRUXTUN.

The gamma alarm instruments on the naval motor launches were not triggered during the visit. Tests regularly made on more sensitive instruments by monitoring teams on the launches at a distance of 200 metres from the ship showed radiation levels not detectably different from the normal natural background levels. A number of measurements were made close to the ship. The maximum readings at about 15 metres did not exceed 12 microrads per hour which is equivalent to the average natural background level on land.

3. AUCKLAND VISIT

The USS LONG BEACH visited the Port of Auckland from 0600 hrs 1 October to 0700 hrs 5 October 1976. The ship was anchored in the harbour at the Anchorage 3 site between the Commercial Harbour and Calliope Dock for the duration of the visit. During anchorage it did not swing closer than 500m from the nearest point on land.

3.1 Training

The training of Defence monitoring teams and health inspectors was conducted by Laboratory officers at the NBCD School, HMNZS TASMAN, Devonport Naval Base during the period 27-29 September 1976. Instruction was in accordance with procedures outlined in Section 2.1 for the Wellington operation.

The number of personnel trained in monitoring and decontamination procedures was significantly larger than in Wellington. The Ministry of Defence provided eleven two-man monitoring teams plus ten drivers and signallers for the monitoring vehicles. In addition 27 health inspectors, health scientists, technicians and medical officers of health from the Auckland District Health Offices and 19 health inspectors and administration officers from the Auckland Regional Authority received instruction. Two classrooms were used for this purpose by the three Laboratory officers assigned to the operation.

Laboratory equipment required for monitoring and decontamination procedures was transported from Christchurch by air. Vehicles for the Laboratory officers were provided by the Auckland District Health Office and the Ministry of Civil Defence.

3.2 Civil Defence Operations

Organisation

The Civil Defence Operations Room, located in the BECA Building, Vincent Street (Auckland city) was manned continuously from 1600 hrs 30 September to 0800 hrs 5 October by a team under the control of the Regional Commissioner of Civil Defence. The team included the three Laboratory radiation officers who attended the Wellington operations, Defence duty staff from the Army HQ Field Force Command, and signallers from the RNZAF. The Defence Command Post and communications centre was established on HMNZS PHILOMEL at the Devonport Naval Base. The Commodore Auckland was the Defence Officer in Charge. The naval ships involved were the motor launches PAEA, HAKU and TAKAPU, and the patrol craft ROTOITI and TAUPO.

A significant difference from the Wellington operation was that, in the event of declaration of a Civil Defence Emergency arising from a nuclear accident the Auckland Regional Authority would immediately assume responsibility for the control of all actions necessary to implement the Public Safety Plan for the Port of Auckland. The procedures for such actions are described in the Auckland Regional Authority document "Civil Defence Contingency Plan in the event of any accidents to nuclear reactors in nuclear powered ships whilst in the Port of Auckland." It should be noted that this arrangement called for a transfer at a critical time of personnel and equipment to the ARA Headquarters.

Monitoring Teams

For this operation eleven two-man teams were formed viz. four Army teams and four Air Force teams for land operations and three Navy teams for the motor launches on patrol duty near the LONG BEACH. In addition the army provided a driver and a signaller for each of the five radio equipped vehicles used by the land based teams. They were all accommodated at the Naval Base while on duty and standby. This presented some problems in mobilising the teams as the Laboratory duty officers were stationed at the CD Operations Room on the opposite side of the harbour. Close liaison with the monitoring teams could therefore not be maintained.

The topography of Auckland harbour is such that the area of greatest risk

could be on either side of the harbour depending on wind direction. This led to the stationing of three vehicles at the Devonport Naval Base and two vehicles at the central police station in Auckland city with a naval launch available for the immediate transportation of the monitoring teams and their equipment to the Auckland side of the harbour. This procedure would overcome any delays which might occur due to traffic congestion on the harbour bridge.

In a state of emergency the monitoring teams were to act as directed by the Laboratory radiation officers. Practice deployments to test equipment and communications were conducted daily as described earlier for the Wellington operation.

Protective Equipment

Sets of protective clothing and respirators suitable for use in areas of significant health hazard were held at the Naval Base. Potassium iodate tablets were held by the medical officer of health at District Health Office, Auckland, and appropriate arrangements were made for their distribution.

Meteorological Service

Meteorological forecasts for Auckland harbour were telephoned to the CD Operations Room at 6-hourly intervals. The wind direction was marked on large scale maps of the harbour and surrounding districts. Southerly winds (160°-280°) of velocity ranging from 10 to 20 knots but seldom exceeding 15 knots on the surface were recorded. Hence the suburb of Devonport with relatively low population numbers was the area at risk.

Decontamination Centres

Decontamination Centres, Welfare Centres and Assembly Areas in the Northern and Central Civil Defence Areas were designated and prior arrangements made for their use in the event of an emergency.

The three-man decontamination teams formed from the specially trained health inspectors from the Auckland District Health Offices were placed on a duty roster prepared by the Medical Officer of Health, Auckland. At least one team was available at two hours notice throughout the visit. The monitoring instruments were held at the CD Operations Room and checked daily for correct operation.

3.3 Routine Monitoring

The procedures outlined in Section 2.3 of this report were followed for

(i) Regular water sampling

(ii) Bottom Sediment Sampling

(iii) Sampling of Filter-feeding Molluscs

(iv) Air sampling.

Air sampling was conducted continuously at 14 of the 35 pre-selected sites around Auckland Harbour. The 14 sampling sites nominated after the anchorage site was determined are shown in Annex C. Mussels were collected at five selected sites in Auckland Harbour.

3.4 Results

(a) Routine Monitoring

The results were similar to those shown in Section 2.4 for the Wellington samples. All samples collected before, during and after the visit of the LONG BEACH recorded levels of radioactivity not exceeding those due to natural radioactivity.

(b) Emergency Monitoring

Sensitive monitoring instruments on the motor launches at a distance of 200 metres from the LONG BEACH indicated radiation exposure levels of the order of normal natural background radiation at sea. Special tests at a distance of 13 metres from the port and starboard areas of the ship did not exceed 10 microrads per hour which is slightly lower than the natural background level on land.

4. ACKNOWLEDGEMENTS

The co-operation of the Government Departments and Local Bodies involved in the operations is gratefully acknowledged.

ANNEX A

Emergency Monitoring Instrumentation

These instruments were selected to make measurements in four main fields of interest:

1. The concentration of radioactive material in the cloud released from the ship.
2. The direct radiation levels from the ship, from the cloud of radioactive material passing overhead, and from radioactive material deposited on the ground.
3. The exposure received by personnel involved in the emergency monitoring.
4. Contamination on and radiation exposures received by members of the public in the affected areas.

The concentration of radioactive material in the cloud can be measured either directly, (by collecting the material in a known volume of air) or indirectly by measuring the direct radiation level from the cloud and relating this to the concentration. Consideration of the latter method indicates that there are too many variables involved for it to be used with confidence. Of the radionuclides in the cloud the radioiodines are generally regarded as being of the most significance. For this reason the decision was made to measure the concentration of I-131 and to use appropriate factors to allow for the presence of other radioiodines and tellurium isotopes. This is done by passing a large sample of air through a suitable filter and then measuring the activity on the filter with a suitable portable monitor. The air sampler chosen is a "Staplex" Model TFIA pump, operating from a 24 volt supply and capable of pumping approximately 0.9 cubic metres of air per minute through the filter. The filters are a simple copper gauze and activated charcoal type, designed and manufactured by the Laboratory, and tested to be capable of efficiently collecting radioiodine. For measuring the activity on the filter an Eberline PRM-5N scintillation monitor is used. This instrument has a pulse height analysing capability, with two preset single channels, one of which can be set on the principal I-131 peak.

Calculations show that for the chosen air sampling time of one minute the possible background radiation from the cloud or deposited material could result in a count-rate on this instrument of several times the count-rate from the filter, requiring measurements on the filter to be made in a low background area. This possibility was covered in the operational training.

For direct radiation measurements an instrument capable of reading from

about 1mR/h to many R/h is required, as radiation levels from the cloud or from the ship can be of these orders. For the general monitoring teams a Reactor Experiments Inc. "Digimaster" exposure rate-meter was chosen. This is a compact digital readout instrument with two automatically changing ranges, 0-100mR/h and 0-100R/h. In addition a number of Radiac No. 2 survey meters, with a top range of 0-300R/h, were made available by the Ministry of Defence. These were designated for use in tugs required to move the ship in an emergency.

For personnel monitoring a Reactor Experiments Inc. "Digidose" exposure dosimeter was chosen. This is a digital readout instrument reading in increments of 1mR up to 9999mR. The register is mechanical and will therefore retain the reading when the instrument is switched off. As each 1mR increment is received an audible electronic "bleep" is emitted. In addition to these instruments a large number of dosimeter packs consisting of an AERE film badge with a TLD capsule, and several 0-5 R and 0-150 R self-reading pocket dosimeters, were available.

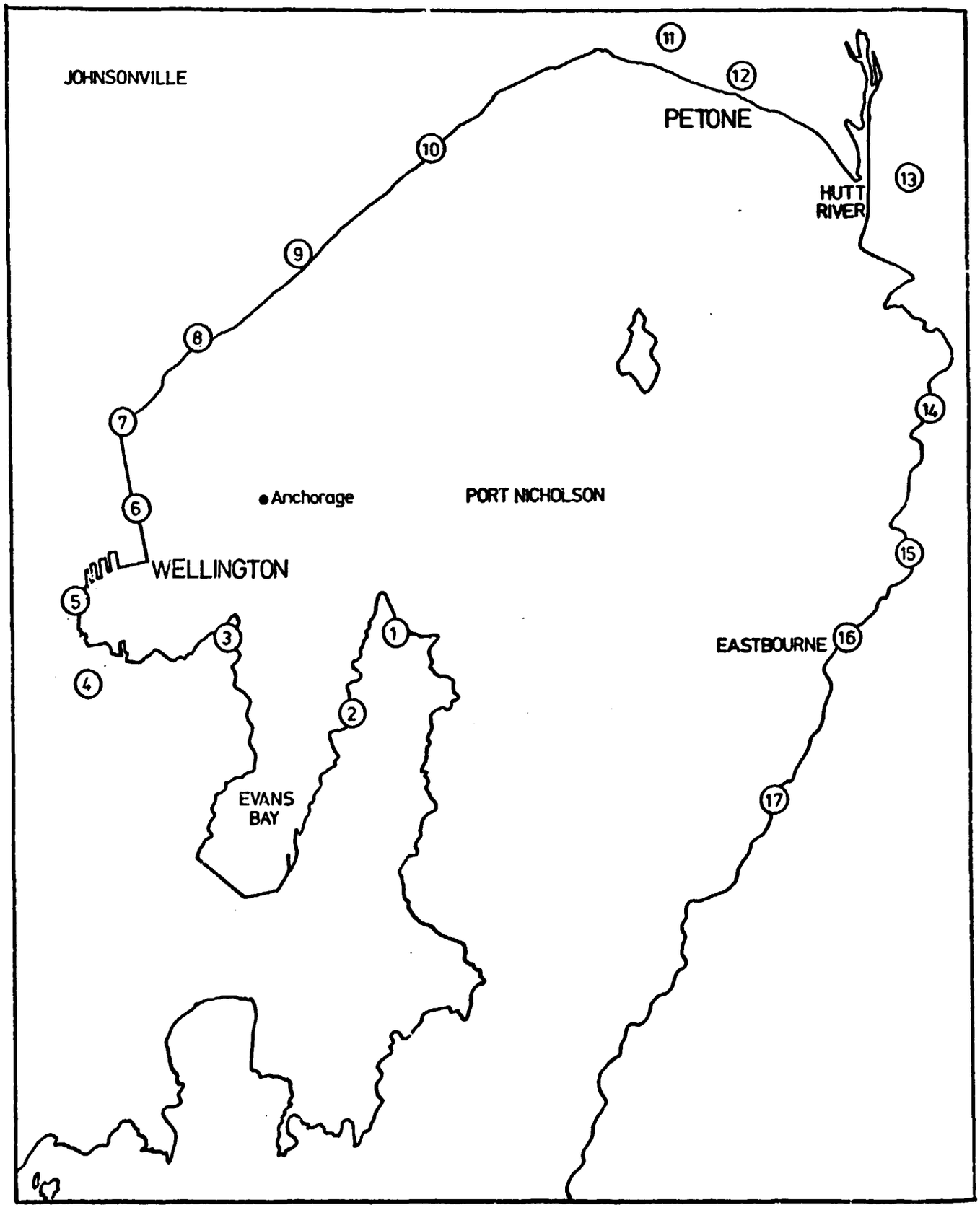
Members of the public evacuated from the affected area would have to be checked for possible radioactive contamination and for their possible uptake of radioactive material. For the first purpose Radiac MD2 survey meters were made available by the Ministry of Defence. These have four thin-window geiger tubes connected in parallel and a logarithmic dial readout. In use they are calibrated against specially prepared standard surfaces contaminated to the reference level of activity. For uptake measurements the level of radioiodine in the thyroid would be checked by measuring the level of I-131 with a Victoreen Thyac III survey meter with either a β-γ geiger-muller probe or a scintillation probe, and allowing an appropriate factor for the presence of other radioiodines.

Five complete sets of monitoring equipment were provided. Each set consisted of: one "Staplex" air pump with accessories and twenty filter cartridges, one Eberline PRM-5N scintillation monitor with a check source, one "Digimaster" and one "Digidose". The duty motor launch and the two land based duty monitoring teams had one set each. The two remaining sets were distributed as required. Each of the two teams designated for monitoring on tugs in an emergency were provided with a Radiac No. 2 survey meter and a "Digidose" dosimeter. The two motor launch teams and the tug teams were also provided with eight or nine pocket dosimeters and a recharging unit. Each

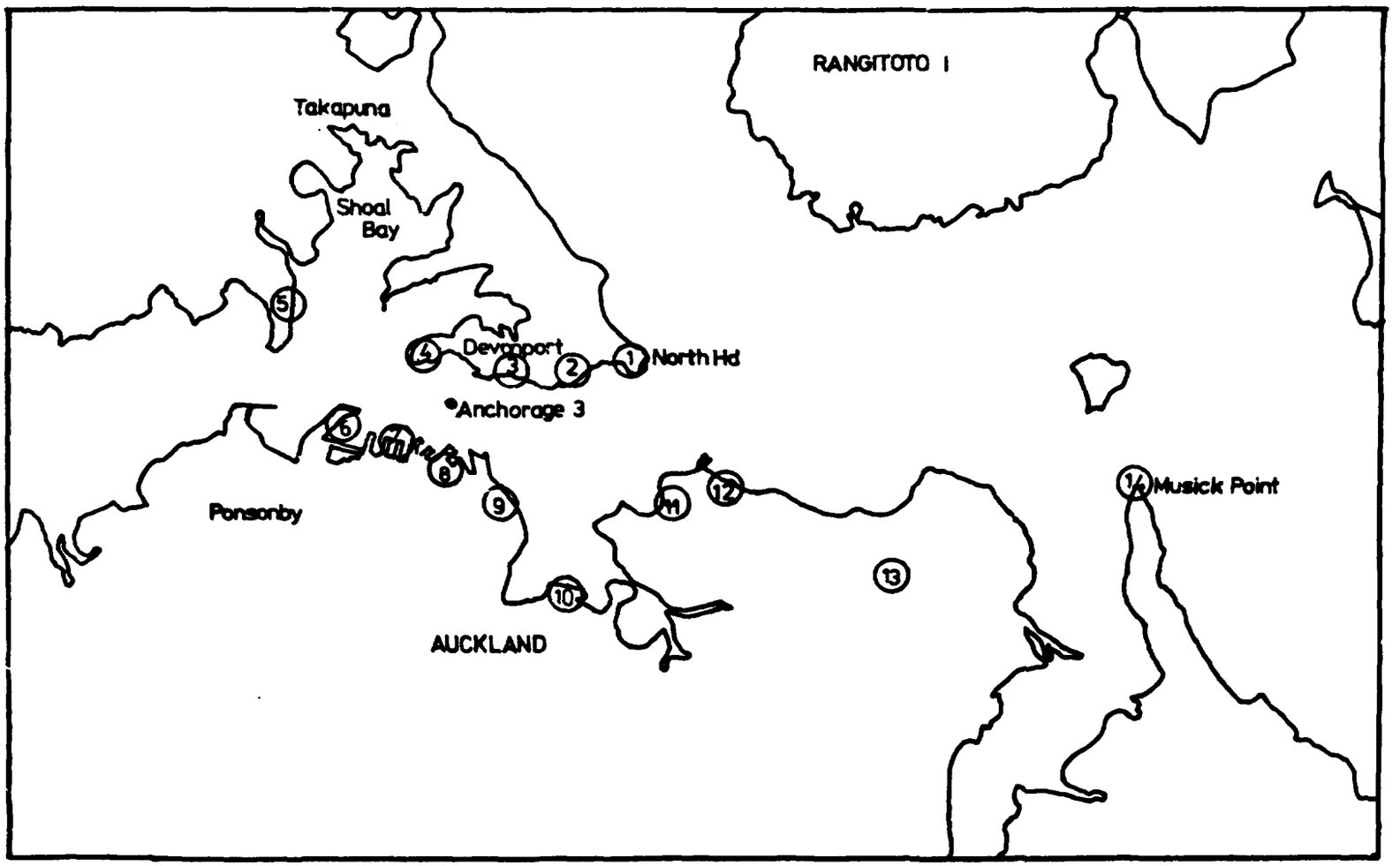
member of the monitoring teams was provided with protective clothing, a respirator, potassium iodate tablets, and a dosimeter pack. The land based teams had four-wheel drive vehicles, and each team had a radio transceiver set for direct communications with headquarters. Protective clothing, potassium iodate tablets and dosimeter packs were also provided for the tug and launch crews.

In addition to the monitoring instruments three Airmec survey meters were modified so that the internal g-m tube would operate a gamma alarm set to trigger at a level of 10mR/h. These instruments were placed in the patrol ships to act as a first indication of possible release of radioactive material.

ANNEX B



WELLINGTON HARBOUR: Distribution of Air Sampling Sites



AUCKLAND HARBOUR: Distribution of Air Sampling Sites

ANNEX D

PLATE 2

PLATE 4

PLATE 1

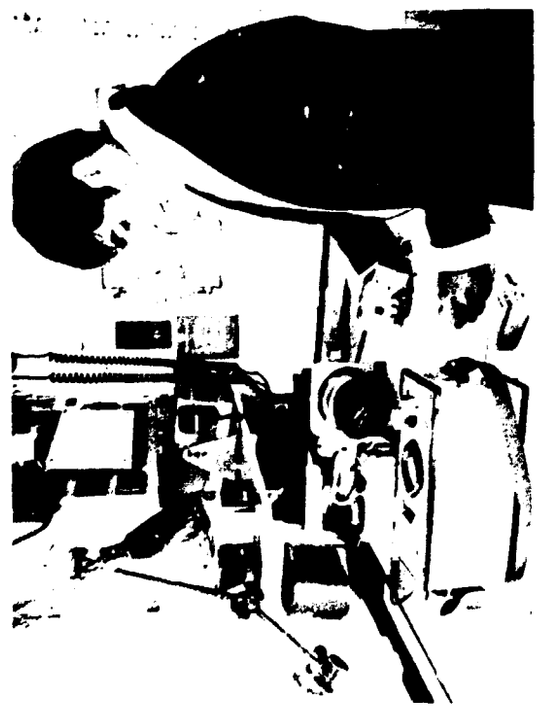


PLATE 3

PLATE 5

PLATE 6

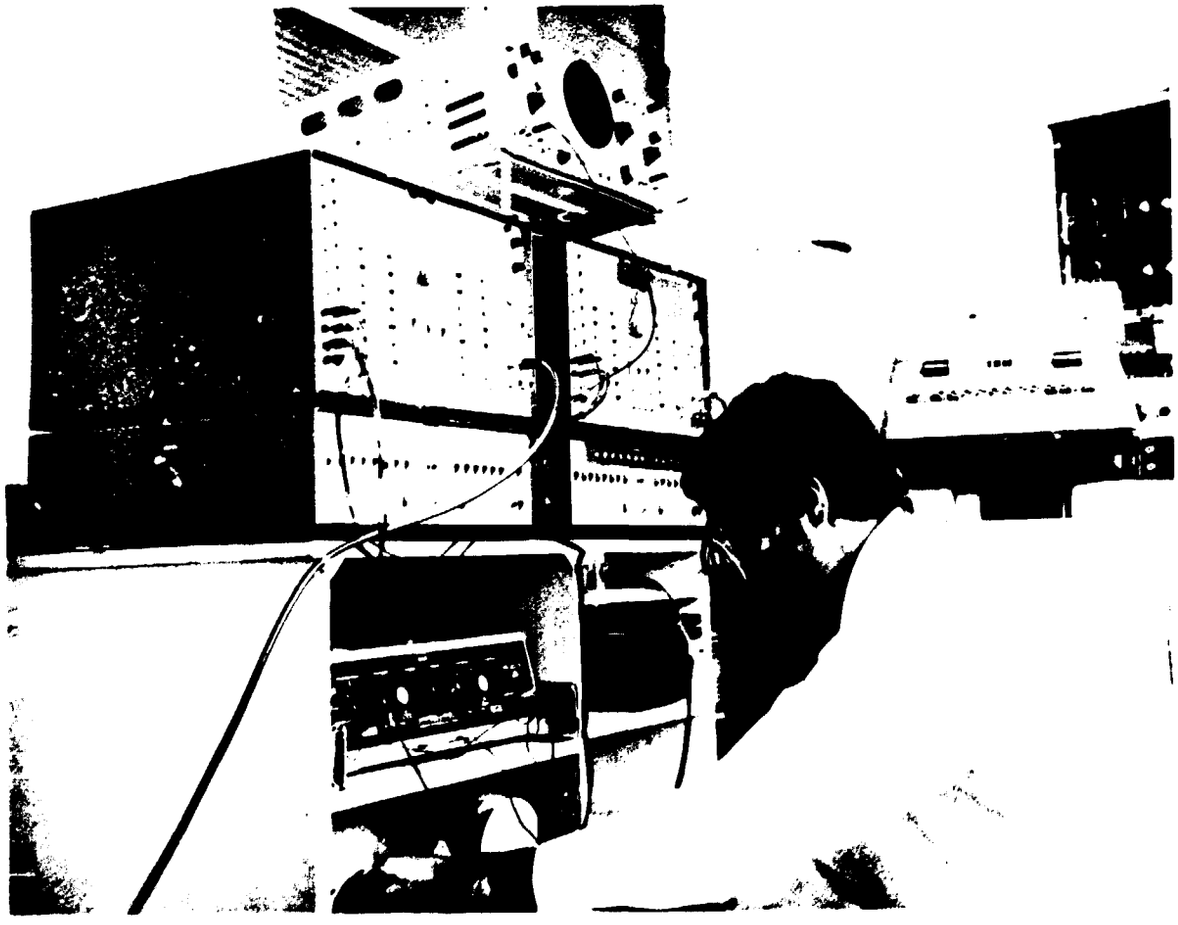


PLATE 7