OPERATION TOKELAU REEF

NZ ARMY REEF BLASTING TEAM

OPERATION TOKELAU REEF POST DEPLOYMENT REPORT

ATAFU AND FAKAOFO REEF CHANNELS TOKELAU ISLANDS

19 OCT 85 — 19 JUL 86

1 FIELD SQUADRON
R.N.Z.E.

OPERATION TOKELAU REEF

POST DEPLOYMENT REPORT

ON ENGINEER WORKS UNDERTAKEN

TO IMPROVE TWO EXISTING REEF CHANNELS

ON TOKELAU ISLANDS

FOR Officer Commanding, 1 Field Squadron, RNZE

BY: Captain A.M. Skinner, RNZE

AT: 0800 hours ON: 30 Sep 86

References:

A. Coral Reef Channels Reconnaissance Report dated 10 May 85 by Lieutenant A.M. Skinner RNZE

B. MFA letter from Mr C.V. Bell, Deputy Director, External Aid Division to Secretary of Defence dated 19 Jul 85

C. LFC 3304/2/2 dated 7 Aug 85

D. Def 23/9/1 dated 26 Aug 85

E. LFC 3304/2/2 dated 3 Sep 85

F. 1 TF 3304/Ops dated 10 Sep 85

G. 1 Fd Sqn 3304/5 dated 28 Sep 85

Distribution:

OC 1 Fd Sqn (6)
File (1)
Spare (1)

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OPERATION TOKELAU REEF

POST DEPLOYMENT REPORT

ON ENGINEER WORKS UNDERTAKEN

TO IMPROVE TWO EXISTING REEF CHANNELS

ON TOKELAU ISLANDS

INTRODUCTION

Outline of Report

1. This report has been written in accordance with Reference A and Annex D to Reference G and details engineer works undertaken to improve, by widening and deepening, the reef channels at Atafu and Fakaofo, Toekelau. It is hoped that the report will be of benefit to any future teams for the planning and conduct of similar long deployments to remote areas. Numerous lessons were learnt during Op Tokelau Reef, and these are included towards the rear of the report for future reference. The report has a brief introduction, then is divided into two parts:

a. Part I : Summary.

b. Part II : Main Body.

Location

2. As explained in Reference A, Tokelau is an extremely isolated New Zealand dependancy consisting of three coral atolls, Atafu, Nukunonu and Fakaofo approximately 500 km north of Western Samoa (see Annex A).

Overview of Deployment

3. The tasks to be undertaken during Op Tokelau Reef deployment were reconnoitered during Feb-Mar 85 and reported on in Reference A. This report recommended that RNZE undertake a deployment to Tokelau Islands to conduct engineer works to improve the existing coral reef channels at Atafu and Fakaofo.

4. Duration. Reference A determined that a deployment to Tokelau to complete necessary improvements on the two reef channels would require 5½ months from leaving NZ to RTNZ. The deployment was planned for period mid Oct 85-end Mar 86. The time was allocated as follows:

a. Advance Party in Apia mid Oct 85 - early Nov 85,

b. Atafu reef channel task early Nov 85 - mid Jan 86, and

c. Fakaofo reef channel task mid Jan 86 - Mar 86.

5. Completion Date The deployment completion date was extended from Mar 86 until Jul 86 and the time re-allocated as follows:

a. Advance Party in Apia mid Oct - Nov 85.

b. Atafu reef channel task Nov 85 - mid Apr 86, and

c. Fakaofo reef channel task, mid Apr 86 - end Jul 86.

This extension was due to additional work being required at Atafu that had not been identified on the reconnaissance and an unforeseen major equipment failure on Atafu.

6. Op Tokelau Reef Tasks. The two reef channel tasks are reported on in detail in Part II of this report (see blue pages -Atafu; yellow pages - Fakaofo). As a priority two task, the ship wreck at Atafu was to be disposed of, this was not completed and a detailed study of the ship wreck is included at the rear of the report (see green pages).

Task Specifications

7. All specifications for undertaking and completing the widening and deepening of the two reef channels remained as stated in Reference A, which were:

a. To achieve a depth of 1.2 m at low tide.

b. Atafu: to widen the LHS and RHS of channel mouth, which involved blasting of approximately 900 m of rock.

c. Fakaofo: to widen the LHS of channel, which involved blasting of approximately 1500 m of rock.

Reporting

8. Task progress was reported to NZ by weekly SITREPs (see Annex B) through Defence radio net and by Progress Charts (see Annex C). A daily radio schedule was also maintained for general traffic.

Team Composition

9. The following trades were included in the eight man Op Tokelau Reef teams:

a. Team Leader (RNZE - Diving Officer)

b. Team 2IC (RNZE)

c. 3 x Combat Engineers (RNZE - one or two divers)

d. Vehicle Mechanic (RNZEME)

e. Cook (RNZCT)

f. Sig/Medic (RNZSigs)

10. The following is a list of the personnel employed during the deployment:

a. Advance Party : 19 Oct-6 Nov 85.

(1) Capt A.M. Skinner, RNZE (Diver)

(2) Sgt R.B. Scott, RNZE

b. Team I : 6 Nov 85-16 Feb 86.

(1) Capt A.M. Skinner, RNZE (Diver)

(2) Ssgt W.D. Toia, RNZE (Diver)

(3) Sgt R.B. Scott, RNZE

(4) Sgt S.J. Walsh, RNZEME

(5) Sgt G.L. Wichman, RNZCT

(6) Cpl L.T. Cooper, RNZE (Diver)

(7) Cpl M.C. Sturgess, RNZE

(8) Cpl T.H.E. Wichman, RNZSigs

c. Team II : 16 Feb-19 Jul 86

(1) Capt A.M. Skinner, RNZE (Diver)

(2) Sgt R.B. Scott, RNZE

(3) Sgt T.K. Hokianga, RNZE (RTNZ Apr 86)

(4) Cpl R.M. Darroch, RNZE (Diver)

(5) Cpl T. Te Rauna, RNZEME

(6) Cpl D. Armstrong, RNZCT

(7) Cpl D.J. Lingard, RNZSigs

(8) Spr M.J. Gillooly, RNZE

OPERATION TOKELAU REEF

POST DEPLOYMENT REPORT

ON ENGINEER WORKS UNDERTAKEN

TO IMPROVE TWO EXISTING REEF CHANNELS

ON TOKELAU ISLANDS

PART I : SUMMARY

Aim

11. The aim of this report is to discuss the engineer works conducted to improve the coral reef channels at Atafu and Fakaofo on Tokelau Islands.

12. RNZE undertook the tasks of constructing the reef channel improvements by employing two eight-man Teams which deployed to Tokelau on Op Tokelau Reef during the period 19 Oct 85 - 19 Jul 86.

Pre-deployment Administration

13. The Team Leader was released from his parent unit on TOD to 1 Fd Sqn from 7 Aug 85 to commence administrative and logistic arrangements, including the compilation of various Mounting Instructions.

14. A concentration period from 2 Sep 85 - 19 Oct 85 was planned for all Team personnel at 1 Fd Sqn, but due to delays in promulgating the necessary authorities, some personnel from other Corps were not released until mid Sep 85.

15. The concentration period addressed the following types of details:

a. Demand, receipt and uplift all spare and non-issue stores including specialist POL, expendable stores and civilian/local purchase items.

b. Procure and pack dry rations for the entire deployment.

c. Pre-deployment training and trials of equipment.

d. Clear stores with H.M. Customs.

Resulting Improvements

16. The following is a summary of the resulting improvements completed:

a. Atafu (See Appendices 1 and 2 to Annex M).

(1) Widening of the LHS by 33.0 m, to a distance of 74.0 m from the seaward end of the LH rubble pile, on a magnetic bearing of 3650 m.

(2) Widening of the RHS by 16.0 m to a distance of 65.5 m from the seaward end of the RH rubble pile, on a magnetic bearing of 4780 m.

(3) Removal of fine large existing rocks on the RHS to a distance of 100.0 m from the seaward end of the RH rubble pile.

(4) Widening of the inner channel on the RHS by 2.75 m for a distance of 35.0 m from the wharf.

(5) Deepening of a majority of all blasted areas to Low tide (LT) - 1.2 m, (the areas not completed to LT - 1.2 m, were such that the locals could complete the work after the departure of the Team).

b. Fakaofo (See Appendices 7 and 8 to Annex H).

(1) Widening of the LHS by 8.0 m, to a distance of 42.5 m from 'Pole 2' (Pole 2 is 4.0 m back from the seaward end of the LH rubble pile), on a magnetic bearing of 3565 m.

(2) Widening of the inner channel, on the LHS by 3.0 m, for a distance of 53.2 m from the 'concrete patch', on a magnetic bearing of 3940 m.

(3) Deepening of a majority of all blasted areas to LT - 1.2 m, (the areas not completed to LT - 1.2 m, were such that the locals could complete the work after the departure of the Team).

c. The 'Handover Certificates' are included in this report as Appendix 1 to Annex K, (Atafu) and Appendix 3 to Annex K, (Fakaofo).

Reef Channel Improvement Tasks

17. Each channel improvement task is reported on in detail in the following areas of this report:

a. Atafu, - blue pages (paragraphs 120 - 257).

b. Fakaofo, - yellow pages (paragraphs 258 - 612).

18. Major activities of each task are chronologically recorded:

a. Atafu; see Table in paragraph 123.

b. Fakaofo; see Table in paragraph 261.

Task Progress and Reporting

19. The progress of each task was reported on in the following ways:

a. Weekly Sitreps via Def Radio net, (see Annex B).

b. Progress Charts, via civilian mail @ five weekly intervals, (see Annex C; Atafu), (see Annex Z; Fakaofo)

Major Equipments

20. The major equipments used on the Op Tokelau Reef deployment were:

a. LM-100 'Crawlair', pneumatic airtrac drill.

(1) Description; (see paragraph 135.)

(2) Employment; (see paragraphs 139, 140, and 141)

(3) Performance Analysis; (see paragraph 213. a)

b. P375, portable 375 cfm compressor.

(1) Description; (see paragraphs 138 and 278)

(2) Employment; (see above)

(3) Performance Analysis; (see paragraph 320. a)

c. D6U air winch.

(1) Description; (see Appendix 1 to Annex S)

(2) Employment; (see paragraphs 183 - 196, 303 - 313 and Annex S.)

(3) Performance Analysis; (see paragraph 320. d)

d. Hand-held pneumatic rock drills.

(1) Employment; (see paragraphs 136 and 276)

(2) Performance Analysis; (see paragraph 320. b)

Explosive Employment

21. During the deployment the explosives were used in the following ways:

a. Borehole charges; "MOLANITE" cartridges of 55 mm diameter and 29 mm diameter.

b. Blast debris clearance; "AMEX" bulk charges generally @ 10 kg each and laid randomly. (See Annex Q).

22. The borehole patterns were drilled using accurate designs that had been calculated to produce the most desirable results.

a. Airtrac borehole blast design; (see paragraph 149).

b. Handdrifter borehole blast design; (see paragraphs 282. a and 282. b)

23. Explosive usage figures are recorded in:

a. Atafu; Appendix 2 to Annex X.

b. Fakaofo; Appendix 4 to Annex X.

24. Overall task blast statistics are detailed in paragraph 215 (Atafu) and paragraph 322 (Fakaofo).

25. Individual blasts statistics are recorded in detail in Enclosure 3 to this report.

26. Total quantities of explosive expended on each task were:

a. Atafu: 5636 kg.

b. Fakaofo: 1974 kg.

Reconnaissance

27. The reconnaissance conducted during Feb/Mar 85 failed, for several reasons, to identify all the associated work necessary to achieve the desired improvements. These reasons were:

a. The reconnaissance was conducted at a different time of year to the commencement of the task and therefore experienced contrasting climatic conditions.

b. Specialist reconnaissance equipment was unable to be taken, such as:

(1) Diving (SCUBA) equipment for detailed reef-edge inspections.

(2) Drilling tools to determine the coral layering and consistency.

c. The reconnaissance was grossly undermanned and consisted of only one RNZE Senior Officer.

28. These shortfalls in the reconnaissance effectively increased the volume of rock required to be blasted at Atafu by 2000 m^3 (from 900 m^3 reconnoitred to 2900 m^3).

Coral Structure

29. It was discovered that the coral structure varied dramatically from site to site. The coral in Tokelau was generally dead and as such was in various forms of decay. This varied from a very hard brittle 'conglomerate' to a dense soft 'pulp'. Annex N displays cross-sections of various coral layering encountered.

Team Composition

30. The following trades were included in the eight-man Op Tokelau Reef teams:

a. Team Leader (RNZE - Diving Officer)

b. Team 2IC (RNZE)

c. 3 x Combat Engineers (RNZE - one or two divers)

d. Vehicle Mechanic (RNZEME)

e. Cook (RNZCT)

f. Sig/Medic (RNZSigs).

31. The deployment dates of each team were:

a. Advance Party : 19 Oct - 6 Nov 85

b. Team I : 6 Nov 85 - 16 Feb 86

c. Team II : 16 Feb - 19 Jul 86

For details of the personnel involved, see paragraph 10.

Supporting Trades

32. RNZSigs. The role, responsibilities and duties of the Team Rad Op are detailed in paragraphs 408 - 417. The RNZSigs equipment deployed is detailed at Appendix 2 to Annex EE, and suggested 'deployment kit' is listed at Appendix 3 to Annex EE.

33. RNZEME. The role, responsibilities and duties of the Team Vehicle Mechanic are detailed in paragraphs 418 - 425. The essential RNZEME equipment deployed is detailed at Appendix 1 to Annex FF. A suggested 'deployment kit' and spares required for the common machinery faults experienced are listed at Appendices 2 and 3 to Annex FF respectively.

34. RNZCT. The role, responsibilities and duties of the Team Chef are detailed in paragraphs 426 - 446. The types of food deployed and the packaging used for the extended period in Tokelau is also analysed in the above-mentioned paragraphs. A suggested 'deployment kit' is listed at Appendix 1 to Annex GG, and the necessary expendables and quantities required for this type of deployment are detailed at Appendix 2 to Annex GG.

35. RNZAMC. No RNZAMC Medic was provided for the deployment. The role of Team Medic was fulfilled by the RNZSigs Rad Op who had received relatively comprehensive first-aid training prior to the deployment at the Papakura Camp Hospital. The type of common ailments contracted by the Team are recorded as Appendix 1 to Annex BB. These were all generally, treated by the Team Medic. More serious complaints, such as inner-ear infections and soft tissue ulcers were referred to the local doctor. For further details in the treatment and prevention of these ailments see paragraphs 394 - 399 and 400 - 402 respectively.

Local Labour Assistance

36. A work gang of locals was provided to assist the Team for short periods of work each day, from the respective villages. The gangs were generally @ 30 men who worked for @ four hours a day.

37. The employment, command and control of the 'Aumaga' (local labour) is explained in detail:

a. Atafu; paragraphs 216 - 230.

b. Fakaofo; paragraphs 323 - 328.

38. Work output constants for volume of blast debris and accumulated fines removed/man/4 hr shift were:

a. Atafu; 0.6 m^3. (See paragraph 231)

b. Fakaofo; 0.36 m^3. (See paragraph 329)

39. Aumaga hours worked were:

a. Atafu:

(1) Average number of man hours/day = 135 hrs

(2) Total number of man hours (task) = 10260 hrs

b. Fakaofo:

(1) Average number of man hours/day = 120 hrs

(2) Total number of man hours (task) = 6120 hrs

Stores

40. Movement. All stores were transported from New Zealand to Apia by two C130 aircraft, with the Advance Party and Team 1 respectively. The explosives (5150 kg) were moved by civil shipping to Apia in Sep 85, then to Tokelau by civil shipping with all the Team stores and personnel on 9 Nov 85.

41. Storage. The storage arrangements made at Apia for the securing of the Team stores and explosives whilst transiting enroute to Tokelau (Oct/Nov 85)

and return (Jul 86) were substandard, insecure and unsafe (explosives). These aspects are explained in detail in paragraphs 89 - 97, 102 - 104 and 106. Appendices 1 - 4 to Annex B records messages sent to New Zealand.

42. Accounting. All accountable stores were taken on charge by 'Op Tokelau Reef' on MD502. Date of periodic stock-checks are recorded in paragraph 460.

43. Usage Rates. For future planning purposes, the usage rates of POL and expendable stores are recorded as Appendices 1 and 2 to Annex M.

44. Annex F details the range of stores deployed to Tokelau.

Accommodation

45. The Teams were accommodated as a complete Team on each atoll. The house occupied at Atafu was satisfactory for the Team's requirements, which included internal rooms and had established water reticulation and hygienic waste disposal facilities. Further details are compiled in paragraphs 448 - 453. The accommodation at Fale Island, Fakaofo was extremely cramped and afforded no privacy at all. The house had no internal walls, nor established water reticulation/disposal facilities. The complete Team was housed under a single roof area of 60 m^2. See paragraphs 449 - 481 and 454 for further details.

Water supply

46. Water supply was a critical aspect of the task due to the unavoidable high usage rates of the Team, such as:

a. Washing of:

(1) machinery,

(2) catering accessories, and

(3) personnel,

b. Human consumption.

47. Planning figures for usage rates are:

400 litres/7 men/3 days

(19 litres/man/day)

48. Storage. No 'in-service' water-storage equipment was available for the deployment. This necessitated the Team purchasing two 7000 litres open storage tanks, (Para swimming pools!). Further details on Water supply are discussed in paragraphs 452 - 455.

Rations

49. The purchasing of all dry-rations for the nine month deployment was calculated on the following scale:

Small Mess Ration @ $3.50/man/day.

This scale was adequate and allowed for the procurement of a good range and variety of canned, processed and dehydrated foods.

50. In total, 5600 kg of food was packed and deployed to Tokelau from New Zealand, refer to Appendix 5 to Annex F.

51. The dry rations were supplemented by fresh food resupplied from Apia on the scheduled shipping service (@ 5 weekly intervals). The task budget had allowed @ $1000 NZ/ship sched for the purchase of fresh food and this was adequate. All relevant catering considerations and details are explained in paragraphs 426 - 446.

Resupply

52. Resupply for routine and essential stores and equipment was by:

a. Regular civil shipping schedule ex Apia @ five weekly intervals.

b. RNZAF airdrops ex New Zealand.

53. Annex B details the resupplied stores food and expendables requested from Apia via civil shipping.

54. The Tables of the major activities of each task record the dates and type each airdrop, refer to paragraphs 123. (Atafu) and 261. (Fakaofo). In total, nine airdrops were received in Tokelau:

a. Atafu; four ex-P3 and two ex-C130.

b. Fakaofo; one ex-P3 and two ex-C130.

55. The airdrops are recorded in detail in Annex U, including Drop Zone locations and Stores Received.

Welfare

56. The welfare considerations for this type of deployment, to an isolated location for an extended period, are complex and extensive. In general, the welfare of the Team personnel was adequately catered for. It became obvious that detailed selection of personnel to take part in the deployment was essential, and that these choices have a direct affect on overall Team morale and personal welfare.

57. The myriad of assorted welfare considerations are detailed in paragraphs 356. - 380. Suggested 'Personnel Selection Criteria' are listed in paragraph 382.

Public Relations.

58. Throughout the deployment, the Teams' experienced a good rapport with the locals, who were thoroughly satisfied with the work undertaken and appreciated the numerous public relations type tasks completed by each Team.

59. The civil tasks undertaken to assist the local population are detailed in paragraph 388. a (Atafu) and paragraph 388. b (Fakaofo). The major task in which the Team assisted, was the transportation of a 2 tonne tractor from ship to shore at Atafu. An "Indemnity Certificate" was requested by the Team Leader prior to the acceptance of the task, and is included as Appendix 2 to Annex K to this report. For further details refer to paragraphs 252. and 388. a(4).

Financial Expenditure

60. Budget. The task budget originally calculated for the deployment was substantially lower than that necessary to fund such a demanding deployment. This is recorded as Annex A to the document included as Annex E to this report and was $187,500. This allocation did not take into account any of the following essential purchases:

a. Expendable stores.

b. Spare parts.

c. Necessary accessories/CES type stores.

This initial budget figure was made without any consultation with the Team Leader and Mounting Unit.

61. The following is an analysis of overall expenditure incurred by resupply request (ex-Apia) from the Team during the Op Tokelau Reef period, Nov 85 - Jul 86:

a. POL

(1)	Diesel	Total =	$7558.02NZ
(2)	Petrol	Total =	$4726.08NZ
(3)	LPG	Total =	$4108.57NZ
(4)	Oxygen	Total =	$ 566.14NZ
(5)	Acetylene	Total =	$ 488.92NZ

b. Fresh Food Total = $5463.32NZ

c. Minor General Stores Total = $ 132.00NZ

d. Overall Total. Total expenditure on POL, fresh food and minor general stores:

Overall Total = $23043.05NZ

62. A monthly breakdown of the above expenditure is listed at Appendix 1 to Annex MM. Expenditure as at 1 Oct 85 on general stores is at Appendix 2 to Annex MM.

63. False Additional Claims by Office for Tokelau Affairs. When in transit through Apia, enroute to New Zealand from Tokelau, the Office for Tokelau Affairs (Director of Finance) incorrectly claimed the Team owed a total Bill of $6465.36NZ.

64. These claims are recorded in detail in paragraph 105., and after some discussion on 17 Jul 86, the Team Leader identified the unsubstantiated claims to the Director of Finance by use of receipts, previous resupply requests in the Sitreps and obvious anomalies in the Offices' financial accounting procedures.

Atafu Ship Wreck

65. A brief report on the Atafu Ship Wreck is included in this report, refer to green pages, paragraphs 483. - 491.

CONCLUSIONS

66. The following is a brief summary of the conclusions made in this report:

a. General

(1) Op Tokelau Reef proved to be an excellent professional experience for personnel of all ranks who deployed in both Teams.

(2) Work undertaken at Atafu significantly improved the channel.

(3) The Fakaofo channel was considerably improved by the work undertaken.

(4) Any further work undertaken on the RHS of the Fakaofo channel will not greatly improve its present state.

(5) The piles of loose rocks on the sides of each channel help to prevent reef top water draining into the channel at high tide and creating a strong 'out-going' rip.

(6) The rubble piles contribute significantly to the infill of each channel with fines, as waves erode the rubble.

(7) The locals at each atoll must establish a routine maintenance programme, which should be conducted progressively, to ensure that each channel remains fully trafficable.

(8) All teams deploying on this type of task must aim to be totally self-sufficient, with regards to:

(a) Accommodation; including bedding and linen.

(b) Water supply; including storage and treatment.

(c) Catering; including cooking, refrigeration and rations.

(d) Communications.

(e) Work related tools and equipment, less local labour assistance.

(f) Power supply.

(g) Medical.

b. Reconnaissance.

(1) The reconnaissance for the Op Tokelau Reef deployment was undermanned and conducted at the wrong time of year.

(2) A reconnaissance for this type of task must be manned in such a way as to accurately identify all the work required to achieve the desired aim of the task, and to correctly address the myriad of associated administrative, Logistic and non-RNZE details.

c. Mounting.

(1) Mounting Orders and Administration Instructions from higher headquarters, must be promulgated as early as possible to ensure that the selected personnel are released from their parent units for the pre-deployment administration phase, at the Mounting Unit.

(2) A pre-deployment administration and training phase is essential and should be a period of at least eight weeks, prior to departure, at the Mounting Unit.

(3) The Team Leader must be released from his parent unit to the mounting unit at least two months prior to the pre-deployment phase.

(4) All personnel, who are part of the Team, must be released from their parent units to the Mounting Units for the entire pre-deployment phase.

(5) A storeman is required to be attached to the Team for the entire pre-deployment phase, to action and receipt stores demands from numerous sources.

(6) Essential financial expenditure for items such as;

(1) spare parts,

(2) expendable stores, and

(3) CES type equipments,

must be allowed for in the overall task budget.

d. Task.

(1) The need to continually improvise, is a fundamental aspect of Pacific Island tasks.

(2) The clearance of blast debris and fines is a major factor in the overall task. This must be addressed in detail prior to leaving New Zealand to ensure that several methods of clearance are available on site.

(3) Coral structure can changes significantly from location to location and is often composed of several contrasting layers.

e. Assistance

(1) The support provided to the Team by OTA was generally sub-standard.

(2) All RNZAF support received via airdrops and aerial photographs was appreciated by all Team members.

(3) The LO in Apia proved to be ineffectual and unreliable.

f. Local Lifestyle

(1) Future Teams must be prepared for, and rapidly learn to live with, respect and understand the local customs, attitudes and 'way of life' on remote Pacific Islands.

(2) The local work force provided as labour assistance to the Team must be well-managed, controlled and directed on the task by the Team, but administered by the Local Administration.

g. Personnel

(1) Team Members must be carefully selected, taking into account the following criteria:

(a) Maturity.

(b) Leadership qualities.

(c) Trade skill and knowledge.

(d) Sound and stable home and personal life in New Zealand.

(e) Ability to communicate.

(f) Initiative, including an ability to improvise.

(g) No adverse qualities; (such as a heavy drinker, is racially prejudiced or is a loud 'snorer' when asleep).

(h) Sense of humour.

(i) Physically fit.

(j) Loyal.

(k) Trustworthy and honest.

(l) Even temperament.

(m) Reliable and dependable.

(n) Ability to work in a small team.

(o) Personality.

(p) Age, suggest > 21 years old.

(2) The Team Leader and Team 2IC must be Army Divers.

(3) This type of deployment requires the following non-RNZE trade supplementations:

(a) RNZCT Cook.

(b) RNZEME Vehicle Mechanic.

(c) RNZSigs Radio Operator.

(d) RNZAMC Medic.

(4) On this type of deployment, all Team members must be confident swimmers, preferably all RNZE personnel to be Government Diver trained and non-RNZE servicemen to be civilian divers.

(5) It is extremely advantageous in a small team to have a broad range of secondary skills such as :

(a) Carpenter.

(b) Plumber.

(c) Surveyor.

(d) APTI.

(e) Blacksmith.

(f) UEO/air cargo handler.

(g) Maori culture knowledge.

(h) First Aid.

(6) All personnel selected for Op Tokelau Reef, including RNZE servicemen, would have benefited from receiving refresher

type instruction prior to or during the pre-deployment phase, on:

(a) Explosive handling, (Demolition Handlers Course for non-RNZE personnel).

(b) Small boating and watermanship skills; including knots and lashings.

(c) Snorkelling, diving and safety in water, (Pre-Dive Course type training).

(7) The long deployment was personally and professionally demanding.

(8) It was difficult for the Mounting Unit and higher headquarters to understand the living and working conditions on Tokelau, due to no 'base' personnel being familiar with the area.

h. **Welfare.**

(1) In isolated locations with no recreational facilities, such as Tokelau, the following are important welfare aspects :

(a) Video and T.V.

(b) Beer supply.

(c) Fresh food.

(d) Highest possible rate of allowances paid.

(e) Personal privacy.

(2) The best possible standard of accommodation for the team is required.

i. **Engineer Equipment.**

(1) The best available equipment must be released for use on this type of deployment.

(2) RNZE has no suitable rafting equipment necessary for the landing of medium-heavy engineer equipment, through surf conditions, on to coral reef beachheads that have had only minor development.

(3) The LM-100 airtrac drill was a durable, efficient and effective item of drilling equipment that greatly increased the Team's productivity.

(4) The D6U air winch did not have a large enough capacity for the work required of it.

(5) An air winch with a capacity of @ 1500 kg line pull would have been more suitable, and effectively employed on this type of deployment.

(6) A 'purpose built' dragline bucket that could have been effectively employed, would have greatly increased the Team's ability to remove existing and blast fines from the channels.

(7) The Corps, at present, has very limited resources of medium capacity water storage and catchment equipment.

(8) In-service, wooden Army survey staffs are not suitable for extended periods of work in tropical salt water conditions.

j. Support Trades.

(1) Daily radio scheds were essential for allowing the flow of routine and priority messages to and from New Zealand.

(2) Although the Team was adequately supported by the Team Medic/Rad Op; a RNZAMC Medic is required as a team member on this type of deployment.

(3) Fresh food resupplies can not be relied upon and must be considered as a 'bonus'.

(4) Food consumed during the deployment must be :

(a) nourishing,

(b) appetising, and

(c) have variety.

(5) The Medic provided to support this type of deployment must be as proficient in the diagnosis and treatment of 'diver-ills' as he is in tropical and routine type medical ailments.

k. Stores.

(1) All stores, equipment and accessories must be accurately manifested to the smallest detail when packaging for an intended move.

(2) Periodic, 100% stock checks of all Team stores are essential to ensure accuracy in accounting and justify resupply requests.

l. Clothing.

(1) Issue black cotton shorts are unsuitable for wearing on tasks in hot tropical conditions which require a high degree of in/underwater work.

(2) The wearing of nylon shorts was popular and these were found to be far more comfortable and durable than issue cotton shorts.

(3) Hard-soled wetsuit boots (Rockhoppers) worn with plastic 'KD' sandals was a sound and practical type of footwear for work on the reef and amongst rubble.

m. Public Relations.

(1) Any assistance and advice able to be offered by the undertaking or supporting of local development schemes or charitable organisations, significantly contributed to the promotion of sound public relations between the Team and the local population.

n. Command and Control.

(1) Rank structure within the Team must be managed to ensure that the Team 2IC is the only Team member that holds his particular rank.

(2) The Advance Party must arrive prior to the Team stores, when transitting through an intermediate country, to allow for the checking of administrative arrangements.

(3) It was essential for sound command and control of the task, that the OC of the Mounting Unit and Team Leader had frequent discussions on the Defence radio net.

(4) The recording of task progress and working conditions by video is an effective way of reporting to New Zealand.

(5) A Team on this type of deployment required a competent and dependable LO for the organisation of 'base' type administrative arrangements. In the case of OP Tokelau Reef this LO would be in Apia and should be a RNZE JNCO Storeman/clerk.

(6) MFA or associated representatives must not have any influence over the command of the Team or their movements.

(7) A changeover of Teams on long deployments is a sound practice.

(8) The Op Tokelau Reef deployment proved that the Army 'System' works.

RECOMMENDATIONS

7. It is recommended that :

a. General.

(1) RNZE continue to undertake deployments of this nature, on a regular basis, to avoid any loss of knowledge or experience from the Corps.

(2) No further widening work be undertaken on the RHS of the Fakaofo channel.

(3) The locals be encouraged to remove all the loose piles of rubble on the sides of each channel to avoid further infill of fines.

(4) Each channel be enclosed on both sides by firm rubble walls, incorporating gabion baskets filled with large coral debris. These would be locally constructed and prevent the drainage of reef top water into the channel.

(5) A programme of routine maintenance, involving monthly hand clearance, be established on each atoll; overseen and directed by the local Public Works Department. This would then cause all channel work to become an 'official' task and would subsequently receive a monetary allocation in the atoll's budget as a Public Works responsibility.

(6) Comprehensive post-deployment reports, for this type of overseas task, be submitted to ensure a reliable source of reference is available for the planning of future deployments.

b. Reconnaissance.

(1) All future reconnaissances for this type of task be manned by the following personnel :

(a) OC Mounting Unit.

(b) Team Leader of the deploying team.

(c) Team Leader from the most recently completed RNZE deployment on a similar task to the Pacific Isands.

(d) RNZE SNCO, preferably the deployment team 2IC.

(e) RNZE surveyor.

(f) Storeman of the Mounting Unit, who will act as the Teams' base logistics NCO in New Zealand during the deployment or as the LO in the intermediate country.

(2) The time of year when the initial reconnaissance is conducted be the same as the proposed task commencement date.

(3) A further confirmatory reconnaissance must be conducted after the initial reconnaissance, to ensure that the necessary administrative arrangements are being actioned in the task location and to check on the provision of support services required from other intermediate/outside agencies, such as OTA. The Mounting Unit 2IC should be included on this reconnaissance.

c. Mounting.

(1) A period of at least eight weeks be allocated for all team personnel to concentrate at the Mounting Unit for pre-deployment administration, training, trials of equipment and logistic arrangements.

(2) The Team Leader be released from his parent unit two months prior to the pre-deployment phase, to commence detailed planning at the Mounting Unit.

(3) Arrangements be made, through the early promulgation of authorities, for all team members to be released from their parent units for the entire pre-deployment phase.

(4) All Corps that are to be involved with the deployment, be represented at all planning conferences and meetings.

(5) A reliable and competent NCO storeman from the Mounting Unit be attached to the Team for the entire pre-deployment phase, deployment period, and the short post deployment phase.

d. Task.

(1) A validation of reconnaissance information be conducted prior to the task commencing, (during the confirmatory reconnaissance).

(2) Considerable attention, prior to deploying, be given to establishing several sound and efficient methods of the disposal and clearance of blast debris and fines.

e. Assistance.

(1) LO's for future tasks of this nature, involving an intermediate foreign country, be provided by Army. Suggest a JNCO storeman/clerk from the Mounting Unit.

(2) Supporting outside agencies be fully briefed on the Teams' support requirements for the deployment and be committed to providing a reliable service. This would be checked on during the confirmatory reconnaissance.

f. Local Lifestyle.

(1) The Team, prior to deploying, receive comprehensive and detailed presentations on the local;

(a) customs,

(b) language,

(c) protocol,

(d) social stratification,

(e) religious beliefs,

(f) food, and

(g) attitudes.

(2) Detailed specifications and a 'Terms of Reference' for the employment of the local work force assistance, be established on site to allow the Team to control and direct the taskings without becoming involved with the administration of the workers.

g. Personnel.

(1) The criteria listed in paragraph 66 g.(7) be adhered to when assessing the suitability of a serviceman for this type of deployment.

(2) All Team members be confident swimmers and, as many as possible, be diver trained.

(3) The manning of future teams involved on this type of task be:

(a) Team Leader (RNZE Diving Officer)

(b) Team 2IC (RNZE SNCO Diver)

(c) Three Combat Engineers (Divers)

(d) Cook (RNZCT NCO, Cpl minimum)

(e) Vehicle Mechanic, (RNZEME NCO, Cpl minimum)

(f) Radio Operator (RNZSigs NCO)

(g) Medic (RNZAMC NCO).

(4) Training for all selected team personnel, prior to deploying, involve :

(a) Small boating and watermanship skills, including knots and lashings.

(b) Snorkelling, diving and safety in water (Pre-Dive course type of training).

(5) Non-RNZE personnel receive training in explosive handling (Demolition Handlers course).

h. **Welfare.**

(1) Emphasis be placed upon providing the following :

(a) High standard of accommodation.

(b) Fresh food.

(c) Beer supply.

(d) Video and TV, including a camera for personal and work related tapes to send home.

(e) Means for Team members to talk to their NOK.

(f) Frequent news relating to the Teams' parent units and peers.

(g) Welfare items via airdrops.

(h) A liaison visit to the task site by the mounting unit OC and SSM.

(i) An efficient mail delivery system.

(j) High rate of allowances.

i. **Engineer Equipment.**

(1) Priority Loan of the Corps equipment and stores be given to the conduct of this type of deployment.

(2) RNZE develop the capacity for the safe landing of medium-heavy engineer equipment, through surf conditions, on to coral beachheads that have had only minor development, by the acquisition of comprehensive rafting equipment.

(3) The Corps procure the following equipment for future deployments of this nature :

(a) Light, compressed air driven airtrac drill with the capacity to drill 65 mm diameter boreholes to a depth of 3 m and complementary portable compressor, suggest the Ingersoll-Rand LM-100 airtrac and P375 compressor.

(b) Man portable air winch with a line pull capacity of @ 1500 kg, suggest the Ingersoll-Rand HU winch.

(c) Dragline bucket, compatible with the air winch capacity, designed for the removal of blast debris and fines for use in and under water.

(d) Open and enclosed medium capacity, @ 7000 - 10000 litres, water tanks.

(e) Modern, lightweight aluminium survey staffs to replace the outdated, cumbersome wooden staffs, currently in service. Suggested replacement is :

(1) 5 m, aluminium, three extension 'Mizoguchi MFG' Co Ltd., Japan, survey staff which comes complete with a nylon carry bag. This item is currently used by the Ministry of Works and Development.

j. Support Trades.

(1) A Defence radio net is established between the task site and the Mounting Unit.

(2) The majority of all food to be consumed during the deployment be purchased and packaged in New Zealand and deployed to the task site with the Team.

(3) The Team Medic undertake a course of instruction in the diagnosis and treatment of 'diver-ills'.

k. Stores.

(1) Routine, thorough stock checks of all Team stores be conducted throughout the deployment.

(2) Detailed manifests be compiled for all moves.

l. Public Relations.

(1) At every opportunity, future Teams undertake as many public relations type tasks as can be managed, without detracting effort from the primary deployment task.

m. Command and Control.

(1) The rank structure within a Team be such that the Team 2IC is the only serviceman holding his particular rank.

(2) The Team Leader and OC Mounting Unit have regular discussions via the Defence radio net.

(3) A video camera be provided for all deployments to allow for accurate recording and reporting of task progress and working conditions, when forwarded to New Zealand, and for future reference.

(4) The deployment of an Advance Party precede any movement of task stores out of New Zealand.

(5) Supporting Government organizations fully understand that the command and control, including employment, of the Team is an Army responsibility.

30 September 1986

(A.M. SKINNER)
Captain
Team Leader
Op Tokelau Reef

OPERATION TOKELAU REEF

POST DEPLOYMENT REPORT

ON ENGINEER WORKS UNDERTAKEN

TO IMPROVE TWO EXISTING REEF CHANNELS

ON TOKELAU ISLANDS

PART II : MAIN BODY

GENERAL STAFF MATTERS

General

68. Engineer works required to improve the Atafu and Fakaofo reef channels were assessed on a reconnaissance during Feb/Mar 85. Due to shortfalls in the information gained on the reconnaissance vastly more work was discovered at Atafu than was expected to achieve the same desired widening at the channel mouth. These shortfalls of information were a result of the following:

a. A grossly under-manned and relatively inexperienced Army reconnaissance team.

b. Considerably rougher sea conditions prevailed during the reconnaissance than were experienced in the early stages of the deployment.

c. No self contained underwater breathing apparatus (SCUBA) was permitted to be taken on the reconnaissance, this restricted all underwater investigation to short duration snorkelling.

d. It was not possible nor feasible to conduct any test drilling or blasting of the coral. (The drilling equipment employed on the task was only purchased after a recommendation in reference A, and necessitates the use of a large compressor. Smaller, man portable, petrol driven, drills could have been used on the reconnaissance to determine coral composition, but it was found that this changed considerably from place to place within the AO, and these drills would have been restricted to conducting trials on coral areas above water level, unlike compressed air drills. The majority of explosive work was 'pattern blasting' incorporating large diameter boreholes in a series of rows. Therefore a test blast, unless it was significantly large enough, would not warrant the miriad of administrative arrangements required to allow explosives to be transported and stored for the reconnaissance).

69. The additional work required at Atafu was only identified after a detailed underwater diving reconnaissance was conducted of the channel mouth

and reef extremity. The further drilling and blasting of two large coral fingers (narrow coral peninsulars extending from the reef extremity towards deep sea) and five large rocks in the channel mouth also on the extremity of the reef (See Annex D). The additional work substantially increased the volume of rock required to be removed, an additional 2050 m^3 (from 900 m^3 reconnoitered, to 2950 m^3).

a. The reconnaissance conducted at Fakaofo proved to be very accurate and suffice for the task to commence unhindered by the requirement to undertake additional work.

Pre-Deployment Administration

70. Basic Considerations. The following are considerations that effect the mounting of the deployment:

a. The tasks involved extensive engineer works on the atolls, 160 km apart in a remote region of the Pacific.

b. The only form of transportation to and from Tokelau and internally, is by a five weekly ocean going cargo ship ex Apia.

c. The deployment was to entail the transit of all Team personnel, stores, rations and equipment through a foreign country (Western Samoa).

71. Subsequently, attention was given to the following points:

a. Team must aim to be totally self sufficient in all aspects including food, electricity, comms, water catchment, task related tools and equipment.

b. Local resources are very limited and their use cannot be relied upon.

c. At both task locations, the team will live amongst a very small community, therefore, the team must aim to make the least impact possible.

d. Logistic/resupply chain is complex and extended.

e. Team members were to be made aware that receipt and postage of mail may be irregular and could entail long delays.

72. Mounting. A deployment such as Op Tokelau Reef requires thorough planning and coordination of work priorities prior to deploying from NZ. Arrangements must be made to allow for the release of the Team Leader from his appointment at his parent unit, to become TOD to the Mounting Unit solely for the purpose of ensuring all aspects of the necessary pre-deployment administration are satisfactorily addressed. During Jun and Jul 85, major critical activities had to be addressed and initiated. Such activities were:

a. Compile and submit a formal order for major equipment requiring import from overseas.

b. Establish general stores required to be obtained from local purchase sources.

The Team Leader was TOD to 1 Fd Sqn on 7 Aug 85 to commence the compilation of various Mounting Instructions. It was found that this was too late to initiate these instructions which held the authority for the essential release of team personnel for pre-deployment training from their parent units. It was planned to concentrate all team personnel at 1 Fd Sqn on 2 Sep 85 and also PON them as ADMIN/EMPLOY. Due to the delay in promulgating LFC Mounting Instruction (dated 3 Sep 85), the subsequent 1 TF and 1 Fd Sqn Mounting Instructions were also delayed (dated 10 Sep and 28 Sep 85 respectively). These activities, unfortunately, were undertaken by the Team Leader in isolation as the RNZE Mounting Unit was not nominated until late Jul 85. The valuable advice of the Mounting Unit OC, who was to command the deployment, would have been of considerable assistance.

73. Personnel. Delays in promulgating authorities for the release of personnel from units caused concern as some team members were given very little warning of their participation in the deployment, and subsequently arrived at 1 Fd Sqn with necessary overseas documentation incomplete. The Team I RNZCT cook was not released from his unit until 18 Sep 85 and then had a very limited time to order, procure and pack (in air/water tight containers) sufficient dry rations required to maintain an eight man team for a seven month period in the tropics.

74. Concentration Period. It was proposed to concentrate Team I at the Mounting Unit in Papakura for the period 2 Sep-16 Oct 85 with departure dates of 16 Oct 85 for Advance Party and Team I(-) 19 Oct 85. The aim of concentrating Team I for six weeks and assembling Team II for one week during that period, was to ensure that all personnel were introduced to the concept of the task and prepared for a long duration away from home in an extremely isolated location. Specific details to be addressed during the concentration, were:

a. Demand, receipt and uplift A Class and C Class (expendable) stores from 1 Sup Coy, Hopuhopu as they became available.

b. Demand, receipt and uplift all specialist oils, greases and lubricants not readily available in the Pacific region, ie Western Samoa.

c. Check all loan equipment and CES's for serviceability.

d. Demand, procure, receipt, uplift and pack all rations.

e. Order all necessary explosives and accessories using a detailed 'Blast Design'.

f. Arrange formal receivership of major new equipments and ordering of necessary CES type items and servicing spares.

g. Procure and uplift stores from local purchase sources within Auckland area.

h. Uplift overseas personal over-issue of clothing.

i. Conduct a thorough serviceability check of all mechanical equipments to be deployed and carry out the necessary repair work including AFNZ 456 action if required.

j. Organise the necessary inspection of all major equipments by HM Customs.

k. Inventory, pack and manifest all equipment and stores.

l. Conduct intensive trials on assault boat raft (employed for all ship to shore and shore to ship moves of Team).

m. Conduct comprehensive training for all personnel on new major key items of machinery, particularly the airtrac drill which required operating skills not practiced in RNZE and a period of low intensity work to 'bed-in' the equipment and identify any potential 'running-in' faults.

n. Organise an attachment for Team Vehicle Mechanic to Ingersoll-Rand Workshops for extensive technical training on the repair and servicing of new equipments.

o. Liaise with RNZAF for the movement of stores to Whenuapai and loading of pallets/aircraft.

p. Conduct liaison visits to:

(1) Drilling company (Ingersoll-Rand),

(2) Explosive company (ICI), and

(3) MOT Meteorological Office.

q. Conduct briefings on:

(1) Typical tropical ailments,

(2) Safety aspects of handling and employing explosives, and

(3) Tokelau customs and language.

r. Brief NZ based Radio Ops on types of RNZE terminology and anticipated types of traffic including the SITREP format.

s. Ensure medical training for Team Medic was undertaken.

t. Check personnel administration.

u. Conduct any necessary personnel administration.

75. The points mentioned in paragraph 74. above warrant a concentration period of 12 weeks of all team personnel at the Mounting Unit. Specific activities such as points in paragraph 74 l, m, p, and q, require the assembling of all personnel who may deploy at various stages, as relief teams. It was proposed to assemble all of Team II personnel from 30 Sep to 4 Oct 85,

unfortunately only two Engineers and the Vehicle Mechanic were releaeed for this week.

76 The Mounting Unit based in the Auckland area was found to be of great benefit during the mounting phase as it allowed for, when necessary, frequent and efficient liaison visits to:

a. LFC.

b 20 Sqn, RNZAF and Movements Flight, Whenuapai.

c. HM Customs.

d. Head Offices of the major civilian firms involved.

e. Local supply sources.

77. Training. The pre-deployment training programme used during the concentration period, is shown at Annex D to Reference G. All aspects in paragraph 74 were addressed, although some rather unsatisfactorily. The aspects that required further time to have completed the training satisfactorily were :

a. Sub paragraph i. Due to RNZE general engineer stores and equipment being constantly employed on tasks within NZ, extensive work is required to upgrade these items to a standard acceptable for a long duration deployment.

b. Sub paragraph l. The assault boat raft was trialed fully laden for several days off Maraetai, but still required a further week to confirm the design due to continual failures with Outboard Motors, (OBMs).

c. Sub paragraph m. The essential training required for team members on the airtrac drill and the necessary 'running in' period, was not adequately completed due to late receivership of the drill and compressor (23 Sep 85).

d. Sub paragraph r. A brief of the NZ based Radio Ops who would man the rear link, to assist in the transmission and receipt of engineer type traffic during deployment, was not undertaken due to coordination problems.

The training undertaken by the Team I Vehicle Mechanic at Ingersoll-Rand was for a period of one week and proved, on the deployment, to be of significant value. Cross-training of the RNZSigs Radio Op as the Team medic at Papakura Camp Hospital proved to be of an excellent standard due to thorough instruction and assistance prior to deploying. He was employed each morning for a period of one month during MIR parades at the Hospital.

78. Prior to the concentration period, it would have been desirable if, as many Team members as possible had undertaken training in the following areas:

a. Demolitions (Handlers Course).

b. Small boating (watermanship skills).

c. Snorkelling (Pre-divers Course type training).

79. Frustrations were created for Team I personnel during the mounting period when a sudden decision was made (Sep 85) to include, as an additional task (Priority 2), the removal of a ship wreck at Atafu. This was included as part of the Team's responsibility with no consideration given to the following:

a. Additional time allowed for Atafu Reef Channel Task to undertake detailed reconnaissances, planning and execution of the ship wreck removal.

b. The reconnaissance report submitted by CPO J. Kearney, RNZN dated 85, discussed feasibility of RNZN removing the wreck. It was totally unsatisfactory for the planning of the task and provided no information about the wreck nor any suggested ' modus operandi'.

c. Specific stores required for the disposal of the wreck could not be identified through lack of information on the wreck.

A detailed study of the ship wreck is included at the back of this report (see green pages).

80. Budget. A breakdown of the planned major expenditure to be incurred on Op Tokelau Reef is at Annex A to the document at Annex E to this report. No allocation was made in the budget for essential items such as:

a. Expendable stores.

b. Spare parts and servicing parts for civilian equipments.

c. CES type items for major new equipments.

d. Unexpected resupply requests for minor stores due to usage. This became apparent as a shortfall of the Reconaissance Report (Reference A), insufficient information was provided for anticipated expenditure of minor support items listed above.

A detailed Analysis of Total Financial Expenditure is included as Appendix 1 to Annex HH. This Analysis has also been provided in accordance with Reference A, Annex E, paragraph 9.

Packing and Manifesting Stores

81. The packing and manifesting of Team stores was an activity that proved to be a very new experience and subsequently a learning exercise for all Team I members involved. All packing and manifesting was undertaken by Team I personnel during the six week concentration period and involved a total work duration of three weeks for eight men.

82. Due to the non-availability of any significant previous reports for reference on this type of deployment illustrating planning figures for expendable usage rates, most lessons learnt were through 'trial and error'. This report includes:

a. Major expendable usage rates, (see Appendix 2 to Annex M).

b. Manifest Documents (See Annex F):

(1) MD 450 Deployment Planning Data Table, (Appendix 1 to Annex F).

(2) MD 442 Load Manifest (Freight), (Appendix 2 to Annex F).

(3) MD 443 Load Manifest (Dangerous Freight), (Appendix 3 to Annex F).

(4) Schedule of Hazardous Material, (Appendix 4 to Annex F).

(5) Food Pallet Weights, (Appendix 5 to Annex F).

(6) Cargo Weight and Volume Calculations, (Appendix 5 to Annex F).

(7) Expendables List, (Appendix 7 to Annex F).

(8) Stores List and Box Configurations, (Appendix 8 to Annex F).

83. HM Customs. All major stores were inspected by an officer of HM Customs on 1 Oct 85, for export clearance (Appendix 1 to Annex G).

Movement to Apia

84. Team I. The movement of Team I from NZ to Apia, Western Samoa was planned for:

a. ETD NZ Advance Party 16 Oct 85 (by Air NZ), and

b. ETD NZ Team I(-) 19 Oct 85 (by 2 x C130 aircraft).

85. Due to a late change of the arrangements and dates of Team I's move from Apia to Tokelau, a delay was caused. The amended ETD NZ dates were cnfirmed as 15 Oct 85 and were as follows:

a. ETD NZ Advance Party 19 Oct 85 (by C130), and

b. ETD NZ Team I(-) 7 Nov 85 (by C130)

The delay of ETD NZ Team I (-) caused some concern and anxiety for the personnel involved due to late notification. Those who were not from the Auckland area had already said their farewells to their families and were prepared to leave.

86. Team II. The replacement team of six personnel moved by civil air from NZ to Apia on 10 Feb 86, after a short concentration period from 3-7 Feb 86 at the Mounting Unit.

87. Equipment and Stores. All equipment and stores including rations, required as part of Op Tokelau Reef, were moved from the mounting unit to Whenuapai using vehicles from 1 Tpt Sqn. During the entire concentration period and for the movement of stores to Whenuapai 1 Tpt Sqn proved to be most cooperative. The equipment, stores and rations were then moved complete in the two C130 flights to Apia. The only stores to be transported to Apia by other means were the explosives, detonators and accessories which went by civil shipping during early Oct 85. All the loading of the aircraft was undertaken by 20 Sqn RNZAF. The pallets were designed and loaded to enable a Combat Off-Load at Faleolo International Airport, Apia. RNZAF believed that a Combat Off-Load was a necessity as they informed the Mounting Unit that there were no forklifts in Apia capable of lifting the 2000 kg pallets of stores.

88. Team II personnel experienced a problem at Auckland International Airport when, on departure, the 'one-way' tickets to Apia supplied by MFA were queried. This was due to them not having any proof from MFA of their return fares.

Administration During Transit through Apia

89. Team I (Advance Party). The Advance Party deployed to Apia on 19 Oct 85 by C130 with 50% of team stores and equipment. (This required the C130 to be fully laden). The combined arrival of the Advance Party and a large quantity of stores proved to be unsatisfactory regarding arrangements that should have been organised for their reception and storage whilst in transit through Apia. The Advance Party was not able to check the arrangements nor change them if necessary prior to the stores arriving. The following were unsatisfactory aspects concerning the arrival and reception of the Advance Party (see Appendix 1 to Annex B):

a. The Combat Off-Load of the C130 commenced at 181740 Oct 85 local time and, due to incorrect pallet loading configurations, the pallets resulted in being top heavy. Significant damage was done to various stores and rations, caused as the pallets rolled 'end for end' after being pushed off the C130 ramp. The C130 then departed, leaving the Advance Party with a huge mess and considerable bad feeling towards RNZAF.

b. Apia Haulage Ltd was the trucking firm contracted by Office for Tokelau Affairs (OTA) for the move of stores, rations and equipment from Faleolo International Airport to storage facilities. Neither the trucking firm nor a representative from OTA arrived at the airport until 40 minutes after the off-load. At that stage, dusk had fallen and, subsequently, the airport security lighting was switched off. Apia Haulage Ltd did, however, provide a forklift for the loading of trucks. This forklift had a 3500 kg lift capacity and would have easily lifted the C130 pallets (2000 kg), therefore avoiding the unnecessary damage.

c. The representative of OTA could not, when queried, inform the Team Leader of:

(1) The proposed movement of stores and the location of the storage facility.

(2) Accommodation arrangements for the Advance Party, and

(3) Any arrangements for an essential meeting required with LO,(OTA Official Secretary, Mr A. Macey).

This resulted in Team Leader having to attempt to make contact with LO who was at home.

d. No arrangements had been made for Advance Party processing through Customs and Immigration at Faleolo. Subsequently, Advance Party passports were confiscated and held by Immigration until early Nov 85.

e. Advance Party were booked into a totally unsatisfactory hotel which was dirty and cheap.

90. Further problems were encountered in Apia prior to the arrival of Team I(-) as the Advance Party attempted to conduct a stock check of all equipment, stores and explosives for loss or damage. It was discovered that, (see Appendix 1 and 2 to Annex B):

a. The explosives were stored in three 'W' Explosive Containers hired from ICI Ltd, 6 m^3 each and were excellent for handling the explosives in bulk and minor security. However the location for these containers in Apia was totally unsatisfactory and extremely unsafe without adequate security arrangements necessary for a large amount of explosives and detonators. The total weight of explosives was 5150 kg and this was stored in a poorly ventilated and busy storehouse adjacent to OTA in central Apia. The storehouse was 10 m from a main road, 160 m from a school and 3 m from the OTA main offices. The detonators were stored in a bulk cargo store, in the same storehouse.

b. The stores, rations and equipment were stored in a shelter at Apia Haulage Ltd in Apia. This shelter was completely insecure, visible from the main road and provided very minimal protection against heat and rain. It was not possible to conduct a stock check as all the stores had been left in a random heap, 10 m x 9 m x 3 m.

91. OTA and Apia Haulage Ltd were unaware of the total volume of Team stores and the necessary secure storage area required. During late Sep 85, the Tokelau Desk Officer at MFA, Wellington had been advised that a weather proof, secure storage area was required with approximate dimensions of 12 m x 15 m. MFA were also informed that the explosives and detonators required particular attention for storage including security and adequate ventilation.

92. It was discovered that Apia Haulage Ltd had been providing support to RAAF by conducting the loading and off loading of C130 aircraft enroute for Kiribati during early/mid 85 and were familiar with the employment of forklifts for the loading and off loading of C130 pallets. The unnecessary damage that was incurred would have been avoided if RNZAF were aware of this experience. 40 Sqn RNZAF informed the Team Leader that there were no forklifts in Apia capable of lifting a 2000 kg C130 pallet and that this had been determined during Ex "Tropic Venture" (Aug-Sep 85) in Western Samoa.

93. Unfortunately, the twice yearly General Fono meeting of elders from each of the atolls and MFA/OTA representatives, occurred at Nukunonu during 26 Oct-4 Nov 85. This meant that there were very few people in responsible positions remaining at OTA during the Fono. This period coincided with the time the Advance Party were in Apia. Subsequently, the logistics of stores movement, control and security could not be improved upon by the Advance Party. No fresh food outlets/suppliers had been determined or investigated prior to the arrival of the Advance Party for team resupplies once in Tokelau. After the General Fono the Team Leader was unable, on several occasions, to get the Liaison Officer (Mr A. Macey, Official Secretary, OTA) to agree to a coordination discussion prior to departure of the Team for Atafu. Therefore, no liaison between the Team and LO was conducted after 25 Oct 85.

94. A considerable deal of confusion regarding 'Basic Principles' of the deployment was very evident at OTA when the Advance Party discussed the concept of the deployment. Until 4 Nov 85 OTA believed that the remainder of Team I were to 'parachute' into Atafu as part of a proposed C130 airdrop for 12 Nov 85 local time and that stores only were to move to Tokelau by civil shipping (see Appendix 3 to Annex B). The essential requirement for the Reef Blasting Team to be allocated a 'dedicated sailing' on the cargo vessel for the move between Atafu and Faleofo, was not fully accepted by OTA until the first week of Nov 85. This need arose through the Team's requirement to transport personnel, explosives and fuels (see Appendix 3 to Annex B). It is believed that the Advance Party would have been far more effective as a control/monitoring resource if those personnel had been deployed to Apia prior to the arrival of the stores. This would have enabled all necessary reception and storage administration for the transit of the Team to be checked rather than assuming that adequate arrangements had been made.

95. Team I(-). The remainder of Team I arrived in Apia on 6 Nov 85, ex C130, with the remainder of the stores and the larger equipments which were taken to the Apia Haulage Ltd shelter. This concentrated all Team stores and equipment less the explosives. The stores and equipment were soon moved to the Apia Wharf (on 7 Nov 85) and secured in ISO shipping containers. This was due to Apia Haulage Ltd not working on Saturdays because of their Seventh Day Adventist beliefs. The ship MV KALI was then loaded on Saturday 9 Nov 85 commenciung at 0300 hours. The Team became frustrated as the ships Tongan crew would not accept any direction or advice for the desired loading sequence the Team had planned to assist in an efficient off-load at Atafu. This' random loading' resulted in the Team spending 8½ hours on 10 Nov 85, enroute to Atafu, in the hold of MV KALI, constructing the assault boat raft in a 43°C temperature. The raft required 1½ hours to construct on land.

96. The attitude that OTA displayed during the transit period through Apia, was one of general uninterest in the Team and created the impression that the deployment was considered very much a routine/procedural type exercise. The Advance Party firmly believed that there was a lack of satisfactory administrative arrangements organised for an efficient transit of the Reef Blasting Team. The Administration Officer at NZ High Commission, Apia proved to be of great assistance to the Team and was able to solve some minor problems (see Appendix 4 to Annex B).

97. Team II. It was found that Team II encountered similar problems to those experienced by Team I on arrival at Apia and subsequent administrative

arrangements. Prior to arrival Team II were not booked into a hotel for the period of their transit through Apia and were also required to pay for all meals. OTA failed to maintain any form of contact with Team II reference the departure of MV WAIRUA for Tokelau. This meant that Team personnel had to constantly 'chase' OTA to ensure that they remained familiar with the arrangements and any changes made. (see Appendix 20 to Annex B).

Movement from Apia to Atafu

98. Team I. The move from Apia to Atafu of Team I occurred during 9-11 Nov 85, leaving Apia at 092145 Nov 85 and arriving at Atafu, after a direct passage, at 110600 Nov 85. The Team's move was a dedicated sailing of MV KALI, a Tongan registered cargo ship at 2400 tons. This ensured that the move of the Team plus all stores, equipment and explosives was conducted without other civilian passengers aboard. All Team members shared double berth and were provided with good food by the ships galley.

99. Team II. Team II arrived at Atafu at 130600 Feb 86 after leaving Apia at 112359 Feb 86 on MV WAIRUA. No problems were encountered during the Team's passage as all personnel were considered as merely passengers on the scheduled Apia-Tokelau-Apia sailing. Team I(-) then returned to Apia for RTNZ on this ship, leaving Atafu at 160930 Feb 86.

Movement from Atafu to Fakaofo

100. Three months overdue, Team II departed Atafu on MV WAIRUA as a dedicated sailing on 251900 Apr 86. The ship arrived at Fakaofo at 260600 Apr 86 with the Team complete. It was found that the Fijian crew, on MV WAIRUA, were extremely friendly and helpful, this allowed the Team to position a LO on board during the loading and unloading. The Team was able to influence the sequence of cargo loading and this proved to be of benefit during the off-loading phase.

Movement from Fakaofo to Apia

101. The Team departed Fakaofo for Apia, via Atafu and Nukunonu, on MV WAIRUA scheduled Jul 86 sailing at 121900 Jul 86. All explosives had been expended on Fakaofo leaving only general engineering stores as the Team's cargo. The rough sea conditions encountered on the return voyage delayed the arrival of the ship at Apia by 22 hours. Arrival time at Apia was 151400 Jul 86.

Administration during Transit through Apia Return

102. The reception of the Team in Apia on return from Tokelau was slightly better organised than on arrival ex-NZ, see paragraph 89. A representative from OTA arrived on the wharf 1½ hours after the arrival of the ship and informed the Team that accommodation was arranged. The stores were loaded out of the ships hold and onto 'Apia Haulage Ltd' trucks for transportation to OTA for storage. When talking with the OTA representative at the wharf, the Team Leader discovered that no transport had been organised for the movement of the Team stores to Faleolo airport. The manager of Apia Haulage Ltd, who was

supervising the loading, was then approached by the Team Leader and agreed to providing trucks for the move to the airport on 17 Jul 86.

103. 16 Jul 86 had been organised with OTA for the following:

a. Final payment of outstanding accounts.

b. Uplift of incidental allowances for Team Members whilst in Apia.

c. Stock check of Team stores in OTA shed.

d. Reimbursement of monies credited to the Team whilst in Tokelau, (due to the payment of bills insitu and the subsequent exchange rate fluctuations when the NZ dollar was converted to WS dollars at OTA).

It was found that the OTA finances were in a state of disorder. Various invoices, receipts and transaction records had been misplaced meaning that the account settlement was re-scheduled for 170800 Jul 86. OTA had not arranged the incidental allowances that were owed to the Team, meaning that this became the Team's responsibility.

104. The loading of all the Team stores onto trucks from Apia Haulage Ltd commenced at 170800 Jul 86 and was complete by 171100 Jul 86. The RNZAF C130, for the return flight of the Team to NZ, was due at Faleolo at 171520 Jul 86.

105. The Teams accounts were settled during the period 170800-171230 Jul 86 between the Team Leader and the Director of Finance. The following unsatisfactory aspects should be noted:

a. The Team had been billed for 12 x pillows and 12 x bed sheets that had been ordered, without the Teams knowledge or request, by the Fakaofo Administration for use by the Team on arrival at Fakaofo. These were not seen by the Team at Fakaofo.

Amount incorrectly charged to the team = $360.00NZ

b. Three bills for liquor during early 1986 totalling $1341.63NZ were claimed to be unpaid. The Team Leader had official receipts from Atafu stating that two of the bills, totalling $741.63NZ had been paid. The third bill was discovered by the Team Leader, only after searching through all the invoices, that the outstanding $600.00NZ was an OTA order for liquor that was consumed by OTA/MFA representatives on a previous visit to Tokelau.

c. The Team had also been billed for a length of PVC pipe, that had not been ordered, nor received by the Team in Tokelau.

Amount incorrectly charged to the Team = $11.62NZ

d. In Mar 86, the Team ordered $252.96NZ worth of camera film. This bill was paid to the Atafu Administration on receipt of the films in Mar 86 and the Team Leader was in possession of an official receipt for this money. This was claimed to be unpaid by the Director of Finance at OTA.

e. 2000mls (2.0 litres) of concentrated battery acid was ordered by the Team from OTA in Mar 85, (for the five wet cell 12 volt batteries as CES to AN/GRC 106 radio). It was found that OTA were incorrectly charging the Team for six x 200 litres of acid.

Amount incorrectly charged to the Team = $534.23NZ

f. On the Jun 86 scheduled sailing, 10 x 209 litre diesel and 12 x 209 litre petrol drums were all the POL that was ordered and received by the Team at Fakaofo. This totalled $621.06NZ, see Appendix 30 to Annex B and Appendix 1 to Annex HH. OTA claimed the Team owed $5185.98NZ for fuel ordered on the Jun 86 ship.

Amount incorrectly charged to the Team = $3964.92NZ

g. Overall total of additional incorrectly charged bills to the Team, claimed by OTA = $6465.36NZ

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None of this Bill was paid to OTA, due to the Team Leader identifying errors in the OTA financial accounting procedures.

106. As experienced by Team I enroute to Tokelau through Apia in Oct/Nov 85 no liaison whatsoever occurred between the Team and the LO OTA (Official Secretary). He claimed he was too busy with administering the travel details of visiting United Nations representatives to be concerned with the logistic arrangements necessary for the Team. No transport was provided by OTA for the carriage of personnel to the airport. A small OTA truck, however, did carry some of the baggage. It was also found that the Team were required to organise their own immigration processing at the airport, as this had not been done by OTA.

107. The RNZAF aircraft arrived Faleolo at 171520 Jul 86 and with excellent support by Apia Haulage Ltd, all the Team stores were loaded at 171815 Jul 86.

108. The Team left Faleolo by RNZAF C130 at 180900 Jul 86 arriving at Whenuapai at 191345 NZ.

Post Deployment Administration

109. The Op Tokelau Reef post-deployment administration period was 21-25 Jul 86. This period was allocated for:

a. The handing back of loan stores to owner units.

b. Submission of outstanding claims.

c. Application for leave.

110. All personnel less the Team Leader, were able to commence leave on 30 Jul 86.

Support from Outside Agencies

111. Officer for Tokelau Affairs, Apia. The support required of OTA was:

a. The supply of necessary POL, fresh food and minor stores ordered by the team in Tokelau on the monthly scheduled sailing of the cargo vessel.

b. The administration of:

(1) The transit of the Advance Party and Team I through Apia in Oct/Nov 85, including the allocation of suitable storage facilities for the Team stores and explosives, accommodation and transport services for the movement of the stores to Apia Wharf.

(2) The transit of Team I and Team II through Apia in Feb 86.

(3) The transit of Team II through Apia in Jul 86, including the arrangements stated in paragraph 111 b(1).

c. The allocation of an OTA representative to act as Team LO in Apia throughout the deployment.

112. It is firmly believed that the support provided by OTA throughout the deployment was totally inadequate and sub-standard to that expected by a team undertaking aid tasks to benefit Tokelau.

113. Ingersoll-Rand Ltd. The Drilling Equipment Sales Manager at Ingersoll-Rand Ltd was of great assistance to the Team. He provided excellent after sales service with the resupply of essential spares and devoted many long hours, working late with the Team Leader, during the pre-deployment administration in advising on the employment of the airtrac.

114. ICI (NZ) Ltd. Advice from the Explosives Technical Consultant ICI (NZ) Ltd was of considerable value to the Team Leader when establishing an initial blast pattern design (see Annex O) to determine the quantity of explosives required for the task.

115. RNZAF. See paragraph 477.

Support from Other Corps

116. RNZSigs. RNZSigs supplied one Radio Operator (Rad Op) for each Team. Additional to his RNZSigs prime role, see paragraph 408, the Rad Op was also the Team Medic, see paragraph 390. 1 Sig Sqn and 4 Sig Sqn, manned a seven-day-a-week rear link in Papakura Camp.

117. RNZEME. Each team included one RNZEME Vehicle Mechanic (VM) from 1 Fd Wksp. Excellent resupply of spare parts and advice was received by the Team from 1 Fd Wksp, through 1 Fd Sqn, throughout the deployment. VM role and tasks, see paragraph 418.

118. RNZCT. One cook (RNZCT) was provided by 6 Comp Sqn for each team, see paragraph 426.

119. RNZAMC. Although requested, no RNZAMC Medics were released for Op Tokelau Reef. Instead, extremely thorough training at Papakura Camp Hospital was provided for the Team Rad Ops. An excellent supply of medical stores, controlled and expendable, were issued to the Team, from the Hospital when it was found that Def Med stores had supplied an inadequate quantity and range. Sound advice was forwarded to the Team throughout the deployment when requested. See paragraph 390.

ATAFU REEF CNANNEL IMPROVEMENT TASK

Introduction

120. Task Specifications. The specifications for the necessary engineer works required to improve the Atafu Reef Channel are detailed in Reference A, Section A - Atafu (Blue Pages). These criteria were adhered to and are generalised as follows:

a. Widen the channel mouth on the left hand side (LHS)

b. Widen the channel mouth on the right hand side (RHS)

c. Widen the RHS of the inner channel.

d. Achieve a minimum depth of 1.2 m at low tide (LT-1.2 m) in the blast areas.

121. Resulting Improvements. The following is a detailed breakdown of channel improvements undertaken during Op Tokelau Reef, (see Appendices 1 and 2 to Annex H):

a. Widening of the LHS by 33.0 m, to a distance of 74.0 m from the seaward end of the LH rubble pile, on a magnetic bearing of 3650 m

b. Widening of the RHS by 16.0 m to a distance of 65.5 m from the seaward end of the RH rubble pile, on a magnetic bearing of 4780 m.

c. Removal of five large existing rocks on the RHS to a distance of 100.0 m from the seaward end of the RH rubble pile.

d. Widening of the inner channel on the RHS by 2.75 m for a distance of 35.0 m from the wharf.

e. Deepening of a majority of all blasted areas to LT-1.2 m, (the areas not completed to LT-1.2 m, were such that the locals could complete the work after the departure of the Team).

122. Initial Survey. The drawings compiled from the initial survey conducted during the Feb/Mar 85 reconnaissance should be referred to and compared with Appendices 1 to 6 to Annex H and Enclosure 1 to this report. It was found that very minimal preparatory type work had been conducted on the Atafu Reef Channel prior to the arrival of the Reef Blasting Team, and was of little change to the initial survey drawings at Annex I to Reference A.

Major Activities

123. The following are the major activities that occurred during the Atafu Reef Channel Improvement Task:

Ser	Date	Activity	Flow
(a)	(b)	(c)	(d)
1	110600 Nov 85	Team I ETA Atafu	
2	111930 Nov 85	Off-load of Team and cargo complete	
3	12-15 Nov 85	Unpack/establish store and house	
4	16 Nov 85	Construct 136.0 m of galvanised pipe in channel	16 Nov 85
5	19-22 Nov 85	Diving reconnaissance of channel mouth	Drill RH Shear line
6	22 Nov 85	Confirmatory 'Long Section' survey of LH and RH fingers	
7	231549 Nov 85	First test blast, 12 x 5 kg, Plaster Charges	
8	25 Nov 85	RH shear line complete	25 Nov 85
9	26 Nov 85	Commence handdrifting and blasting of rocks in inner channel	
10	30 Nov 85	Initial reconnaissance of ship-wreck from landward side	27 Nov 85 Drill LH Shear line 4 Dec 85
11	091500 Dec 85	First airtrac pattern blast = 119.0 kg	9 Dec 85 Pattern Blasting
12	120905 Dec 85	Airdrop from P3 (SWR/GS Stores/ Welfare)	
13	191038 Dec 85	Largest single pattern blast at Atafu including 3 x types of explosive = 341.0 kg	
14	24 Dec 85	Dec resupply ship	Expl Shiv
15	28 Dec 85	Confirmatory ship wreck reconnaissance from seaward side	WINCH
16	201120 Jan 86	Airdrop from P3 (1 x 106 radio complete/GS/Welfare	

Ser (a)	Date (b)	Activity (c)	Flow (d)
17	24 Jan 86	Jan resupply ship	
18	311700 Jan 86	Last pattern blast	31 Jan 86
19	031700 Feb 86	Airdrop from C130 (explosives)	
20	13 Feb 86	ETA Atafu Team II/Feb resupply ship. Ship to shore transport of local Tractor (PR task)	
21	16 Feb 86	ETD Atafu Team I(-) for RTNZ	
22	181603 Feb 86	Airdrop from P3 (Snatch block/ chain/GS/Welfare)	
23	18 Feb-8 Mar 86	Concentrated explosive clearance	
24	8 Mar 86	All Atafu explosive expended	8 Mar 86
25	19 Mar 86	Official handover of channel improvements to the Tokelau Administration and Atafu Council of Elders	15 Mar 86
26	21 Mar 86	Mar resupply ship. Load ship with GS Stores for anticipated ETD Atafu	
27	22 Mar 86	Compressor u/s therefore off-load ship of all stores	22 Mar 86
28	221700-121630 Mar 86	Return trip to Fakaofo to uplift Mar resupply items	
29	31 Mar 86	Disposal of Phosphorous Marine Markers	
30	2-15 Apr 86	Public Relations tasks at Hospital and Administration Office	
31	070843 Apr 86	Airdrop from C130 (essential compressor/mechanical spares/ welfare)	
32	131345 Apr 86	Airdrop from P3 (GS stores/ welfare)	15 Apr 86
33	16-22 Apr 86	Packing Team stores for anticipated ETD Atafu	23 Apr 86

Clearance Cleared Unserviceable Compressor Hand

Ser	Date	Activity	Flow
(a)	(b)	(c)	(d)
34	24-25 Apr 85	Apr resupply ship. Load all Team stores, equipment and explosives on ship	
35	251900 Apr 86	ETD Atafu Team II for Fakaofo	

124. Off-load of MV KALI. The off-load of MV KALI was conducted during 0600-1930 11 Nov 85. This involved the Team identifying two distinct priorities:

a. Priority I. Off load and transportation to Atafu of two essential, heavy engineer equipments. This required the employment of the 'assault boat raft'.

b. Priority II. Assist the locals in continuing the off load of Team general stores employing three x individual assault boats.

125. The off load necessitated a journey of about 500 m from ship to shore through 1.0 m swells. By 1330 hrs, the two Priority I moves were successfully completed and the Priority II moves commenced. Sea conditions at 0830-1100 hrs were ideal for the critical rafting moves that had very little tolerance for heavy seas. Subsequently, the Team were fortunate that MV KALI had a hold capacity such that it allowed for the off load of the assault boat raft as a complete unit. The two heavy loads were thus able to be off loaded whenever the Team decided the sea conditions were suitable. These critical heavy engineer items were:

a. Ingersoll-Rand LM-100 'Crawlair' airtrac drill rig, weight 2450 kg, and

b. Ingersoll-Rand P375 SD, 375 c/m compressor, weight 1920 kg.

126. Assault Boat Raft. For all relevant information on the assault boat raft:

a. Design. (See Appendix 1 to Annex I)

b. Load securing. (See Annex Y)

c. Accident precautions. (See Annex Y)

127. Stores, Equipment and Explosives. During the off load of Team stores, equipment and explosives, other than catering/domestic stores, were taken to the store the Team was to occupy overlooking the channel. The stock piling of cargo within the store required further sorting and a stock check was conducted during 12-15 Nov 85. It was discovered that reasonably large quantities of food, beverages, and clothing (such as sandals, gloves and overalls) were unaccounted for. It is believed that these stores were pilfered by MV KALI crew enroute to Atafu or during transit through Apia. A Team member was responsible for

ensuring all of Team cargo off loaded at the wharf went straight to the Team shed and then was secured under a further Team members direction. It is also believed that no stores were pilfered by the Atafu people during the off load. The catering and domestic type stores were moved directly to the Team's accommodation, by the RNZCT cook about 650 m from the channel.

Work Priorities

128. The priorities for commencing engineer works to improve the Atafu Reef Channel were:

a. Conduct confirmatory reconnaissances (both dry and under water).

b. Liaise with local elders for confirmation for desired improvements.

c. Identifying the 'Task Concept' and Area of Operations (AO).

d. Establish a work routine.

129. Conduct Confirmatory Reconnaissances. During the period 19-22 Nov 85, reconnaissances were conducted to confirm the information gained on the Feb/Mar 85 reconnaissance. Five under water diving reconnaissances were conducted and one reef top long section survey was undertaken to identify the slope of the RHS and LHS. These reconnaissances produced sufficient information to accurately plot the plan at Appendix 1 to Annex C and the cross sections at Annex J. Appendix 1 to Annex C also details the allocated nicknames given to various land marks and reference points.

130. As detailed in paragraphs 68 and 69 these confirmatory reconnaissances also determined the requirement for a great deal of additional work to be undertaken to ensure that the improvements constructed would achieve the specifications stated in Reference A.

131. Liaison with the Local Council of Elders (Toeaina). Discussions and meetings with the Toeaina were extremely important to ensure that the their wishes coincided with the Reef Blasting Teams anticipated work specifications. No problems were encountered as the Toeaina fully supported the Team's channel improvement recommendations. During these meetings, arrangements were also made for:

a. Daily local labour assistance from the local work force (Aumaga), see paragraph 216.

b. Provision of a daily cleaning woman at the Team's accommodation, see paragraphs 448.

132. Task Concept. The concept of the Atafu Reef Channel Improvement Task was then formulated. An AO was determined, (see Appendix 1 to Annex C), and approximate m^2/m^3 calculations were done on all areas now within the AO (see Appendix 2 to Annex C). The location of the various areas and their accessibility determined which machinery/tools would be employed for the drilling of borehole patterns (see Appendix 3 to Annex C). The 'Modus Operandi' was as follows:

a. Establish semi-permanent reference poles on the existing reef to mark the 'edge of excavation' (see Appendix 1 to Annex C). These 'poles' consisted of a jumping bar placed into a borehole with a 2.0 m length of galvanised pipe placed over the jumping bar, resting on the reef top, and spray painted for ease of recognition.

b. Construct 136 m of 50 mm diameter galvanised steel pipe line on the channel bottom for compressed air reticulation to the AO, see paragraph 138.

c. Hand clear a 2.5 m wide strip through the rubble on both sides of the channel edge to allow for easy access to and from the AO.

d. Drill a shear line on the right hand side (RHS) and left hand side (LHS) of the AO on the existing reef between the poles, see paragraph 147.

e. Conduct test blasts of the existing coral reef employing plaster charges and patterns of boreholes to determine the reaction of the coral rock, see paragraphs 142 and 149.

f. Drill borehole patterns using the airtrac and hand-drifters in the detailed areas of responsibility (see Appendix 3 to Annex C).

g. Lay explosive charges and detonate the borehole patterns.

h. Conduct the clearance of blasted areas employing explosives, the air winch, dragline bucket and hand clearance onto rubble piles and improvised rafts.

i. Conduct a cross-section survey of the completed channel tasks.

j. Formally hand over the completed Atafu Reef Channel Improvement Task from the NZ Army Reef Blasting Team to the Tokelau Administration and Atafu Toeaina (see Appendix 1 to Annex K).

k. Undertake minor Public Relations tasks when time allowed.

133. Work Routine. A work routine became established as the task commenced and was as follows:

a. Low Tide.

(1) Airtrac and handdrifter drilling borehole patterns as far forward as necessary/possible in accordance with future intentions.

(2) Laying of explosive charges in completed patterns.

(3) Explosive clearance of blast debris and rubble.

(4) Employment of the daily local labour assistance for the four hour shift on winch/raft/hand clearance of blast debris and rubble.

b. High Tide.

(1) Explosive clearance of blast debris and rubble.

(2) Winch clearance of blast debris and rubble.

(3) Underwater reconnaissances of future blast patterns.

(4) Charge make up.

(5) Maintenance of equipment and tools.

c. Completion of Daily Work. On completion of work daily, all tools and equipment were washed down in fresh water and sprayed with a rust preventative compound of CRC and oil, then submerged in oil baths overnight.

Borehole Pattern Drilling

134. Equipment. Three types of drilling equipment were employed on the Atafu Reef Channel improvement task and were as follows:

a. Self-propelled, pneumatic drill rig.

b. Man portable, pneumatic, hand held rock drills, (handdrifters).

c. Man portable, petrol driven, hand held rock drills, (Pionjars).

135. LM-100 'Crawlair' Airtrac Drill. The Ingersoll-Rand LM-100 'Crawlair' airtrac drill (airtrac) was the primary equipment used for the drilling of borehole blast patterns. It had the ability to drill 65 mm diameter boreholes to a depth of 15.0 m. The airtrac was 2450 kg in weight and was self-propelled on caterpiller tracks by pneumatic drive motors. The operation of all drilling functions was by hydraulic rams with a hydraulic pump powered by compressed air. The airtrac was a one man operation whilst drilling but required two personnel to ensure accurate positioning of the airtrac when commencing holes, particularly in heavy surf. For airtrac specifications, see Appendix 1 to Annex M to Reference A.

136. Pneumatic Hand-held Rock Drills. The two handdrifters were fully employed on minor drilling tasks during the deployment, such as:

a. The drilling of borehole patterns on outer areas of the AO with restricted access.

b. Drilling in totally submerged areas by divers using self-contained underwater breathing apparatus (SCUBA).

c. Secondary drilling of blast debris and boulders for 'rock popping' (see paragraph 158).

d. The drilling-in and placing of rock anchors (see paragraph 209).

The hand drifters had the ability to drill 58 mm diameter boreholes to a depth of 1.5 m. The operation of each drill was a one man task but regularly required

two personnel to assist in the placing and commencement of drilling a hole, to watch for large waves or as a 'buddy diver'. This additional driller was also necessary to ensure that there was a person in a position to assist in the event of one of the pair being swept off the reef and getting into difficulties in rips and, at times huge breakers.

137. Petrol Driven Portable Rock Drills. As a back-up drill for use in limited areas, two Pionjar rock drills were deployed as part of the Team equipment. These drills proved extremely useful when resources became stretched and although restricted to 'above water' work, were used on the following tasks:

a. Drilling-in and placing of rock anchors.

b. Compaction of backfill areas.

c. 'Breaking' of rubble into manageable sizes.

d. Grinding of tools using the grinding wheel accessory.

e. Drilling of small blast patterns in the area of the wharf.

138. Compressed Air Supply and Delivery. The one critical and essential item of equipment throughout the entire task was the P375 SD, four wheeled, portable air compressor. This diesel powered compressor weighed 1920 kg and provided 375 cubic feet of air/minute (375 cfm) at 100 psi (10.5 m^3/min at 1 kg/cm^3). Due to compressors having a very limited tolerance to changes in gradient whilst in operation, a static, level location had to be identified for it to work from. The airtrac was capable of towing the compressor as the compressor provided the air for the training motors. It was found that when having to 'man handle' the compressor, particularly over irregular coral or across the sandy beach, the four wheeled chassis was of considerable advantage over a two wheeled model. The compressor was permanently located in front of the Team store about 140 m from the nearest edge of the AO and about 245 m from the furtherest. 136 m of 50 mm galvanised pipe was constructed and delivered compressed air at negligible psi loss to the closest edge of the AO (in the vicinity of Poles II/III). The majority of the pipe line ran the length of the channel underwater and was secured to the channel bottom by OPH pickets and wire. The pipe line also travelled about 50 m across the reef top from the compressor to the wharf and incorporated one galvanised stand pipe at the wharf (No 1 stand pipe) and a rubber stand pipe half way along the channel (No 2 stand pipe). On the far end of the galvanised pipe was a delivery manifold, attached by rubber pipe, with one 50 mm and four 25 mm outlet taps. This was mounted above high tide level on either Pole II or Pole III. For compressed air pipe line design, see Appendix 1 to Annex L. For delivery manifold design, see Appendix 3 to Annex L. For compressor fuel consumption and hours,m see Appendix 1 to Annex M.

139. Procedure for Airtrac Employment. As shown in Appendix 1 to Annex L a sufficient volume of air at the correct pressure could be efficiently supplied to the closest edge of the AO to operate the airtrac; (from LM-100 specifications at Appendix 1 to Annex M to Reference A) the airtrac requires 425 cfm at 100 psi (12 m^3/min at 1 kg/cm^3), the task compressor was therefore underpowered by 50 cfm (1.5 m^3 /min). Three factors considered during pre-deployment administration in New Zealand that governed the compressor selection were:

a. The airtrac was capable of operating in every way at a reduced performance level using a 375 cfm compressor.

b. The assault boat raft capacity was limited to a maximum load of about 2500 kg (see Appendix 1 to Annex I).

c. A 425 cfm compressor was about $15000 more expensive than the 375 cfm compressor purchased.

140. It was found during drilling that the lack of required air only became evident when a soft coral layer was reached and the force of drill rotation was insufficient. This constantly caused the bit to become clogged and jam in the hole. Only one 65 mm button bit was lost due to jamming in the hole, this success was mainly due to the YD-90 drifter on the airtrac having 'independant rotation' (the force of rotation could be independantly adjusted in magnitude to the drilling force exerted on the drill steel). The daily procedure of moving the airtrac from the store, 140 m across the reef to the AO then to the store site was as follows:

a. Once the compressor was 'first paraded' and warmed up, and the pipe line 'blown out' to clear any overnight condensation, either two x 20 m lengths of 50 mm rubber reinforced bull hose (for (RHS) or three x 20 m lengths bull hose (for LHS) were connected between No 1 stand pipe and the airtrac.

b. As the airtrac moved, between 10-15 men were required to carry the bull hose to avoid excessive wear and snagging on sharp coral.

c. When the airtrac reached the limit of the bull hose length, it was disconnected from No 1 stand pipe and reconnected to No 2 stand pipe.

d. This procedure was repeated until the airtrac was working from bull hose connected to the delivery manifold.

e. As many lengths of bull hose as was required to enable the airtrac to work in the specific task area of the AO were then connected (up to four 20 m lengths from the manifold at Pole II or Pole III were required for the drilling of the outer reef area).

This twice daily procedure was both time consuming and labour intensive. It became necessary to move the airtrac as far forward as possible during high tide to ensure that no drilling time was lost during mid or low time. Problems were only encountered when the daily local labour shift finished work prior to the airtrac being forced in by high or rough seas. Modifications to the exhausting of all the air motors was conducted to allow safe operation of the airtrac, when the air motors were submerged, without the risk of any 'suck back' of water into the motors once they were not in use. Lengths of hydraulic hose were attached to the exhaust of each motor then collectively fixed to a vertical stand on the airtrac chassis. A 1.5 m length of galvanised pipe, on a bracket, provided the stand and gave a clearance of about 2.5 m above ground level for all exhaust air and excess oil to escape. The breathers for all motors were manifolded in the same way ensuring no water contaminated any oil or entered the main air motor housing. The noise level for the generator was also considerably lessened by the manifolding.

141. The airtrac was the primary borehole drilling equipment with Team I in Tokelau and was the only item capable of drilling 65 mm diameter boreholes. This became a key aspect of the task as 80% of all cartridge explosive taken to Tokelau was 55 mm diameter and required the additional 10 mm for easy insertion into the boreholes once the initiating detonating cord (det cord) was attached (see paragraph 160). Concern at not having a readily available back-up equipment on the Deployment was expressed by the Team and a request was made for the BMP-32 wagon-jack drill rig to be deployed with the Team from 25 ESS. This was refused due to work requirements for that equipment on the Argo Road during the 85 construction season occurring at the time of the Deployment. However, arrangements were made for the BMP-32 to be released for resupply to the Tokelau on a priority airdrop if deemed necessary by the Team Leader. This situation did not arise due to the excellent performance of the airtrac (see paragraph 213. a). At one stage, during Dec 85/Jan 86, the drilling output of the airtrac was found to be critical and was at that stage the factor that was determining the rate of blasting work. Night work was considered in some detail and plans were made for a 24 hour shift to be established working airtrac on the reef during all mid/low tides available for drilling. Ingersoll-Rand compressed air lights had been deployed with Team I and a frame was constructed to permit the mounting of two of these lights on the airtrac for operator safety and control. It was found that, just prior to the shift work commencing, the requested extension for work at Atafu until Mar 86 was agreed to and negated the requirement for night work.

Borehole Pattern Blasting

142. Preliminary Blast Design. A Preliminary Blast Design was completed in NZ during Jul/Aug 85 in consultation with Mr N.B. Adkins, Explosives Technical Consultant, ICI Ltd. This design was done to determine the range and quantity of explosives and accessories required for the anticipated tasks to be undertaken. The following assumptions were made during the preparation of the Preliminary Blast Designs:

a. That, because explosive calculations could not be determined in New Zealand for coral, the most similar rock calculations available would be for limestone and would therefore be used. This meant trialing the Preliminary Blast Design (see paragraph 149).

b. That the hard coral layers were competent and that the soft layers were 'mush' (see Annex N). This meant that Design provisions must be made to account for this situation if it arose (see paragraph 145).

c. That badly designed blasts will probably cause large cracks (back-break) in the coral surrounding the blast zone and that these cracks could travel for some considerable distance (see paragraph 146).

d. That in the soft coral layers, the holes may collapse once the drill is extracted (see paragraph 148).

143. Explosives Deployed. The Preliminary Blast Design is included in this report (see Annex O). It was known from the reconnaissance, that all the boreholes would be 'wet'. Therefore a waterproof explosive was required,

preferably manufactured as a cartridge, and with a resistance to humid temperatures to avoid 'weeping'. It was decided that 'MOLANITE' could be employed as borehole charges (55 mm diameter cartridges for airtrac holes and 29 mm diameter cartridges for handdrifter patterns) and that pre-mixed ANFO (AMEX) would be employed in rubble clearance. The following is a list of the explosives and accessories deployed with team I:

a.	'Molanite' 55 mm x 420 mm cartridge :		90x25 kg cases
b.	'Molanite' 29 mm x 300 mmcartridge :		20x25 kg cases
c.	'Amex'		80x25 kg bags
d.	'Red Cord' Detonating Cord		19x334 m rolls
e.	Detonators 'L' series:		
	(1) Delay No 0	100	
	(2) Delay No 1	50	
	(3) Delay No 2	50	
	(4) Delay No 3	50	
	(5) Delay No 4	50	
f.	Shot firing cable		8x100 m coils

NOTE: A further resupply of explosives and detonators was received ex-C130 airdrop on 4 Feb 86 (see Annex W). For quantities and the circumstances requiring further resupply see Appendices 12 and 17 to Annex B.

144. Current Leakage. Consideration was given to purchasing 'submarine' detonators due to the majority of blasting work being under or in close proximity to the sea. Current leakage from the connection of the detonator in the shot firing cable was considered as a possible problem in the expected work conditions but these detonators were far too expensive for the quantities required. It was decided that the purchase of 'Isobloc Connectors' (water-resistant electrical connectors) would also be too extravagent and that Detonating Relay Connectors (DRCs) would probably be more susceptible to current loss than the 'L' series delay detonators. Therefore every effort was made to ensure the detonators and connections remained above water level as much as possible. No misfires were encountered.

145. 'Deck Loading'. It will be seen in the Preliminary Blast Design, (see Annex O) that provision was made for 'deck loading' of the boreholes (loading the bottom of the borehole with about 2/3 the designed explosive quantity/hole, then stemming the hole and placing the remaining about 1/3 of the designed explosive quantity higher in the hole.) Annex O details the use of 29 mm MOLANITE cartridges as the deck loaded charge if situations occurred where the competent surface coral layer was extremely thin and the soft layer was deep ($\geq$ 1/2 depth of the borehole). It was found that there was no requirement on the entire task to deck load any of the boreholes as generally the soft layer was reached within the first 0.3 m - 0.4 m of drilling.

146. Shear Lines. It was also decided that, in the long term, the drilling of shear lines a few metres back from the edge of excavation and parallel to the blasts would be of benefit to counter any severe back-break (cracking) that may be caused as a result of blasting. This was believed to be particularly important during early blasting as the Preliminary Blast Design was trialed and adjusted as necessary. The shear lines were designed to intercept any cracks that may run across the reef through weak areas in the coral.

147. The shear lines were drilled on the LHS and RHS, and consisted of 65 mm holes at a spacing of 260 mm (4d) and depth of 2.0 m (blast hole depth + 1/3). The RHS shear line was 44.0 m long (170 holes) and LHS shear line 50.0 m in length (192 holes). The drilling of the shear lines was time consuming (see paragraph 123.) and appeared relatively unproductive. It was found that the pattern trials and the final adopted design did not create the anticipted back-break problems and would indicate that the blasts were well managed and sound. It is believed that the shear lines did assist in reducing ground vibration from large blasts.

148. Collapsing Boreholes. The possibility that the boreholes may collapse when drilled through soft coral layers as the drill was extracted was considered. The desired solution was to have PVC piping that could be cut to length and placed immediately into the borehole after drilling. No suitable PVC pipe could be obtained in NZ to allow for placing in 65 mm boreholes and the insertion of 55 mm explosive inside, ($\geq$ 55 mm internal diameter and $\leq$ 65 mm external diameter). The closest piping available was 72 mm external/65 mm internal or 60 mm external/53 mm internal, the Team selected 60 mm external diameter piping and employed it as 'Hole Retainers' (see paragraph 152) and in water supply (see paragraph 452).

149. Adopted Blast Design. After the trials of the Preliminary Blast Design (see Annex O) a blast design was established and became adopted. The following design was found to be the most efficient (kg of expl/m^3 coral) and effective for the size of rubble debris produced:

a. Borehole Blast Design for 65mm Diameter Bit (Airtrac) Borehole Depth = 1.5 m

Ser	Technical Term	Measure-ment	Description	Remarks
(a)	(b)	(c)	(d)	(e)
1	Bit dia (d)	65 mm	Borehole diameter	Button and 'X' design bits employed. Most successful was found to be the 'X' bit
2	Borehole depth (H)	1.5 m	Depth to be drilled	It is determined by task specifications and desired excavation depth results

Ser	Technical Term	Measure-ment	Description	Rem
(a)	(b)	(c)	(d)	
3	Burden (B)	1.0 m	Distance between holes perpendi-cular to face	Also mea face to
4	Spacing (S)	1.0 m	Distance between holes parallel to face	S must
5	Subgrade Drilling (S_d)	0.3 m	Additional depth drilled below design depth of borehole to account for soft or weak rock layers	Sd = 0. necessa bands o coral e base of All bor drilled
6	Final Stemming (F_s)	(0.7 m) best Fs found = 0.87 m	Depth of backfill of sand/drilling fines tamped on top of explosives in borehole	Fs ≈ B rock (c but gen = 0.7 B
7	Explosive Column (E_c)	0.63 m	Depth of borehole available for explosive load-ing	Ec = H = 1.5 m 0.63m= 55 mm M (1 x ca long).
8	Explosive/hole (M_c)	1.71 kg	Quantity of explosive in kg to be loaded into each borehole	1.71 kg carts 5 MOLANIT = 1.14
9	Rock Volume (V)	1.5 m^3 / hole	Volume of rock to be removed by each hole	V = H x = 1.5m
10	Rock Mass (R_m)	3000 kg/ hole	Weight of com-petent rock each hole was responsible for removing	Rm - Vx = 1.5m^3 2.0 kg Sg = Sp Gravity was not therefo limesto
11	Powder Factor (P_f)	1.14 kg/ m^3	Kg of explosive/ m^3 of bank rock	Pf = $\frac{Mc}{V}$

150. Delay Detonators. The above Borehole Blast Design was effectively employed using delay detonators to produce a 'throw' of the blasted rock in a predetermined direction or directions. The delay detonators used are stated in paragraph 143. The 'L' series detonators are 500 milli-second delay detonators with 3.6 m lead wires. The delays are numbered from '00' (detonate instantaneously), to '01' (detonate 500 milli-seconds after '00'), to '02' (detonate 500 milli-seconds after '01'), to '03' etc. These delays were employed in such a way as to allow the forward row of boreholes (closest to the face (to be detonated instantaneously (00), the row behind that to be detonated 500 milli-seconds later (01), the row behind that to detonate a further 500 milli-seconds later (02) and successively back to the rear row of the pattern. The delayed initiation of the borehole rows produced a 'throw' or movement of the rubble forward ensuring the new face was clear of debris. The lead wire length (3.6 m) allowed the detonators to be placed in numerous positions over water without running short of lead length to connect to the short firing cable. The use of delay detonators also reduced ground vibration during blasting and increased the fragmentation of the rock by creating 'mid-air' collisions of debris.

151. Firing on more than one Face. Advantageous situations arose where the blast zone extended from one free face (existing rock edge) to another and allowed for the pattern to be drilled between the two. This situation arose mainly on the reef edge fingers (see Appendix 1 to Annex C - Ladder Rock, Tunnel Rock and LH Outcrop). The calculated use of delays enabled the blasted rubble, on initiation, to move towards both faces therefore achieving a more effective dispersal of the debris (see diagram at Appendix 3 to Annex P).

152. Infill of Fines. A real problem did occur with the infilling of boreholes with fines from reef top debris mainly caused by previous blasting which was washed into the boreholes by the reef top rip during the change of the tides. The 65 mm diameter boreholes were drilled by the aitrac and problems were found in attempting to clear these holes. Due to it not being 'hand held', the airtrac had to be positioned in exactly the same position. This of course was impractical and an expedient 'hole retainer' was manufactured. These were sections of PVC pipe cut to 400 mm in length with an external diameter of 60 mm. A lug ring was glued around the centre of the retainer to ensure, when being inserted into a borehole, it was not pushed too far down. Generally about 200 mm of the retainer stood proud to the reef top. The end of the retainer was bevelled to allow for easy insertion into a borehole and a cordage handle was attached through holes drilled in the retainer (see diagram at Appendix 5 to Annex P). At times, these retainers 'bedded in' to the hole and required some force to be removed when commencing the laying of explosives in the pattern. In the most cases, two men and a jumping bar were able to remove awkward retainers. Several instances occurred where reef top rubble was washed out to sea in rough conditions across drilled patterns and resulting in the 'shearing off' of hole retainers about reef top level. Due to the retainers having an internal diameter of 53 mm (too small for the loading of 55 mm MOLANITE and det cord through the retainer), these broken pipes had to be further drilled out by handdrifters.

153. It was found that boreholes, overnight, could fill up with fines to within 0.1 m of the reef top if the PVC hole retainers were not inserted. The expected infill of boreholes with hole retainers emplaced was about 0.25 m over two days. When laying the pattern with explosives, it was standard practice to employ one or two hand drifters (depending on pattern size) ahead of the laying party, to clear the boreholes by 'blowing' the fines out after the hole retainers had been removed (see paragraph 177 for laying procedure).

154. Drilling Rules. During the task, blast results were constantly analysed to perfect rock fragmentation, rock 'movement' and uniformity of the new face. Subsequently some very important Drilling Rules were established and adhered to. These were:

a. Establish the length of the pattern to be drilled (parallel to the face) and identify the line of the first row closest to the face.

b. Coral tended to shear at the rear row at about 40° angle leaving a sloping face. This sloping face realistically increased B by up to 75% therefore it became standard practice to drill the first row as close to the top of the face edge as possble.

c. Drill in the first row (this gave an accurate base line to take all successive hole measurements from).

d. As the seas permitted, investigate the slope of the face and drill additional 'IOE' holes (Irregular Outer Edge) forward of the first row, (this accounted for rocky outcrops on a non-uniform face and any slope encountered). At times isolated existing rocks forward of the free face were required to be drilled as IOE (see Appendix 1 to Annex C - LH Outcrop). The drilling of the IOE was commonly termed 'Include All Relevant Rock'.

e. Ensure that the drilling of consecutive rows behind the first row, until the blast width was drilled (perpendicular to the face), is accurate. Accuracy was of extreme importance and the drilled boreholes must have H, B and S equalling that of the design (see paragraph 149 Serials 2, 3 and 4). If the pattern was not drilled to the exact specifications of the design and then loaded and fired, all sorts of rubble problems would most certainly have resulted creating a huge clearance problem. The term 'Go for Real Estate' was commonly used when referring to the need for borehole spacings to be accurate, and to ensure that the entire area proposed for blasting, was drilled and included in the pattern. See Appendices 1 and 2 to Annex P for illustrations.

155. It is firmly believed that the following would occur if the above Drilling Rules were not adhered to:

a. If the pattern is not accurately drilled, there will be a non-uniform distribution of explosive/m^3 coral rock and will result in poor rock fragmentation and large rocks in the blast zone requiring further secondary explosive clearance.

b. Inaccurate pattern drilling would also cause problems in managing the delay sequence of borehole rows and would not achieve an effective movement of rock that could be anticipated if drilled correctly.

c. Borehole rows that are not drilled straight and parallel to the first row (see paragraph 154 a) will create an uneven and irregular face thus requiring extensive IOE drilling for the next pattern, leaving an irregular and sloping face (see Appendix 2 to Annex P).

d. Non-parallel borehole rows also contribute to producing unwanted back-break problems due to having greater than the designed explosive/m^3 rock in any one area of the blast zone (this is particularly evident when the two rear rows are not parallel).

Refer to diagram of blast pattern layout at Appendix 3 to Annex P.

156. Handdrifter Employment. On the Atafu task handdrifters were employed in a minor role in drilling blast patterns in areas inaccessible to the airtrac (see Appendix 3 to Annex C). As such, no detailed blast design was done for handdrifter borehole patterns. The reasons for this were:

a. Generally, the handdrifter AOs were existing narrow, irregular rocks or rocky outcrops that didn't allow for detailed patterns to be laid out.

b. Coral composition varied greatly on isolated rock areas on the outer reef area.

c. The rocks and outcrops were such that the blasted rubble was not restricted by a limited area for debris dispersal (see Appendix 1 to Annex C - Huey, Duey and Luey).

157. The most common handdrifter drilled boreholes for delay blasting were 1.2 m deep and 0.8 m apart using 41 mm 'X' design bits. The largest handdrifter borehole pattern was 40 x 1.2 m boreholes, 0.9 m spacing. The most common employment of the handdrifters was on borehole drilling in boulders for secondary explosive clearance of debris (commonly termed 'Rock Popping').

158. 'Rock Popping'. Handdrifters were employed for a majority of the task on secondary explosive clearance of previous blast debris. Rock popping was a task that involved the drilling of boreholes in large rubble rocks to varying depths. A 41 mm diameter borehole was used to allow the loading of the holes with 29 mm MOLANITE cartridges in all rock popping tasks. The borehole depth varied with the size of boulder to be drilled, but was generally $\geq$ 0.5 m, $\leq$ 1.0 m. The number of boreholes required varied greatly with the shape of the boulder, but generally for a boulder of about 1 m^3 three 41 mm diameter boreholes were drilled (this gave a Pf of 0.57 kg/m when each of the three holes were loaded with one 29 mm MOLANITE cartridge of 0.19 kg each). 0.5 x 29 mm MOLANITE cartridges were also employed on rock popping tasks as the m^3 of a rock or any fracturing from previous blasting dictated. Rock popping proved to be a constructive task that could be conducted during low or high tide, at times by divers on SCUBA equipment. Rock popping could also be conducted concurrently with major airtrac pattern drilling occurring in other areas. Secondary explosive clearance of large debris in this way was successful in breaking down non-manageable rocks into sizes capable of being winched (see paragraph 184) or hand cleared (see paragraph 197).

159. Coral Structure. The coral structure greatly influenced:

a. The size of blast patterns.

b. Type of loading (see Deckloading, paragraph 145). and

c. Anticipated blast debris dispersal. The coral layering was not consistant and often varied greatly even on an average sized

pattern (about 62 m^2 see paragraph 215). Annex N diagramatically illustrates the most common coral layering encountered. The soft, kilikili layers varied between being a coarse, brittle conglomorate of sand and gravel $\leq$ 200 mm in diameter to an extremely fine 'mudstone type' of rock that, once drilled, turned into a thick 'paste'. These weak kilikili layers of coral caused constant concern about the effect of the explosive on facturing the competant firm coral layers. At times a large percentage of explosive energy was believed to have dissipated through the kilikili layers and subsequently the rock fragmentation results were not as good as expected. The Adopted Blast Design (see paragraph 149) was such that generally any explosive energy lost through weak layers proved to be negligible and did not affect the resulting fragmentation.

160. Charge Make-up. The two major explosive charges employed on this task were:

a. Borehole cartridge charges.

b. Ammonium Nitrate Fuel Oil (ANFO) bulk charges.

'MOLANITE' 55 mm and 29 mm cartridges were the borehole charges (55 mm MOL for 65 mm diameter airtrac-drilled boreholes and 29 mm MOL for rock popping and handdrifter-drilled boreholes). The ANFO explosive used was AMEX (a pre-mixed Nitropril explosive) and was employed as bulk 10 kg charges in face clearance (see Appendix 2 to Annex P) and on secondary, explosive, debris clearance (see paragraph 182). Explosive primers, such as ANZOMEX, were not used. The detonating cord (Red Cord) in close contact with a MOLANITE cartridge was suffice to initiate a charge (see diagram Appendix 1 to Annex Q). 'Down-the-Hole' initiation of charges (detonator inserted into charge at bottom of borehole) was not considered as feasible for the following reasons:

a. 'L' series detonators were not water-proof.

b. Excessive current loss could be expected at all lead wire connections due to these being underwater.

c. Short duration low tides often meant that 'tying-on' after the charges were 'loaded' and 'stemmed' (see paragraph 178) was often conducted in rough conditions. The tying of a clove hitch and taping the Red Cord riser onto the line main (see Appendix 2 to Annex Q) was far quicker and more simple than attempting to 'twitch' lead wires together.

d. This method would require an excessive amount of detonators (one x det/charge). These quantities were not available to the Team.

161. 'MOLANITE'. MOLANITE is a relatively modern explosive (since about 1978) and is an extremely water-resistant, non-toxic, water-gel, slurry explosive (for specifications see Appendix 1, 2 and 3 to Annex L to Reference A). MOLANITE was easy to cut (for 0.5 cart 55 mm MOL charges for airtrac patterns) which left a 'soggy end'. The initiating charge (the cartridge attached to the Red Cord) was inserted into the borehole first by lowering it on pre-cut riser lengths of Red Cord (see paragraph 173 for varying red cord lengths). The

0.5 cartridge - soggy-end first - was then pushed down the borehole to 'slump' on top of the initiator. A tamping stick (shovel handle) was employed to ensure that both charges were firmly placed at the bottom of the borehole by applying a small amount of force. This practice proved beneficial when the bottom of some boreholes were 'blown out' in a soft coral layer caused by the compressed air blown through the drill bit. This resulted in a cavern at the bottom of the borehole and it was found, after an amount of experience, that charges could be 'manipulated' to fill the cavern using the tamping stick. The borehole was then stemmed as with any other borehole. The clove hitch was an excellent knot for tying the Red Cord to a charge, and ensuring it is tight and taped well, including the spare end, the charge will not snag going down the borehole. The Red Cord is pulled tight after tying the close hitch at the bottom and a half hitch at the top secures the red cord. Firm taping is required to ensure close contact with the explosive half hitches and at the places along the length of the charge. Further security was added by 'frapping' (winding) the red cord around the charge between the clove hitch and half hitch (see Appendix 1 to Annex Q).

162. Bundles of 55 mm and 29 mm MOLANITE cartridges were also employed as a clearance explosive, with only limited success. Towards the completion of the Atafu Reef Channel improvement task, the Team had become critically short of AMEX and employed excess cartridge explosive for the dispersal of fines. The bundles of MOLANITE varied in size from seven 55 mm cartridges (for boulder clearance about 7.89 kg/bundle) to five (for fines dispersal about 5.7 kg/bundle), initiated by Red Cord and taped firmly together (see Appendix 3 to Annex Q). 29 mm bundles were constructed in the same manner and consisted of 12 cartridges (about 2.28 kg/bundle) employed only on fines dispersal. A pattern was not established for the laying of cartridge bundles due to the desired effect being to retreat a blast face of fines through the debris using single line necklaces of charges parallel to the channel centre line buried in about 300 mm deep holes. It was found that the MOLANITE explosives rapid rate of detonation was too fast, as compared with the slower AMEX, to significantly disperse debris fines.

163. 29 mm MOLANITE was initiated by Red Cord in the same way as 55 mm cartridges. 29 mm cartridges were used as rock popping charges, handdrifter borehole charges and as primers for AMEX charges.

a. Rock Popping charges, generally one 29 mm MOLANITE cartridge/hole was successfully employed, at times 0.5 cartridge were used when the rock was severely fractured from previous blasting or the rock m^3 did not warrant a whole cartridge.

b. In handdrifter borehole blasts, drilled with a 44 mm bit, these were generally $\leq$ 25 boreholes about 1.2 m deep and 0.9 m spacing. Explosive loading was three 29 mm MOLANITE cartridges loaded one on a top of the other, (of which the bottom cartridge was the initiator - see Appendix 1 to Annex Q). Results although acceptable, generally indicated that if the handdrifters were to be employed on the drilling major pattern blasts, an accurage design would be required, as was done for the airtrac. It is believed that spacing and burden should be decreased by about 50%.

c. 29 mm cartridges were also effectively employed on borehole blasting in areas close to existing structures and/or in close proximity to the firing point. Inner channel widening was

conducted on the RHS from the wharf to a distance of 35.0 mm up the channel. Various methods were trialed at blasting this narrow and restricted area (≤ 2.75 m wide). The aim was to 'peel' a strip of coral rock off and into the channel for subsequent winching without fracturing this into small rubble. The most successful method was:

(1) Drill a shearline where the distance back from boreholes = B of borehole row(s), at hole spacing of 4d = 164 mm and unloaded. This controlled any undesirable back-break.

(2) Borehole row (maximum required was to rows) drilled to about 0.75 m deep and B = 0.5 - 0.9 m, S = 0.75 m and loaded with 0.5 29 mm cartridge/hole. Each charge was made up as an initiator with the Red Cord 'frapped' (wound around) the cartridge and taped due to lack of explosive length to tie a clove hitch (see Appendix 1 to Annex Q).

(3) Delay detonators were employed using a 1000 milli-second delay for two rows (see Appendix 4 to Annex P).

This method proved successful in producing rubble about 0.75 m the 'peeling' effect was relatively easy to produce due to the majority of the channel sides having very porous soft coral layers eroded by rising and falling tides.

d. Primers for AMEX charges were one 29 mm cartridge/10 kg charge. The primer was made up as an initiator and placed in the centre of the AMEX charge (see paragraph 165).

164. 'AMEX'. The bulk clearance explosive employed was AMEX and proved to be a very effective explosive for:

a. Clearance of large blast debris (boulders).

b. Dispersion of accumulated fines.

c. Irregular blast face clearance (incorporated with pattern blasts).

165. AMEX was extremely useful and simple to employ in, generally, difficult and uncomfortable conditions. Several methods of charge make up were trialed, the most successful being:

a. 5 kg AMEX into a double skin plastic bag and taped for water-tightness (twice), 29 mm MOLANITE cartridge (primer) between the two 5 kg charges and the two 5 kg bags taped together to ensure the primer is not dislodged, 10 kg 'bundle' into a 'nitropril' bag and firmly taped, a second 'nitropril' bag (outer) had three GS shovel loads of sieved sand in the bottom then the 10 kg charge and a further three GS shovel loads of sieved sand on top with the Red Cord from the primer pushed through the side of the bag, the top of the outer nitropril bag was then rolled and stitched using a locally manufactured (improvised by Team using available resources) bailing needle and twine. A further modification was to tie the ends of the rolled and sewn bag top to meet and form a handle, (see Appendix 4 to Annex Q).

166. The clearance of large blast debris was the role in which AMEX was constantly employed. A single 10 kg charge was sufficient to dispose of a boulder about 1.0 m^3. The explosive was always placed on the landward side of the boulder to increase the chance of debris being thrown towards the sea and to decrease the possibility of fly rock landing around the firing point or village. Where possible, all charges were attempted to be 'dug in' under the rock (up to ½ of the charge length) to utilise a percentage of the upward explosive force, which is generally lost to the surface. Charges were randomly placed where the debris dictated in a given area.

167. AMEX was extensively used in dispersing accumulated and/or small diameter fines that were awkward to hand clear. This involved the laying of charges in such a way as to produce predetermined results. These results were calculated using known blast crater dimensions when well tamped with sandbags in coral fines (see Appendix 5 to Annex Q). The layout of charges shown at Appendix 4 to Annex Q was adhered to (10 kg charges at 1.75 m spacings) to ensure that known results would be achieved, (1.5 m deep crater). Generally, 'necklaces' (a line of charges) were laid, two at any one time, consisting of up to 20 x 10 kg AMEX charges in total. The charge limit restrictions were imposed by the length of time available to lay, tamp and tie-on the charges. The necklaces of charges required accurate placing and demanded some form of excavation or burying of the explosive in the fines. It was discovered that it was extremely difficult to excavate the desired depth hole for the charge of about 500 mm due to the accute angle of repose of coral fines and the constant rip out to sea continually back-filling any holes. Most charges were able to be placed in about 300 mm - 350 mm holes.

168. When situations from previous blasting resulted in the face being scattered with large blast debris unable to be winched (see paragraph 187) AMEX charges were effectively face clearance. Up to seven or eight 10 kg charges were randomly placed, where necessary, around large debris in front of the face, (see Appendix 2 to Annex P). The AMEX charges were considered as vital to clear the debris prior to the delayed pattern blast being initiated, allowing unimpeded rock movement across the face/debris area. The clearance charges were incorporated in the pattern blast delay sequence and were initiated instantaneously ('00' det) ahead of the IOE row ('01' det) of borehole charges.

169. The charge make-up ensured that once under water it had sufficient negative buoyancy to remain in the position in which it was laid (in calm to moderate seas). If the charges had to be laid in rough sea conditions (as was generally the case due to the rubble causing the sea to be turbulent) up to four sandbags of sieved sand were required to tamp the charges and anchor them in position. It was found that to add further sand inside the nitropril bag rendered them too heavy for a one man carry across the reef to the blast zone (up to 130 m) and virtually impossible for the movement of the charges around the blast zone underwater due to the increased weight once the sand became wet. Generally, whenever AMEX was laid, the potential blast zone was a random heap of exceptionally jagged rocks with razor sharp corners and edges, which was predominately submerged with breaking waves and, at times, an unworkable rip. It was also accepted by those personnel conducting the laying of AMEX charges, that they would sustain numerous cuts and grazes during the conduct.

170. It was found that, due to the type of conditions expected for AMEX laying, SCUBA equipment was not feasible due to its bulkiness, potential for snagging and the reduced manoeuvrability for divers. Those personnel laying AMEX charges were always qualified Army divers and used only snorkels and face masks.

171. Only sieved sand was used as charge weights and tamping to achieve the maximum increase in weight once wet and to ensure that any potential fly rock was kept to a minimum. Rocks were rolled around (not on top of) the placed AMEX charge when necessary to increase the stability of the charge in rough conditions. The employment of AMEX was conducted between depths of 0.05m - 4.0 m. Caution was exercised in the use of AMEX due to its ability to 'powder' large rocks into fines. This powder at times created further debris removal problems (see paragraph 190).

172. 'Red Cord'. The detonating cord used throughout the task was Red Cord. This proved to be an effective detonating cord which had a high tensile strength and was extremely water-resistant. Clove hitches, when tying-on, were easily tied and remain tight once taped. The bright red colour of the outer plastic coating of Red Cord was of great assistance when underwater visibility was reduced due to breaking waves or silt. It was also easily identified against the brilliant white of newly blasted coral rock.

173. Lengths of Red Cord to be used as charge risers (Red Cord from the charge to be tied on to the line main) were pre-cut to specified lengths during the make up of the various charges. Known lengths of Red Cord used were:

a. For 55 mm MOLANITE initiator:

(1) to be used in a 1.5 m borehole
Red Cord length = 1.9 m

(2) to be used in a bundle charge
Red Cord length = 1.7 m

b. For 29 mm MOLANITE initiator:

(1) to be used as rock popping
Red Cord length = 1.3 m

(2) to be used as a primer for AMEX
Red Cord length = 1.5 m

(3) to be used on channel edge trimming
Red Cord length = 1.2 m

(4) to be used in a bundle charge
Red Cord length = 1.5 m

(NOTE: All Red Cord lengths include about 200 mm for tying-on to initiator and about 150 mm for tying-on to line main).

174. Stemming or Boreholes. It was known that to achieve successful blast results with borehole charges, the charge must be well tamped in the base of the borehole and that any air voids around the charge must be prevented. The method employed, to ensure that the stemming (back-fill of fines in a borehole on top of a layed explosive charge) was done effectively and efficiently, was one that used 'locally manufactured' funnels and tamping sticks. It was found, at worst, stemming would be undertaken on a borehole pattern in 0.75 m of water (plus surge and waves) and that, at best, water covering the reef would be as low as <0.1 m. The problem to overcome was in efficiently pouring the stemming

into the borehole without excessive wastage of the stemming material or time/hole. The stemming material used should be angular and generally the best and most readily available source of stemming in a quarry is the drill tailings from a drilled hole. On this task, it was impossible to retrieve any of the drill tailings due to any fines that were blown out of the hole, whilst drilling, being carried away by the constant surge of the sea. An area of coarse coral sand was found on the beach and exploited for stemming material, this sand was also sieved through 'grizzly' (consisting of window security mesh and ½ 44 gallon drum) which produced material up to 0.01 m diameter. At times this was found to be too large and so a second screen was added and provided $\leq$0.005 m diameter fines. The need for the smaller diameter fines arose from 0.01 m material often jamming in the funnel.

175. The funnel constructed for the stemming of 65 mm boreholes was made of PVC pipe (external diameter = 60 mm) with a box shaped tin scoop on top for loading the stemming into. A lug ring was glued around the pipe to avoid it being pushed too far into a borehole and a slot was cut from the end of the pipe up and through the lug ring to ensure the Red Cord from the charge to remain undamaged during the stemming. The end of the pipe was bevelled to allow for easy insertion into a borehole (see Appendix 1 to Annex R). Once the stemming funnel was correctly placed into a borehole, a shovel handle (LHRM) was then used down the centre of the funnel to tamp (compact) the sand as it was poured into the scoop, water was added to the scoop to increase the 'flow' of the sand into the borehole. The desired tamping of the stemming was eight layers of about 100 mm (fs = 0.87 m), however, this was extremely difficult to achieve particularly during rough sea conditions when the stemming teams were often 'washed off' the equipment by large waves. The accepted 'wash out' of stemming from stemmed boreholes was generally about 60 mm caused by the reef top rip (see Appendix 2 to Annex R).

176. For the stemming of 41 mm boreholes (handdrifter), another type of funnel was constructed. A damaged fuel funnel about 200 mm diameter was attached to the end of an odd section of grey PVC pipe, (found around the local area), that had an external diameter of 35 mm. The same lug ring and Red Cord slot were also added. The tamping stick used was a broom handle about 25 mm diameter. All other techniques explained above (paragraph 175) were adopted for the stemming of handdrifter drilled boreholes. In extremely difficult and awkward situations (primarily rock popping well forward in the AO or patterns on very irregular/isolated rocks or rocky outcrops in the surf zone), it was found that to attempt to stem laid boreholes with sand was impossible. An expedient method was employed to stem holes, only when it was absolutely necessry. "Rags Old' were forced into the 41 mm diameter holes, up to four pre-cut rags old (about 120 mm x 120 mm) were jammed into the borehole using the tamping stick. This procedure did not produce the most desirable results, but was the only possible method of stemming laid borehole charges in these types of awkward situations. Damage that rendered either type of funnel unserviceable was, when in a borehole, it was sheared off at the lug ring by rough seas.

177. Blast Pattern Laying Procedure. The loading, stemming, tying-on and firing of blast patterns (including AMEX clearance charges, rock popping and handdrifter blast patterns) was established during the trialing of the initial 65 mm borehole pattern blasts. The following procedure details that that was adopted for the laying of 65 mm blast patterns (which incorporated about 80% of all existing rock blasting involved on the Atafu Reef Channel Improvement Task). The procedure involved:

a. Establishing a forward explosives dump on the reef in close proximity to the blast zone.

b. Removal of PVC hole retainers and the clearance of the accumulated infill of fines with handdrifters.

c. Loading the cartridge(s) of explosive into the boreholes and ensuring the explosive is firmly seated at the base of the borehole.

d. Stemming/tamping the boreholes.

e. Laying out the line main(s) and tying-on of the Red Cord risers, including the taping of the Red Cord spare ends,

f. Laying out the shot firing cable, testing for continuity/discontinuity and checking the detonator(s) for serviceability.

g. Taping-on and connecting of delay detonator(s) to line main(s) and shot firing cable.

178. The manning and equipment employed during the laying of an 'average sized' blast pattern (see paragraph 215b for definition) was:

a. Forward Explosives Dump.

(1) Manning 1 x Team Member
1 x local

(2) Equipment - All necessary pre-made explosive charges required for proposed blast including 10% spares for any charges that may be/become unserviceable, stock pile of sandbags of sieved stemming sand, all necessary accessories including exploder and key, tape, Red Cord, knives, spare tamping sticks, galvanometer etc.

b. Hole Retainer Removal/Borehole Clearance.

(1) Manning - 2 x Team members
- 2 x locals

(2) Equipment - 2 x Handdrifters
(c/w steels, bits, necessary lengths of air hose, airline lubricators)

c. Explosive Loading.

(1) Manning - 1 x Team Member (Team Leader)
- 2 x locals

(2) Equipment 1 x tamping stick, 2 x sandbags
(one with each of the locals, generally one bag = initiators, other bag = 0.5 cartridges, carried forward from explosive dump).

d. Stemming/Tamping.

(1) Manning - 2 x Stemming Teams, each =
1x Team Member
1 x Locals

Total = 2 x Team Members)
= 4 x Locals

(2) Equipment - (each Stemming Team) member 1 x Stemming funnel (held by Local)
1 x water scoop
1 x sandbag of sieved stemming sand with 1 x local) - general usage rate of stemming material
= about 1 x sandbag/5 x boreholes.

(NOTE: Team Member of each team must have a face mask to ensure that the funnel is seated correctly in the borehole and not causing any damage to the Red Cord, see Appendix 2 to Annex R).
(Total = double the above for 2 x teams)

e. Laying Line Mains, Tying-on Charges and Taping Spare Ends.

(1) Manning - 1 x Team Member (Team Leader after paragraph 178 complete) lay out line main and tie on all Red Cord risers from boreholes.

- 3 x Team Members (2 x pers after paragraph 178d complete,
1 x per after paragraph 178b complete) and 2 x locals to tape all clove hitches on line main, frapping and taping all spare ends of Red Cord risers.

(2) Equipment - Insulation Tape

f. Laying Shot Firing Cable, testing and Checking Delay Detonators, Test Exploder.

(1) Manning - 1 Team Member (after paragraph 178b. complete.
1 x Local

(2) Equipment - Galvanometer tester
- Nissan 50 Exploder
- Short length of galvanized pipe in which to test the detonator(s).

g. Taping-on and Connecting of Delay Detonators

(1) Manning - 2 x Team Members (to include Team Leader after paragraph 178e complete, other after paragraph 178a complete.

(2) Equipment - All necessary delay detonators and insulation tape.

179. The above procedure is a good guideline for understanding the methods employed on the laying of the various other explosive tasks. All other explosive lays were less complex and less manpower intensive. The laying of AMEX clearance charges was always conducted by the Teams' divers. It will be noticed that, at anyone time throughout the laying procedure in paragraph 178 a. maximum of only six of the eight Team Members are employed. Generally, one Team Member was employed on supervising concurrent local labour in other areas of the channel and at least one Team Member was on 'shore duty' (out of the water due to infected coral cuts etc).

180. At times, when laying in exceptionally rough sea conditions or during restricted low tides, the need arose for the laying out of the line mains and tying-on of borehole charges to commence prior to the completion of the loading and stemming. This was not a desirable procedure as it meant that the line mains were subject to damage as men and equipment were washed across the blast zone.

181. Prior to any laying commencing, O Groups were conducted and included all of the personnel involved (Team Members and locals). The O Group was used to detail specific tasks, identifying priorities (if necessary) and re-emphasise important safety points. It was found to be most advantageous to have all involved personnel including locals issued with a mask and snorkel.

Clearance of Blast Rubble

182. The clearance of blast rubble was the most time consuming, manpower intensive and unrewarding work throughout the task. Various methods were employed for rubble clearance, there were:

a. Winching:

(1) Large rocks.

(2) Dragline bucket.

b. Hand clearance, employing:

(1) Sandbags and shovels (fines).

(2) Improvised rafts (hand-liftable rocks).

c. Rock breakers.

d. Secondary explosive clearance, employing:

(1) AMEX.

(2) Rock popping.

183. D6U Air Winch. The winch purchased for Op Tokelau Reef was an Ingersoll-Rand D6U air winch. The winch specifications are at Appendix 1 to Annex S and show that it was man portable, due to its relatively light weight (125 kg), easily bolted to an anchored winch base plate and had the capacity of employing Steel Wire Rope (SWR) of a reasonable length (109 m). The line pull

capacity (m^3 rock) was found to be considerably less than that desired during the task. Numerous winching configurations were employed (see Appendices 4 and 15 to Annex C). These incorporated blocks anchored to the reef by rock anchors (Split Sets', see Appendix 2 to Annex S) to either increase the mechanical advantage of the line pull or to pull the rock in a direction other than directly towards the winch position.

184. Two winch positions were established for the task, one being on the concrete wharf for use of the dragline bucket, the other 70 m from the wharf on top of the LHS rubble pile above the high tide mark for the removal of large rocks. The winch was not water-proof and therefore required to be out of the splash zone of changing tides (protection against rain was overcome using tarpaulins). The winch anchorage on the LHS rubble pile included:

a. Construction of a rubble mound about 1.5 m above the existing level of the rubble pile, using 300mm x 300mm x 300mm rocks and then sand-bagging (the mound was specifically constructed on top of a very large rock about 10 m^3 for rock anchors to be drilled into).

b. The section of Class 30 Trackway, that the winch was mounted to, was then anchored with four rock anchors through the trackway into the large buried rock (all about 2.0 m long) and by four rock anchors into rocks forward of each corner of the trackway at original rubble level, then secured to the trackway by tensioned SWR strops (the rear SWR strops about 6.0 m long, were tensioned by mounting the winch on the trackway, securing the winch rope about 10 m forward of the mound, connecting the SWR to the trackway then winding-in on the winch. This pulled the trackway forward until the strops were at their maximum tension, the four 2.0 m rock anchors were then emplaced, the two forward anchors at 90° to the direction of pull with the rear ones at 60°. The forward SWR strops were tensioned by hand and were designed to prevent any lateral movement of the anchorage. See diagrams at Appendix 3 to Annex S.

The anchorage construction proved sound and valuable in permitting the winch to work well forward near the AO and therefore decreased any mechanical advantage lost due to the distance of the winch to the AO and increased efficiency of control between the winch operator and those personnel on the work site. This position allowed for the winch to be employed during all tides and remain in situ from day to day.

185. The alternate winch position, on the concrete wharf, was simple to establish but was rarely used. The anchorage consisted of a steel base plate with pre-cut holes in it; one in each corner for the anchoring of the plate by Split Set rock anchors (see paragraph 209) and four holes in the centre of the plate for the insertion of the winch mounting bolts with the nuts spot welded on the under-side. This winch plate remained on the wharf and allowed for the winch to be moved to the forward site then easily relocated with four bolts back on the wharf when necessary (see Appendix 4 to Annex S). The anchorage was designed for the employment of the winch and a dragline bucket to clear the existing channel of infilled fines. No large rocks were ever pulled from this position (see Appendix 1 to Annex H and Appendix 4 to Annex S).

186. Winching Large Rocks. The winch proved an essential piece of equipment for the removal of blast debris in a whole state. The obvious advantage of removing, in a whole state, a large piece of rubble from the blast zone, was evident and avoided time consuming 'double' or 'triple' handling of debris with explosives or other means until satisfactorily disposed of. The Atafu locals had no secondary use for the large rocks and were more in favour of destroying them with explosives. However, some effective winch configurations from the LHS rubble pile position were employed and allowed for debris to be pulled out to deep sea and up onto the LHS rubble pile (see Appendix 4 to Annex C). Once the majority of the blasting was complete, further winch configurations were employed to increase the capacity of the winch and therefore enable the removal of large debris. These winch configurations involved establishing anchor points (Split-sets as rock anchors) and using a 2:1 or 3:1 configuration blocks and SWR (see Appendix 15 to Annex C).

187. Winch Capacity. It was found that the winch was capable of:

a. on a straight pull (using no blocks) over undulating coral rubble;

winch capacity = 0.5 m^3 rock (dimensions 1.1 m x 0.8 m x 0.55 m average)

b. on a straight pull (using no blocks and attaching the SWR strap/chain in a way in which to roll the rock 'end for end') over undulating coral rubble;

winch capacity = 1.5 m^3 rock (dimensions 1.2 m x 0.7 m x 1.8 m average)

c. on a 2:1 pull (using a block) over undulating coral rubble;

winch capacity = 2.5 m^3 (dimensions 1.7 m x 1.2 m x 1.3m average)

d. on a 3:1 pull or attempting to roll a rock 'end for end' on a 2:1 over undulating coral rubble;

winch capacity = 3.0 m^3 rock (dimensions 1.3 m x 1.4 m x 1.7 m average)

Sub-paragraphs 187b and d above were slow and rather inefficient methods involving time consuming work continually adjusting the position of the SWR strop or chain on the rock. This also meant that personnel were required to be continually in the vicinity and, at times, in some danger as the large rocks were rolled. This, for the majority of the time, was conducted in very rough rubble conditions and amongst breaking waves. It was found that the winch performance was not affected when worked concurrently with the airtrac.

188. The chain that was employed as a self-tightening yoke around the rock to be removed was;

8.0 m long, short link, mild steel, SWL 1800 kg, link rod diameter 11 mm

When it was found that the sea conditions were too rough to allow workers to carry or drag and heavy chain to rocks requiring winching, a SWR strop was employed just as effectively. The SWR did, however, become easily damaged and required constant maintenance and often cutting and re-clamping. The chain also incurred some wear through being continually dragged across jagged coral. In the worst cases links, generally just ahead of the rock as it was being winched, wore the link rod diameter from 14mm to 6mm in about four months of continuous 6 days/week work. It was found that the reduced link rod diameter did not create safety problems with the chain breaking, (prior to the resupply of the above chain, a locally acquired small diameter wild steel chain was employed with limited success, but constantly broke due to link deterioration and an insufficient Safe Working Load (SWL).

189. The winch was required to be employed in adverse conditions for machinery. This was evident with the deterioration experienced with the winch SWR. The winch came complete with 109 m x 8 mm SWR, as winching configurations were developed and established a further 160 m x 7 mm SWR was resupplied and cut into a 52 m length and a 108 m length. These lengths were calculated in some depth considering, particularly, the winching of rubble out to sea employing a block established on Anchor Rock (see Appendix 4 to Annex C). These calculations allowed for a maximum length of SWR to be employed with a minimum of SWR joins requiring time consuming unshackling and shackling of the joints to pass it through a block. The SWR on the winch drum became unserviceable after about three months of continual usage for the following reasons:

a. Extended usage in salt water conditions with a minimum amount of preventative maintenance available (the only viable maintenance was to ensure the SWR was well oiled and washed in fresh water, due to the winch remaining permanently anchored on the LHS rubble pile).

b. Majority of the winch operating was done by locals and resulted in the SWR being continually kinked and poorly laid on the winch drum, due to:

(1) Team personnel being fully involved in technical explosive or drilling tasks.

(2) There being no effective or efficient method to lay the SWR currectly when the SWR was under tension (winching a large rock). The manning on the winch was always two personnel; one to operate the winch controls and the other to attempt to influence the lay of the rope by hand using gloves.

An expedient roller was constructed incorporating a length of reinforced steel rod, on a wooden box, with a 'sleeve' of galvanised pipe to roll on the reinforced rod, (a greatly improved roller was employed on the Fakaofo Task, See Appendix 5 to Annex S). The winch had modifications completed on it. They were:

a. The exhaust outlet was manifolded vertically above the operator's head using a 1.0 m length of 25 mm Alkathene piping, to reduce the high pitched noise of escaping compressed air.

b. The breather on the winch air motor was manifolded in the same way as the exhaust, which allowed excess oil to be expelled and avoided any contamination of the oil by water.

c. An air line lubricator was permanently attached to the winch housing, when it was discovered that an insufficient supply of oil was being provided when the lubricator was not adjacent to the winch.

190. Removal of Fines with Dragline. The proposed method of removing fines from the existing channel and from areas affected by blasting was to employ a dragline bucket attached to the winch SWR and towed along the bottom of the channel gathering fines. The plan appeared simple and effective results were expected. In reality, the dragline operation proved to be totally inefficient and extremely unproductive.

191. A bucket was acquired in NZ prior to the deployment commencing. It is believed that this disused bucket was for a Hough 30 back actor. Design modifications were conducted on the standard bucket to permit man-portability and allow for water to escape without a loss of fines during the dragline operation (see Appendix 6 to Annex S). The sides and back of the bucket were cut out and replaced by wire mesh gauze, the front cutting edge was cut and lowered, and 'control' handles were attached to allow for continual adjustment of the penetration rate of the cutting edge into the fines normally by divers/personnel following behind the bucket.

192. The modified bucket was trialed continuously with little or no success in varying tide/sea conditions and in various depths of water, including employing Team Divers with SCUBA equipment. The problem that was not solved was preventing the bucket from overturning forwards as the cutting edge 'bit' into a firm area and the winch continued to wind-in, the bucket was not heavy enough to remain on the channel bottom and 'cut through' the firm area. The divers or personnel following the bucket attempted to keep the rear low but were constantly 'flung' off the handles as the bucket overturned forfeiting any load gathered. The pulling positions on the bucket were constantly adjusted to lower the centre of gravity hoping this would overcome the overturning, this did not solve the problem even when the bucket was pulled from 50 mm above the cutting edge.

193. The use of the modified Hough 30 bucket in the dragline operation was considered extremely inefficient and totally unproductive, and was therefore not employed after the preliminary trials.

194. A locally manufactured dragline bucket was constructed from an empty (Diesel) 209 litre drum. The drum had one end removed and the other perforated with a hole punch to allow water escape. The mouth of the bucket was flattened on one side to create a cutting edge and three pulling points were established, one on the top of the mouth and one on either side of the cutting edge (see Appendix 7 to Annex S). This drag line bucket was effectively employed in the removal of accumulated fines from the existing channel area. This was conducted with the winch mounted on the wharf and dragged fines towards the wharf. The bucket was then pulled on to the wharf by use of an improvised ramp and the fines transported to the beach and dispersed. The ramp was a length of Class 30 Trackway, about 3.3 m x 0.6. m.

195. The '209 litre' dragline bucket was not successfully employed in the removal of blast debris, due to its light construction.

196. The Class 30 Trackway lengths were effectively employed as 'sledges' loaded with rubble rolled on then winched up the channel to the wharf area. The SWR was attached through two pulling points on the forward edge of the sledge. The rubble was then subject to secondary breaking by petrol driven or hand held tools (see paragraph 202).

197. Hand Clearance. Concurrent with the employment of the winch, hand clearance was conducted. This task was generally restricted by tides and sea conditions and often dictated the areas of the AO which could be concentrated on. Hand clearance was also affected by any explosive work conducted to disperse blast debris, as often manpower was required for assistance in laying explosive charges and, at times, the explosives were to be placed in areas that hand clearance was being conducted in.

198. Hand clearance was generally conducted by the daily local labour work force (Aumaga) - see paragraph 216. The Team however considered hand clearance an essential aspect of the overall Atafu Reef Channel Improvement Task and made every effort to assist the Aumaga. For the majority of the task, all Team Members were fully employed on technical aspects, such as:

a. Drilling.

b. Explosive make-up and laying.

c. Diving reconnaissances.

d. Forward planning.

e. RNZEME/RNZCT/RNZSigs related specialist tasks.

199. Emphasis on hand clearance became a priority in the mid/latter stages of the Task, as and when it became evident that the AMEX clearance charges were not producing an effective dispersal of debris but rather pandering small rubble into undesirable 'sand'. When this 'sand' was produced, the explosive clearance operation was ceased in that area of the AO.

200. The continuous, on-going hand clearance operation was:

a. Time consuming.

b. Labour intensive.

c. Monotonous.

d. Uninteresting.

e. Often frustrating (due to receiving numerous cuts and grazes on the hands, arms, and legs.

f. Tiring.

201. Various methods were employed to increase the efficiency of the hand clearance task and included:

a. The use of improvised rafts, for the carriage of mid-sized debris, either;

(1) out to deep sea past the 'drop-off' for disposal, in favourable sea conditions, or

(2) up the channel to the wharf, for disposal on the rubble piles or at the beach area.

b. The filling of sandbags, by hand, for man-handling on to the rubble piles or beach.

c. Pulling large debris on to the rubble piles using 20+ men and a 8 m chain.

202. The following tools were found useful for the removal of mid-sized rubble - fines:

a. Picks.

b. Shovels (LHRM and GS).

c. Jumping bars (2.2 m).

d. Sledge hammers (12 lb).

e. 'Pionjar' petrol driven rock breakers.

203. An excessive amount of sandbags were used during the hand clearance operation as it was found that the original Army hessian sandbags were not durable enough for this type of work because they quickly rotted in the salt water. The latter, resupplied, 'coarse weave' nylon sandbags were far more suitable and lasted about five times as long (each nylon bag remained serviceable for about nine working days). It was found that the empty Nitropril bags were far more suitable for the hand clearance task, of removing fines, because a LHRM could fit into the wider bag.

204. The designs of the improvised rafts used on this task are shown at Appendices 2 and 3 to Annex I.

205. It is estimated that about 1500 m^3 of accumulated fines, ex-existing channel, and blast debris was hand cleared during the task period (mid-Nov 85 - mid-Apr 86).

206. Rock Breakers were employed, in a limited role, breaking rubble into manageable sizes. The only breakers deployed with the Team were two Pionjar 120 machines (see paragraph 320c).

207. Secondary Explosive Clearance. The clearance of debris by explosives proved an effective, efficient and productive activity in terms of the employment of necessary manpower and time required to lay the explosives (see paragraph 158 'Rock Popping' and paragraph 164 'AMEX'). In the latter stages of the task, the Team ran low of AMEX for clearance work (ensuring an amount was kept for the Fakaofo Reef Channel Improvement Task - see Yellow pages), bundles of MOLANITE Cartridges were employed (see paragraph 162).

208. AMEX proved an excellent and reliable explosive in the role of debris clearance. 10 kg charges were found to be the most successful size in terms of:

a. Minimum weight of explosive for desired results.

b. Effectively and efficiently tamping the charge.

c. Maneouvreability of the charge under water or in difficult sea conditions

(ensuring that the charges are well 'dug in' - see paragraph 167). Due to AMEX being such a successful explosive, the team found that there was 'never' sufficient quantity available to permit explosive clearance to be conducted whenever desired. Also excessive use of AMEX resulted in the production of 'sand'. Thus, AMEX was selectively employe and sound results were achieved.

209. Rock Anchors. The rock anchors employed throughout the task were 'Split Sets', manufactured by Ingersoll-Rand (see Appendix 2 to Annex S). As mentioned in paragraphs 183 and 184 these were successfully employed as anchorage points for blocks both on the reef top and under water. Split Sets were extremely simple to place, and remained sound and reliable once in the rock. They are described as 'friction rock stabilizers' and are designed for 'underground roof and rib support' relying on the powerful outward force exerted by the Split Set on the rock.

210. The Split Set rock anchors are a tube of high strength steel, with a slot along its entire length. One end is tapered for easy insertion into a hole drilled in the reef. The other end has a welded ring flange to retain an anchorage plate. The borehole in the rock is slightly smaller in diameter than the tube (hole = 29 mm diameter, Split Set tube = 32 mm diameter). As the Split Set is driven into the hole, the tube is compressed. This enables the tube to exert pressure on to the surrounding rock. The tube of all the rock anchors (except the longer Split Sets employed on the winch anchorage - see Appendix 3 to Annex S), inserted for the task were 590 mm in length and the anchorage plate, 125 mm x 125 mm. This had a hole pre-cut in one corner, but was too small in diameter for a shackle and therefore required gas cutting, (see Appendix 3 to Annex S). A handdrifter drill bit had to be 'manufactured' locally to enable the drilling of the narrow 29 mm diameter hole, (a drill steel grinding wheel attachment for the Pionjar rock drills was brought and used to manufacture the drill bit. The grinding wheel was not a tungsten grinder and in the making of the bit rendered the wheel unserviceable). The insertion of the Split Set was by a 'thumper' shank that could be fitted to either a Pionjar or a hand drifter and the percussion of the machine quickly forced the rock anchor into the reef.

211. The holding power of each of the 590 mm long Split Sets was 4536 kg (5 tons - information from Ingersoll-Rand Split Set publication). Unfortunately, no 'extraction machine' was acquired prior to the deployment nor was any effective method developed during the task for extracting the Split Sets. This meant that, once placed, the Split Sets could not be retrieved and re-used; requiring accurate positioning when placed. During the Atafu Task, 15 x Split Sets were used and this number was adequate for the establishment of all the winching configurations, (shown at Appendices 4 and 15 to Annex C).

Technical Overview

212. A brief overview of aspects relating to the suitability of the equipment employed on the Atafu Reef Channel Improvement Task is compiled below. This also includes comments on the employment of explosives and records blasting statistics.

213. Equipment Performance Analysis. The following are points that were noted relating to the performance and employment of the equipment used on the Task:

a. LM-100 Airtrac Drill. The airtrac was an essential item of equipment and was by far the major piece of drilling machinery. It proved extremely reliable and no down time was lost due to the airtrac ever being unserviceable. It produced an excellent work output allowing drilling to continue for longer periods than was possible with hand held tools. The airtrac was capable of drilling precision patterns in extremely rough seas and strong reef top rips; the maximum depth of water drilled in was about 1.0 m, the accompanying swell/breaking wave surge often meant the airtrac was drilling in depths of sea water up to 1.6m (this also necessitated the drill operators - wearing face masks and snorkels!). It was found that, even in such extremely rough sea conditions, the airtrac was unhindered in drilling and was only once caused to move slightly. In rough seas, the operators were able to stand on the tracks or chassis to avoid being knocked over by the waves. It is firmly believed that the resulting channel improvements would not have been completed during the time allocated without the use of the versatile airtrac, (see Appendix 3 to Annex C and Appendix 1 to Annex H). The airtrac did however have several undesirable aspects that could have easily been overcome with minimal preventative maintenance, (this suggested maintenance was not available to the team):

(1) Extensive chassis corrosion was sustained through the prolonged period of work in salt water. This required the painting of the chassis and 'hard to get to' areas, with an oil based gloss paint. (The rate of corrosion was impeded by the daily washdown procedure, see paragraph 133c).

(2) The lengths of 50 mm reinforced rubber Bull Hose necessary to enable the airtrac to work well forward of the manifold, on the edge of the reef, sustained moderate to severe wear. This was caused by the hose constantly being rubbed 'back and forth' on the sharp reef top by wave surge. The required preventative maintenance necessary to reduce wearing of the hose by friction would have been to 'sleeve' each of the hoses with a tough canvas 'fire hose' type of replaceable hose. This could be held in position by the coupling clamps at each end of the hose.

It was also found that long lengths of bull hose (> 40 m) as were often required in'leap-frogging' the airtrac to and from the AO each morning and evening, between the various standpipes, was labour intensive and relatively time consuming (requiring about 30

minutes for 20 men for hose carriage). The bull hose, once it had the 'air on' became extremely rigid. This often kinked if the hose was not absolutely straight (no slight twists), and did become quite dangerous for the personnel holding the hose. It was impossible for a man to control the hose once it began to twist, and at times fingers and hands were painfully trapped within the kinks. These kinks could also totally block the flow of air if they were not observed and checked by turning the air off at the compressor. Operator expertise was, out of necessity, gained by 'on the job' training. This was due to a lack of time being available with the equipment during the pre-deployment training for the conduct of a satisfactory period of work. The desirable work period would have been about two weeks with the airtrac and compressor drilling in a quarry of similar rock (limestone). During the conduct of the Task, it was found that a very small proportion (two x personnel) of the eight man team gained any extensive experience operating the airtrac due to continuing technical expertise being required on other tasks concurrent with drilling occurring. This lack of opportunity for a broad range of experience was not a problem, as it was found that the airtrac was extremely simple to operate. When Team I departed Atafu (16 Feb 86) the two remaining personnel were confident that they could pass on the necessary knowledge of the drill and operating expertise to the replacement team (Team II).

b. 375 cfm Compressor. See paragraph 320a. (Yellow Pages).

c. Handdrifters. See paragraph 320b. (Yellow Pages).

d. Pionjars. See paragraph 320c. (Yellow Pages).

e. D6U Air Winch. See paragraph 320d. (Yellow Pages).

f. Split Sets. See paragraph 320e. (Yellow Pages)

g. Assault Boat Raft. See paragraph 320f. (Yellow Pages).

h. Outboard Motors. See paragraph 320g. (Yellow Pages).

i. Exploders. See paragraph 320h. (Yellow Pages).

j. Demolitions Tester. See paragraph 320i. (Yellow Pages).

214. Explosive Employment. To ensure the effective and timely employment of explosives, thorough forward planning was required to pre-determine anticipated explosive usage. This enabled sufficient explosive charges to be pre-

made prior to a lay commencing and alleviated any potential down time. It is believed that the explosive employment and blasting techniques, previously discussed in this report, were sound and proved satisfactory for this task. No misfires occurred throughout the task. Several points relating to various techniques were identified:

a. It was found, that once skilled in the art, the tying on of charges using clove hitches was far quicker than using 'Junction clips' and that the taping of any spare ends was less complex.

b. Due to the distance from the detonator tie-on point to some handdrifter patterns and AMEX clearance blasts, well forward in the AO, an extremely high usage rate of detonating cord was encountered. At times, a line main of up to 70 m was required to reach the blast area from a point on the reef that the detonator would be tied-on above water level. The majority of the AMEX clearance blasts required charges to be randomly placed in those positions necessary to achieve the maximum results. This generally caused the charges to be a considerable distance apart and entailed a further high usage of detonating cord to connect all the charges.

c. An amount of 'explosive wastage' was accepted as essential to ensure the production of desired blast results. All blast patterns were calculated on the 'minimum amount of explosive required to blast x m^3 of rock'. However, the IOE holes, drilled forward of the first row, and additional holes added to the pattern to 'include all relevant rock' were deemed necessary for reasons previously discussed (see paragraph 154).

d. It is believed that greater and more advantageous rock movement, (the throw of rock caused by delayed pattern blasts), would be achieved if a delay of 20 milli-seconds was employed in pattern blasts (the use of 00, 02, 04, 06, 08, detonators). For the majority of the patterns laid, the Team was forced to employ 10 milli-second delays due to the range of detonators deployed, (00, 01, 02, 03, 04 and 06). The 06 detonators were resupplied in Feb 86.

e. The only insulation tape suitable for wet/under-water explosive taping was found to be 'Nitto' PVC tape. "Nitto" PLASTIC tape was found to be unsatisfactory for the taping of spare ends in the water, as it lost a majority of its adhesive properties. This tape was however retained by the Team and used in the make-up of charges in 'dry' conditions.

215. Blasting Statistics. The following is a statistical analysis of all the drilling, blasting and explosive work undertaken during the Atafu Reef Channel Improvement Task:

a. Total Blasts = 64.

b. Pattern Blasts:

(1) Airtrac -largest (Blast 14) = $252m^2$
Expl = 341 kg.

-average = 65m²
Expl = 75 kg

(NOTE: largest airtac pattern blast includes 50 kg AMEX)

(2) Handdrifter-largest (Blast 6) = 120m²
Expl = 247 kg

-average = 50 m²
Expl = 75 kg

(NOTE: Largest handdrifter pattern blast includes 160 kg AMEX)

c. Clearance Blasts:

(1) AMEX -largest (Blast 9) = 21 x charges
Expl = 210 kg

-average = 9 x charges
Expl = 90 kg

(2) Rock Popping -largest (Blast 48) . = 21xholes,
Expl = 3.6 kg
average = 14 x holes
Expl = 2.4 kg

d. No of Boreholes Drilled:

(1) Airtrac -average blast = 44 x holes
time/1.5 m hole = 9 mins (65 mm dia)

(2) Handdrifter - average blast = 45 x holes
time/1.0 m hole = 12 mins (41 mm dia)

(3) Shear Lines
LHS = 192 x holes (2.0 m)
RHS = 170 x holes (2.0 m)

(4) Total for entire task -
airtrac @1300 x holes
handdrifter @ 400 x holes.

e. Total Metres Drilled:

(1) Airtrac @ 2500 m.

(2) Handdrifter @ 750 m.

(3) Overall total m drilled @ 3250 m.

f. Total Explosive Used:

(1) MOLANITE 55 mm = 2675 kg (2355 x carts).

(2) MOLANITE 29 mm = 461 kg (2710 x carts).

(3) AMEX = 2500 kg.

(4) Detonators = 106.

(5) Red Cord = 10020 m.

(6) Overall Total Explosive Used - 5636 kg.

g. Total m^3 Existing Rock Blasted = 2963 m^3 (1975 m^2).

h. Distance from Firing Point to:

(1) Closest Blast (Channel Edge Trimming) = 47 m.

(2) Closest Pattern Blast = 130 m.

i. Total use of Sand Bags = about 950.

j Total use of Nitropril Bags = about 600.

Local Labour Work Force (Aumaga)

216. Reference A clearly stated that the support provided by the Army, in terms of an Engineer Blasting Team, would be agreed to on the understanding and assurance of the Tokelau Administration that the necessary preparatory type work, of removing large quantities of accumulated fines in the existing channel, would be undertaken and completed by local labour prior to the Team arriving. This arrangement was to ensure that:

a. The Team was not unnecessarily distracted, from the primary task of coral blasting, by requests or demands from the locals to clear these fines and deepen the existing channel.

b. The locals, on arrival of the Team, were prepared for a long period of strenuous work concentrating entirely on the Team priorities and to ensure that the locals had an enthusiastic attitude towards the channel task.

c. The best possible channel conditions were provided (depth and width) for the critical off loading and safe entry into channel of the Teams equipment and stores.

Although assurances, prior to the Team deploying from NZ, were received from Ministry of Foreign Affairs (MFA), Wellington, claiming that the locals at both Atafu and Fakaofo were "totally absorbed in the channel task and thoroughly engaged in clearing the accumulated fines which would definately be complete on the arrival of the Team", neither channels were satisfactorily completed.

217. On arrival of the Team at Atafu (11 Nov 85), it was discovered that a quantity (about 60 m^3) of rubble (generally small - medium sized rocks, 0.5 - 0.75^{3}m each) had been recently recovered from the existing channel and disposed of on the rubble piles. It is believed that this debris had recently, in rough weather, fallen into the channel from the rubble piles. No removal of

accumulated fines nor significant deepening of the channel was evident. A rough survey was conducted of the channel bottom to determine the depth of the accumulated infill. An OPH picket (about 0.4 m length) was randomly prodded into the fines and not once did this picket ground on solid permanent coral. This indicated that, along the entire length of the channel, the bottom depth would have been increased by > 0.4 m with the removal of the fines. An estimated minimum of 360 m^3 of accumulted fines should have been removed by the locals prior to the Team arriving, but were not.

218. The state of the Fakaofo Reef Channel and degree of preparatory work undertaken prior to the Team arriving are reported on in paragraph 260.

219. The lack of anticipated preparatory work at Atafu resulted in the following undesirable circumstances:

a. When entering the channel on the raft (see Appendix 1 to Annex I), with the compressor (11 Nov 85) the RHS OBM was rendered unserviceable as it ran aground (about 90 m from the wharf) on the shallow bottom. The OBM was unable to be made serviceable and was eventually written-off.

b. Throughout the entire Atafu Reef Channel Improvement Task, the Team was constantly frustrated by the locals requesting that work emphasis be placed equally on the removal of the accumulated fines, as on the blasting task. It was firmly believed by the locals that the removal of these fines was part of the Improvement Task. This was contrary to the clear statements of the Army responsibilities in Reference A, to which MFA and OTA had agreed.

220. The employment of local labour was agreed to, through Reference A, and the arrangements of the detailed manning was established by the Team Leader with the Atafu Toeaina. It was agreed that a work force of 20 men/day would assist the Team for 4 hours/day, 6 days/week. The Team were in the position of being able to direct the type of employment and, when necessary, priorities of work for the local labour (Aumaga). The Team, was also informed that at any stage, given three days notice the Aumaga gang could be increased if it was felt the Team's request was justified. On 27 Jan 86, the Aumaga was finally increased to 40 men/4 hour day and the Team managed to gain the ability of working a 'justified' few for an additional two hours/day, (up to two hours/day overtime).

221. On about 12 occasions during the five months of work, the village was a whole worked in the channel, clearing fines by hand. This generally occurred just prior to the arrival of the monthly cargo vessel. On one occasion, for a two hour period; 88 x men and 43 x women were counted working in the channel. These 'village workdays' were extremely productive but unfortunately of a very short duration, about 2 hours/day). They generally occurred without any prior knowledge of the Team and it was found that no success at all was gained in attempting to organise these workdays by requests from the Team.

222. Command and Control. The Aumaga were employed in the following roles and tasks:

a. Winch operation.

b. Hand clearance.

c. Operating the improvised rafts for rubble disposal.

d. Assisting with the laying of explosive charges.

e. Assisting in the movement of the airtrac drill, by carriage of the bull hose, to and from the AO.

f. Assisting with drilling handdrifter boreholes.

It was decided that a 'Boss' of the gang would be chosen and that he would direct the Aumaga's employment in accordance with the Team's instructions (each gang, four x 20 man teams, generally worked one week on, three weeks elsewhere). The 'Boss' was selected by the Toeaina and this selection was consistantly made using one credential, "the oldest man in the gang was the 'Boss'". Due to the 'Boss' not being selected for his ability to understand instructions nor for his grasp of engineering concepts (which several of the younger man exhibited), it was necessary to employ one team member as Aumaga IC (Team 2IC). He was responsible for ensuring that work emphasis was being applied in those areas decided by the Team Leader and that all necessary tools were available. At times, it was extremely difficult to persuade the 'Boss' to direct the Aumaga to work on specific tasks or place emphasis on various aspects of the clearance work as and when priorities became essential or changed. It was found that, generally, the 'Boss' would, given the chance, employ as many men as possible in the clearance of the existing channel. This, of course, detracted from the essential and necessary work continuously required in the blast zones, (working conditions were a lot more frustrating and less comfortable in the blast zone area, due to the surf, than in the existing channel area). A translator was also identified to ensure an accurate passage of information occurred between the Team and the Aumaga.

223. The local Pastor (Congregational Denomination - London Misssionary Society') was an extremely respected and honoured person on the island, due to his appointment. He, generally, took a keen interest in the task and would often work shifts with a gang without payment. Although this was of benefit to the Team, (an extra pair of hands), it did create 'command and control' problems as it was discovered that the entire gang, including the 'Boss' would readily consult the Pastor on work matters and often alter their employment to coincide with any suggestions or advice the Pastor may have offered contrary to the Team's directions. The 'Aumaga IC' therefore found it far easier to adopt the Pastor as the gang 'Boss' on those days that he worked and the Team in general, once realizing the value of the Pastor's influence, began to use him as a convenient mediator between the Team, the Aumaga and the Toeaina.

224. Administration of the Aumaga. The Aumaga were paid by the Tokelau Administration through the regional offices at each of the atolls. A rate of $NZ2/hour was struck (the rate suggested by OTA was $NZ1/hour). The administration of the hours worked/man and pay earned was controlled by the Team. Each individual in the gang signed on prior to work commencing. This became a time consuming task for the 2IC but was required to be supervised to ensure accuracy and to avoid the initial dishonesty that was discovered, (it was found that, on occasions, some men were signing on twice and others were signing on themselves and several of their sons who were not at work!). Subsequently, the Team Members were constantly questioned about pay

discrepancies that the locals believed had occurred. The 'Roll Book' recorded the time period worked by each man and this was confirmed at the end of each shift by the translator and the 'Boss'. This primarily related to any men that had left work prior to the completion of the shift and the necessary hours were then deducted and recorded in the Roll Book. The 2IC, at the end of a gangs work period (generally six days), would take the book to the Administration Officer for the payment of wages to the workers.

225. All of the work force involved in the channel work (Team Members included) were susceptible to and received numerous cuts, lacerations and abrasions. An agreement was reached between the Team, the Administration and the local hospital to deal with the payment of any of the Aumaga who received injuries whilst at work. This was:

a. A minor injury: dealt with by the Team Medic or other Team Members using Team medical supplies and returned to work in the channel. No time nor pay was deducted for this type of incident.

b. An injury unable to be dealt with using Team resources: the casualty was referred to the local doctor at the hospital. If the casualty returned to work less a 'Doctor's Certificate', time away from work was deducted and reflected in his pay. If a Doctor's Certificate was presented, the casualty was deemed on 'Sick Leave' for the stipulated period on the certificate and paid the full amount about $2/hour for a four hour daily shift.

226. The Aumaga proved to be good workers when well directed and supervised. They were both physically strong and extremely competent divers. During the task, an apathy towards work in the channel developed particularly during the Christmas/New Year period. This was mainly due to the 'festive spirit' but conflicted with critical work required in the blast zones. The majory of the large pattern blasting was complete by mid-Jan 86, but extensive hand clearance was a priority from mid-Dec 85. Local traditions were such that the entire village, (including the Aumaga), would play 'local style' cricket for days on end commencing about three days before Christmas Day and continue to the final game on 8 Jan 86. This created a rather large period of downtime and meant that the Team (who worked continuously through this period, had to adjust drilling/blasting priorities to enable a concentration of effort on clearing debris that should have been cleared by the Aumaga.

227. Problems of 'continuity' were encountered with the continual changeover of Aumaga gangs. Various individuals were found to be particularly reliable or competent in different aspects of the task. These locals were thus employed in such a way as to benefit from their skills or abilities. Unfortunately the six day shift week of work was too short to enable any sort of efficient procedure to be deveoped employing the locals in responsible, technical roles. When the Toeaina finally agreed to increasing the gang numbers to 40 men/six day week, it was found that, if requested, certain locals could be included in the work gang for several weeks continuously. This was of great benefit as the Team were able to instruct and develop the locals in to reliable workers, and this also promoted an enthusiasm towards the task.

228. It is believed that a gang of 40 men/day was ideal. This allowed sufficient flexibility for their employment on several concurrent, such as winch, hand clearance and raft operating. The Team were able to effectively employ

each man according to his age and capabilities ensuring that the Administration received the most effective value for money/man, and that the high work output of the larger gang significantly benefitted the channel task. The ideal situation would have been to have had the same men assisting the Team for the entire period of the Task.

229. The allocated budget for the employment of 'casual workers' in the channel was rapidly exceeded by the Atafu Administration due to the generous $NZ2/hour wages agreed to by the Toeaina, (any other 'casual labour' empoloyed in Tokelau such as assistants at the hospital or Post Office were paid 68¢/hour). Requests by OTA for the Team to 'oversee' and account for all payment of locals ih the channel work work gangs were refused by the Team Leader. It was felt that the undesirable potential could have been created for the Army to be held responsible for the expenditure of vast sums of OTA money. The budget was, however, continuously abused by the Aumaga who, at times, held 'stop work meetings' during a shift to discuss the channel task or when sea conditions were rough and work was uncomfortable. The Toeaina would also create frustrations, when they would direct all of the men to have a 'rest day' or go on a 'village fishing' day. On these days the Aumaga would receive full pay as they claimed they "wanted to work, but were not allowed to" and asked that the Team record their names in the Roll Book to ensure the payment. The Team refused and informed the Adminsitration that the Roll Book would only be used to record work undertaken in the channel and that the Army had no interest in 'compensatory pay' for no work days.

230. Other problems encountered were:

a. During the Christmas School holidays, regular Aumaga men would send their young sons to work in their place in the channel. This created an undesirable circumstance which restricted the Team in the employment of these boys. They were not capable of the same work output of a grown man nor were they as confident swimming in rough sea conditions around rubble. The Team quickly overcame this situation by instructing the Administration that men under the age of 18 years, would not be 'signed-on' in the Roll Book.

b. During the initial stages of the task, the locals had difficulty in convincing themselves that the Channel Improvement Task was a village project and that the primary aim of the Task was to benefit the village, not purely an Army training exercise. This meant that the Aumaga would only work when paid and they would frequently sit for hours watching the Team at work. Voluntary work was only provided during the few 'Village Work Days'.

c. The Team soon learnt that the locals could be best employed during specific tide conditions relating to the particular task required to be performed, such as :

(1) High tide;

(a) winching large rocks underwater, (which lessened their 'dead weight'),

(b) 'swimming' the improvised rafts carrying debris out to deep sea, and

(c) placing clearance charges in shallow or rough low tide positions.

(2) Low tide;

(a) hand clearance,

(b) extensive winch clearance, and

(c) laying of pattern blasts.

Difficulties were encountered when trying to convince the Toeaina that, if extensive hand clearance was necessary, the Aumaga were required to work their 4 hour shift to coincide with the Low Tide of that day. This period of course, could occur at any stage during the 12 hours of daylight but the request was not received well, as the locals continued to insist that they must work early in the morning regardless of tide conditions, causing problems for the Team in finding effective employment. It was also discovered that the locals had a far lower resistance to colds and flu, than did the Team.

231. Work Output Constants.

- No of days worked (Aumaga)	= 76 days
- Average no of men/daily shift	= 27 men
- No of man hours worked/day (averge)	= 135 hrs
- No of man hours worked entire task	= 10260 hrs
- Approximate total volume of blast debris and accumulated fines removed	= 1500m^3
- Volume of blast debris and accumulated fines removed/man/hr	= 0.15m^3
- Volume of blast debris removed/man/4 hr shift	= 0.6 m^3

Storage on Atafu

232. Stores and Equipment. All Team stores and equipment, (less catering/household and personal stores) were stored in the 'store' near the task site. The store was situated about 60 m from the wharf on the edge of the village playing area with cooking houses to the north and a large copra shed 20 m to the south. The store was on a raised concrete pad and had timber walls. 75% of all wall space was louvre windows with wire security mesh on the exterior. The interior had exposed timber roof trusses to galvanised iron and no interior walls. Two double doors were the only access points into the building, which was allocated solely for the Team's equipment. Floor area = 150 m^2 and was satisfactory for the Team's requirements. As expendables, such as food, were consumed, the available floor space increased and allowed for desk space for charts etc and a vehicle mechanic's 'workshop'.

233. Explosives. All explosives, including detonators, were stored in the same store explained in paragraph 232 due to no other suitable sites being available.

234. POL. The types of POL employed on the deployment are detailed at Appendix 1 to Annex M. All POL, less diesel and petrol, was stored in the store. This, generally amounted to about two x 209 litre and 1- x 60 litre drums. The remaining petrol and diesel (209 litre drums) were stored outside in the shade of the eaves of the store and nearby copra shed.

235. Due to the inquisitive nature of the locals, it was found that some form of 'crowd control' was required. This was achieved by organising the store into tidy and easily accessible storage areas, allowing the restricted movement of personnel to be controlled by inserting 'flap doors' beween table tops. This increased the efficiency of signing-on each day and safety of controlled items such as explosives and equipment. The store, out of necessity, was open from the start of work (about 0630 hours) to the end of work (about 1800 hours) daily. This was due to the continual requirements for repair work to be undertaken, resupplying the AO with necessary tools and equipment, and the possibility of an emergency occurring requiring urgent stores such as medical supplies or fire extinguishers.

Diving

236. Underwater SCUBA diving was an extremely important and essential facet of the task. This equipment used extensively, by the qualified divers in the Team, for work and reconnaissances in the areas shown at Annex D ('Areas Not Reconnoitred').

237. After a period of several weeks, the Divers became confident of working in the sea on the reef edge and learnt how to 'read' various sea conditions. This lead to the Divers choosing to use snorkels, fins and face masks rather than the cumbersome SCUBA equipment, in most tasks requiring short duration underwater work. Snorkelling equipment was also selected above SCUBA for work in rough seas or amongst jagged rubble, due to the increased bulk of a diver and to ovecome the possibilities of becoming snagged on the rubble in SCUBA equipment. At times, divers were working, on snorkels, to a depth of 4.5 m and at all times, when it was evident that divers may be 'bounced' across the jagged rubble by breaking waves, only snorkelling equipment was used (to increase the divers chances of being able to manoeuvre themselves more easily and perhaps avoid any serious cuts).

238. Equipment. The diving equipment had a hard life throughout the deployment due to the constant requirement for its use. All Team Members were issued with a mask and snorkel, and although only three of the Team were divers, all personnel frequently used the masks in the following types of typical situations:

a. Handdrifting in waist to shoulder deep water and surge.

b. Laying explosive patterns in waist deep water and surge.

c. Hand clearance.

d. Winching.

e. Routine checking for damage of the galvanised pipe line.

As the tidal conditions were often very rough during work on the reef, face masks and snorkels were constantly washed off the faces of the personnel. Some of these masks were later recovered on dive reconnaissances, but in most cases, they were not retrieved. When the Team was fortunate enough to have spare masks, these were loaned out to the Aumaga and were generally the poorer quality masks that had undoubtedly undergone numerous repairs and improvisations.

239. Diving knives, which were attached to the lower calf, were found to be extremely useful for underwater demolitions work in cutting Red Cord and for minor clearance of blocked boreholes. These were also susceptable to loss through rough seas, however only three were not recovered.

240. Spare Parts. It became evident that an extensive and comprehensive range of all types of diving spares were required to ensure that, at all times, the Team had fully serviceable equipment. A list of stores and spares required to support three divers for six months in an isolated location is at Appendix 1 to Annex T.

241. Additional Equipment. Although the best available diving equipment was taken from 1 Fd Sqn, this was not in a condition to withstand months of rigorous work in a tropical environment. Continual repairing of particularly, face masks and snorkels, was undertaken to extend the life of the equipment but was limited to the resources available. Due to the rough working conditions, the divers would have been significantly assisted in the carriage of tools and/or equipment if a 'work/safety harness' had been acquired. A suggested drawing of such a piece of equipment is at Appendix 2 to Annex T. This harness would also be useful for the attaching of a lifeline to a diver with the least possible discomfort and restriction of movement. It was also found that the 'Diving Boxes' currently in service for the carriage of cylinders and diving accessories were too heavy and were capable of carrying too much equipment, thus sensitive equipment such as gauges and masks are prone to damage. A suggested construction of more practical Diving Boxes is included with a stores list at Appendix 3 to Annex T.

242. Diving Times. The following is a record of dive times/diver during Atafu task:

a. Skinner : 788 minutes

b. Toia : 678 minutes

c. Cooper : 596 minutes

Resupply

243 The team was resupplied at Atafu by two means:

a. Airdrops from RNZAF aircraft.

b. By sea from a chartered ocean-going cargo vessel ex-Apia.

Airdrops. RNZAF airdrop resupplies included:

a. Engineering stores.

b. Signals equipment.

c. Explosives.

d. General stores.

e. Medical stores.

f. Essential spare parts.

g. Welfare items.

Six airdrops were, gratefully, received at Atafu, four ex-P3 and two ex-C130. These are explained in detail in Annex U.

245. Ship. The chartered resupply vessel called at Atafu five times, once each month (Dec 85, Jan 86, Feb 86, Mar 86 and Apr 86). The Nov 85 ship transported the Team to Atafu, the Apr 86 ship took the Team to Fakaofo. The Team was able to demand for the resupply of:

a. Fresh food.

b. POL.

c. Minor general stores.

d. Small quantity of beer (paid for by personal funds).

Survey

246. The comments made in paragraphs 242 to 247 apply equally to the surveying of the Atafu Reef Channel as the same procedure was adopted at both Fakaofo and Atafu.

247. See Appendices 1, and 2, to Annex H and Enclosure 1 for plan drawings of the final survey of the Atafu Reef Channel Improvement Task. As Enclosure 1 to this report, the full range of detailed x-sections and plans are compiled.

248. The Survey Sheets used to record the survey information from which the drawings were taken, are compiled as Enclosure 2 to this report.

Reporting and Recording

249. The Atafu Reef Channel Improvement Task was reported to 1 Fd Sqn by:

a. Daily radio scheds (see paragraph 408).

b. Weekly SITREPs; transmitted by radio (see Annex B).

c. Progress Charts; sent by civilian mail on the resupply vessel (see Annex C).

250. Accurate records of expenditure and task progress were kept in the following ways:

a. 'RNZE Reef Blasting Log' (see Appendix 1 to Annex X); used to record all technical data related to every blast detonated. This Log was a locally produced form, and replaced the commonly used 'RNZE Blasting Log'. It has details relevant to blasting work in coral and disregards unapplicable quarrying information.

b. 'Explosive Record' (see Appendix 2 to Annex X); used to keep an accurate and up to date record of all explosive expenditure and also included SITREPs of Nitropril bags and sandbag usage due to their primary use being in explosive work.

c. An 'RNZE Task Diary' was locally produced and operated by the Team 2IC. This was primarily used to allocate detailed taskings to team Members for the following days activities, but was also used to record POL expenditure and hour meter readings daily at the completion of work (see Appendix 3 to Annex X).

d. Other minor records kept were:

(1) Personal Dive Logs; for Team divers.

(2) Aumaga hours worked/day; in local Roll Book and were also usually recorded in RNZE Task Diary.

All of the abovementioned records were both essential and of extreme importance to ensure that an accurate statement of all critical stores was available at any stage. It was quickly learnt that <u>all</u> items of this nature must be continually counted, checked and recorded.

251. The completed RNZE Reef Blasting Logs for the Atafu Reef Channel Improvement Task are compiled as Enclosure 3 to this report.

<u>Public Relations Tasks</u>

252. Public Relations (PR) tasks were undertaken during less intense periods of channel work (Apr 86 when menchanical failures caused the work in the channel to be solely hand clearance). PR tasks completed were:

a. Transportation of a light tractor (2 tonne) from ship to shore using the Teams assault boat raft (see Indemnity Certificate for the exercise at Appendix 2 to Annex K).

b. Upgrading of the water supply and catchment at the local hospital.

c. Assisting in the demolition of the Administration Block.

d. Levelling the new foundations for the Administration Block.

e. Dismantling an unserviceable 'Braithwaite' water tank.

Move off Atafu

253. 23/24 Apr 86. The ship arrived at Atafu at 230600 Apr 86 and, in extremely rough seas, the locals began to off-load all the remaining cargo (only Atafu stores remained on board as ship had previously called at Fakaofo and Nukunonu). The off-load was proposed to be complete by about 231400 Apr 86 to allow the Team to commence loading for a planned ETD Atafu of the Team at 241900 Apr 86. Due to the rough sea conditions, the off-load of the Atafu cargo was not complete until 240910 Apr 86. The logistics were further delayed as a rain storm covered the island during midday forcing the ship out to sea and therefore the Team did not start on-loading until 241430 Apr 86. By last light 24 Apr 86, 90% of all Team stores, equipment and explosives were on-board.

254. 25 Apr 86. The critical on-loading of the airtrac and compressor was required to be the last activity due to the restricted hold capacity of MV WAIRUA. These items and the assault boat rafting equipment were to be transported to Fakaofo as deck cargo, on top of the hold covers. This was of some concern to the Team in general, meaning that the subsequent off-load of the Team stores at Fakaofo all revolved around the successful off-load of the airtrac and compressor. After successfully loading these last two items, about 251145 Apr 86, the Team stripped the raft for subsequent on-loading while the Team Leader requested authority from MFA representatives, attending a meeting at Atafu, to, if necessary, hold the ship at Fakaofo for a short period to ensure that the compressor and airtrac were off-loaded during the best sea conditions. The channel at Fakaofo (Fale) was notoriously renowned as the roughest of all the channels in Tokelau and the disturbed weather at Atafu was likely to be present also at Fakaofo. The MFA reaction to this request was not favourable and the Team were instructed 'at all costs', to ensure that the off-load at Fakaofo was complete by last light 26 Apr 86.

255. Team was complete on ship and ETD Atafu 251900 Apr 86.

General Points

256. Ship Wreck. A brief reconnaissance report on possible disposal of the ship wreck at Atafu is included in this report (see green pages).

257. See Annex W for Atafu Channel Task Appraisal dated 30 Dec 85, including explosive resupply requested.

FAKAOFO REEF CHANNEL IMPROVEMENT TASK

Introduction

258. **Task Specifications.** The specifications for the necessary engineer works required to improve the Fakaofo Reef Channel are detailed in Reference A, Section C - Fakaofo (yellow pages). These criteria were adhered to and are as follows:

a. Widen the channel mouth and inner channel area on the left hand side (LHS)

b. Achieve a minimum depth of 1.2m at low tide (LT - 1.2m) in the blast area.

259. **Resulting Improvements.** The following is a detailed breakdown of channel improvements undertaken during Op Tokelau Reef, (see Appendices 7 and 8 to Annex H):

a. Widening of the LHS by 8.0m, to a distance of 42.5m from 'Pole 2' (Pole 2 is 4.0m back from the seaward end of the LH rubble pile), on a magnetic bearing of 3565m.

b. Widening of the inner channel, on the LHS by 3.0m, for a distance of 53.2 m from the 'concrete patch', on a magnetic bearing of 3940m.

c. Deepening of a majority of all blasted areas to LT - 1.2m, (the areas not completed to LT - 1.2m, were such that the locals could complete the work after the departure of the Team).

260. **Initial Survey.** The drawings compiled from the initial survey conducted during the Feb/Mar 85 reconnaissance, should be referred to and compared with Annex H and Enclosure 1 to this report. It was found that the condition of the Fakaofo Reef Channel, on the arrival of the Reef Blasting Team, was of no change to the initial survey drawings at Annex K of Reference A.

Major Activities

261. The following are the major activities that occurred during the Fakaofo Reef Channel Improvement Task:

Ser	Date	Activity	Flow
(a)	(b)	(c)	(d)
1.	260600 Apr 86	Team II ETA Fakaofo.	
2.	260700 Apr 86	Commence off-load.	
3.	261200 Apr 86	Compressor safely ashore at Fale.	

er (a)	Date (b)	Activity (c)	Flow (d)
4.	261307 Apr 86	Assault boat raft over-turned in channel mouth, dropping airtrac into @ 3.0m water. Raft and OBM's U/S.	26 Apr 86 ↓ AIRTRAC DRILL U/S AND RTNZ
5.	261930 Apr 86	Off-load of Team and cargo complete.	
6.	27/28 Apr 86	Team divers recon submerged airtrac.	
7.	29 Apr 86	Airtrac winched on-board M.V. WAIRUA.	
8.	27 Apr - 1 May 86	Unpack/establish store and house, (including constructing water catchment and reticulation systems for the house).	
9.	30 Apr - 8 May 86	Conduct confirmatory surveys of channel and AO.	
0.	1-9 May 86	Diving reconnaissance of channel mouth.	
1.	5-7 May 86	Construct 117.0m of galvanised pipe in channel.	
2.	5-8 May 86	Construct winch anchorage on backfill behind existing seawall.	8 May 86
3.	8 May 86	Commenced handdrifting LH Inner Channel area.	WINCH HAND PAT → 16 May 96
4.	10 May 86	Commenced handdrifting LHS (as sea conditions allowed).	CLEARANCE CLEARANCE TERN BLAST 4 Jun 86 VISIT OC SSM 10 Jun 86
5.	16 May 86	First and largest pattern blast = 129.5kg	23 May 86 EXPLOSIVE CLEARANCE
6.	281831 May 86	Airdrop ex C130 (50hp OBM/ Medical stores/3 x handdrifters/ VM spares/welfare items).	
7.	4 Jun 86	May/Jun resupply ship. ETA OC/SSM 1Fd Sqn.	
8.	101634 Jun 86	Airdrop ex P3 (Sandbags/Mail).	
9.	10 Jun 86	ETD Fakaofo OC/SSM.	

VERY ROUGH SEAS

er (a)	Date (b)	Activity (c)	Flow (d)
0.	151348 Jun 86	Airdrop ex C130 (Sandbags/ Mail/Welfare).	
1.	16 Jun 86	Last pattern blast.	16 Jun 86
2.	1 Jul 86	Explosive clearance complete.	
3.	3 Jul 86	Explosives and equipment display at local school; blasts = 800m surface laid detcord and 253 kg	
4.	3 Jul 86	Commenced destroying MOLANITE by fire (2 x fires each @ 7 x 55mm MOL).	
5.	4-7 Jul 86	PR task : gas cutting and disposal of wrecked track vehicle on wharf (ex 1963 Army task).	5 Jul 86
7.	5-9 Jul 86	Packing Team stores for ETD Fakaofo	
0.	7-8 Jul 86	PR task : construction of 2 x 60m pig fences on LH and RHS of channel.	
6	5 Jul 86	Final destruction by fire of MOLANITE (5 x fires each @ 10 x 55mm MOL).	
8.	7 Jul 86	PR task : destruction of four large coral heads in lagoon blast = 430 kg.	
9.	8 Jul 86	Disposal of excess explosive at sea = 2526.5 kg.	
1.	9 Jul 86	Disposal of excess detonators (242) and det cord (3100m).	
2.	9 Jul 86	Official Handover of channel improvements to the Tokelau Administration and Fakaofo Council of Elders.	
3.	110600 Jul 86	Jul resupply ship at Fakaofo.	
4.	111100 Jul 86	All Team stores loaded on to ship.	
5.	121900 Jul 86	ETD Fakaofo Team II for Apia.	

262. Off-load of M.V. WAIRUA. The off-load of M.V. WAIRUA was conducted during 0700-1930 26 Apr 86. The off-load priorities did not change from those stated in paragraph 124a and 124b. Due to the off-loading restrictions imposed on the Team, explained in paragraphs 253 and 254, rapid transportation of the major engineer equipment (airtrac and compressor) was essential. This, unfortunately, meant that the employment of the limited capability assault boat raft, (see Appendix 1 to Annex I for design draft), was inflexible and the Team was forced to move regardless of the sea conditions. During the whole of 26 Apr 86 the sea was extremely rough, particularly in the channel mouth, and at times up to 6.0m breakers were forming on the reef edge and surging across the reef and up the channel. This situation caused all Team members to become extremely anxious about their safety and the degree of success that would be achieved in attempting to conduct this critical operation. All possible precautions were taken to ensure the safest entry to, and exits from, the channel were made. The compressor was successfully transported ashore, but, due to a combination of mechanical failures and extremely adverse sea conditions, an accident occurred whilst transporting the airtrac into the channel. The raft was overturned, nose for stern, losing the airtrac and rendering the raft and OBM's totally unserviceable. The airtrac was later recovered and returned to New Zealand in an unserviceable state. All relevant details of precautions taken, mechanical failures, local knowledge, adverse weather conditions and imposed off-loading restrictions are recorded in an Incident Report submitted to OC, 1 Fd Sqn (see Annex Y), also refer to Appendix 28 to Annex B.

263. Assault Boat Raft. See paragraph 126.

264. Stores, Equipment and Explosives. The locals assisted the Team in the off load by conducting all the necessary transportation of stores from ship to shore. The store to be used by the Team during the task was an enclosed area of part of a large copra shed in close proximity to the channel. The stock piling of the cargo in the Team store was supervised by a team member and no losses were encountered during the move from Atafu to Fakaofo. The catering and domestic type stores were taken directly to the house that the Team would occupy, @ 200m from the channel. This was conducted by the RNZCT cook.

Work Priorities

265. The priorities for commencing engineer works to improve the Fakaofo Reef Channel were:

a. Conduct confirmatory reconnaissances (both dry and underwater).

b. Liaise with the local elders for confirmation of desired improvements.

c. Determine what the Team's capabilities were and how these had been effected by the loss of the airtrac drill.

d. Identify the 'Task Concept' and AO.

e. Establish a work routine.

Conduct

266. Confirmatory Reconnaissances. During the period 30 Apr - 9 May 86, reconnaissances were conducted to confirm the information gained on the Feb/Mar 85 reconnaissance. Seven underwater diving reconnaissances and numerous reef top surveys and tape measurements were conducted to enable the drawing of an accurate channel plan. One long section survey was conducted on the RHS for a distance of @ 50m forward of the concrete mooring block along a reef finger. These reconnaissances produced sufficient information to accurately plot the plan at Appendix 7 to Annex H and draw the Progress Chart plan at Appendix 1 to Annex Z, which includes the allocated nicknames given to various landmarks and reference points.

267. It was found that the confirmatory reconnaissances validated the information gained on the Feb/Mar 85 reconnaissance and did not identify any further work necessary to be completed to achieve the specifications in Reference A.

268. Liaison with the local Council of Elders (Toeaina). After several meetings with the Toeaina, they identified 'on the ground' the improvements to the channel which they desired. These requests were:

a. Widen the LHS from the seaward side of the LH rubble pile, priority 1.

b. Widen the RHS from the area of the concrete mooring block to 'Shark Re-entrant' (see Appendix 1 to Annex Z), priority 1.

c. Priority 2 task, widen LHS inner area from seaward side of LH rubble pile to a mid point down the LHS of channel.

269. During the meetings with the Toeaina, arrangements were made for:

a. Daily local labour assistance from the local work force (Aumaga), see paragraph 323, and

b. The provision of a daily cleaning woman at the Teams' accommodation, see paragraph 450.

270. Team Capabilities. When considering the capabilities of the Team and the degree of work that could be realistically undertaken, the following aspects were taken into account:

a. The drilling capability of the Team had been significantly decreased during the loss of the airtrac drill. The team, at this stage, was reduced to two light hand drifters for the drilling of boreholes.

b. The Team manning had been reduced from eight personnel to seven, due to the RTNZ of one member in Apr 86.

c. Two Team members were suffering from extremely septic coral cuts received on Atafu and restricted them to 'out of water' work.

d. Op Tokelau Reef had already been extended by three months past the Estimated Date of Completion (Mar 86).

e. Proposed RTNZ date of the Team was Jun/Jul 86.

f. The Toeainas' requests for desired improvements were extensive and entailed far more work than was identified during the Feb/Mar 85 reconnaissance.

271. Task Concept. It was decided that, after considering the points in paragraph 270:

a. The Teams' work output potential was significantly less than that experienced at Atafu.

b. Only that work which the Team was convinced could be completed in the time allocated would be undertaken.

c. The request to remove the huge area on the RHS (RH Finger and associated rocks), would not significantly improve the channel considering the direction of the waves. This request was considered unjustified, (see Appendix 1 to Annex Z).

272. The Team Leader informed the Toeaina that only the following work would be undertaken:

a. Widening the LHS from the seaward side of the LH rubble pile by @ 5.0m - 6.0m, priority 1.

b. Widening the LH Inner area from the 'concrete patch' on the LHS of the channel to the seaward side of the LH rubble pile by @ 2.5m - 3.0m, priority 2.

c. As an extremely low priority and unlikely task, trim @ 1.0m -1.5m off the RHS of the channel forward of the concrete mooring block to 'Dicey Finger' (see Appendix 1 to Annex Z).

Further diving reconnaissances determined that the channel bottom of the RHS of the channel mouth was extremely irregular and that the channel side of the RHS was not uniform and ranged in depth from 0.25m - 3.0m. This convinced the Team that attempting even minor work on the RHS would entail a considerable amount of effort and time consuming work to create any noticeable or significant improvements. The Toeaina were then informed that work on the RHS was no longer considered a responsibility of the Team, (19 May 86), (see Appendix 32 to Annex B).

273. The concept of the Fakaofo Reef Channel Improvement Task was then formulated. An AO was determined, (see Appendix 1 to Annex Z) and approximate m^2 calculations were done on all areas within the AO, (see Appendix 2 to Annex Z). The 'Modus Operandi' was as follows:

a. Establish semi-permanent reference poles on the existing reef to mark the 'edge of excavation', (see Appendix 1 to Annex Z). These 'poles' consisted of a jumping bar placed into a borehole with a 2.0m length of galvanised pipe placed over the jumping bar which rested on the reef top.

b. Construct a 50mm diameter galvanised steel pipe line on the channel bottom for compressed air reticulation to the AO, see paragraph 278.

c. Hand/winch clear a 1.5m - 2.0m wide strip through the rubble on the channel edge on the LHS to allow for easy access to and from the AO.

d. Drill handrifter borehole patterns within the AO. Pattern drilling emphasis was to be, LHS (priority 1) and LH Inner (priority 2).

e. Lay explosive charges and detonate the borehole patterns.

f. Conduct the clearance of blasted areas employing explosives, the air winch, the dragline bucket and hand clearance onto rubble piles, improvised rafts and reclaimed as backfill.

g. Conduct a X-section survey of the completed channel task.

h. Formally hand-over the completed Fakaofo Reef Channel Improvement Task from the NZ Army Reef Blasting Team to the Tokelau Administration and Fakaofo Toeaina, (see Appendix 3 to Annex K).

i. Undertake minor Public Relations tasks when time allowed.

274. Work Routine. The work routine employed at Fakaofo was not changed to that established during the Atafu task. This is explained in detail in paragraph 133.

(Note: the employment of the airtrac drill during low tide stated in paragraph 133a (1) was non-applicable at Fakaofo).

Borehole Pattern Drilling

275. Equipment. Two types of drilling equipment were employed on the Fakaofo Reef Channel Improvement Task and were as follows:

a. Man portable, pneumatic, hand held rock drills, (handdrifters).

b. Man portable, petrol driven, hand held rock drills, (Pionjars).

276. Pneumatic Hand-held Rock Drills. The Team effectively employed five handdrifters on the Fakaofo task. The two light handdrifters were deployed from New Zealand with Team I and were used extensively at Atafu, (see paragraph 69). Three medium handdrifters were resupplied to the Team at Fakaofo ex-C130 airdrop on 28 May 86. These handdrifters were used for:

a. The drilling of all borehole patterns.

b. Secondary drilling of blast debris and boulders for 'rock popping', (see paragraph 293).

c. Drilling in totally submerged areas by divers using SCUBA equipment.

d. The drilling-in and placing of rock anchors, (see paragraph 318).

The manning required and operation of the handdrifters is explained in paragraph 136.

277. Petrol Driven Portable Rock Drills. The two Pionjar drills were used in the same role as that employed at Atafu. They were used, primarily, as 'back-up' drills for the handdrifters and although restricted to 'above water' work, were employed on the following tasks:

a. The drilling-in and placing of rock anchors.

b. Compaction of back-fill areas.

c. 'Breaking' of rubble into manageable sizes.

d. 'Chisel breaking' of overhangs along the sides of the channel.

e. Grinding of tools using the grinding wheel accessory.

278. Compressed Air Supply and Delivery. The compressed air was supplied by the 375 cfm portable compressor deployed with Team I from New Zealand, this is discussed in paragraph 138. The compressor was permanently located in level ground near the Team store on top of the existing 2.0m high seawall. This site was @ 70m from the nearest edge of the AO and @ 160m from the further. 117m of 50mm galvanised pipe was constructed and reticulated compressed air at a negligable psi loss to the closest edge of the AO, (in the vicinity of Poles II/III). The majority of the pipe line ran the length of the channel under water, however three 6.5m lengths were above water between the sea wall and the channel. The pipe line incorporated one rubber stand pipe @ 72m from the wharf to allow for flexibility with drilling in the LH Inner area reducing the use of small diameter high pressure hose. On the far end of the galvanised pipe was the delivery manifold mounted in the same way as in Atafu, see paragraph 138. For compressed air pipeline design, see Appendix 2 to Annex L. For compressor fuel consumption and hours, see Appendix 1 to Annex M. For delivery manifold design, see Appendix 3 to Annex L.

Borehole Pattern Blasting

279. Preliminary Blast Design. No preliminary blast design for the use of handdrifter borehole patterns was done in New Zealand. A successful blast design was completed on Fakaofo and produced good results. All calculations for the design were based on experience gained during the Atafu task and this is included in paragraph 282.

280. Explosive Resupply. Due to the usage of explosives at Atafu being far greater than that expected (because of the increased area of the AO), a resupply of explosives was received at Atafu by airdrop from C130 on 4 Feb 86, see paragraph 123. The calculations done on Atafu when requesting this resupply, used the following assumptions, that:

a. the airtrac would be employed in borehole drilling on Fakaofo, and

b. the area identified for excavation on the Feb/Mar 85 reconnaissance would be undertaken.

Both these assumptions proved to be wrong and this influenced the calculation of the handdrifter blast design.

281. The following aspects were considered when calculating the blast design:

a. A large quantity of 55mm diameter MOLANTE cartridge explosive had been resupplied, therefore large diameter boreholes were a requirement.

b. No shearlines were to be drilled at Fakaofo. It was believed that the time consuming task of drilling shearlines was not justified as no severe backbreak was encountered on Atafu, (see paragraphs 146 and 147, for technical specifications and aims of shearlines).

c. Handdrifters were capable of drilling boreholes with a maximum depth of 1.5m.

d. Deck loading of boreholes (see paragraph 145) was not considered, as this was not necessary on Atafu.

e. The largest diameter borehole that handdrifters could drill was 58mm.

f. It was found on Atafu that 'PVC hole retainers', see paragraph 85, were too large in diameter to fit into the 58mm boreholes.

282. Handdrifter Blast Design. The following are the two blast designs used during the Fakaofo task:

a. Borehole Blast Design for 58mm diameter bit, Borehole Depth = 1.5m.

Ser	Technical Term	Measure-ment	Description	Remarks
(a)	(b)	(c)	(d)	(e)
1.	Bit diameter (d)	58mm	Borehole diameter.	All bits were 'X' design
2.	Borehole depth (H)	1.5m	Depth to be drilled.	H is determined by task specifications and desired excavation depth results.
3.	Burden (B)	0.85m	Distance between holes perpendicu-lar to face.	Also measured from face to first row.

Ser	Technical Term	Measure-ment	Description	Remarks
(a)	(b)	(c)	(d)	(e)
4.	Spacing (S)	0.85m	Distance between holes parallel to face.	S must be > B
5.	Subgrade drilling (Sd)	N/A	Additional depth drilled below design depth of borehole to account for soft or weak rock layers.	N/A
6.	Final Stenning (F_s)	0.87m	Depth of back fill of sand/drilling fines tamped on top of explosive in borehole.	$F_s \approx B$ for limestone rock (coral similar), but generally = 0.7B.
7.	Explosive Column (E_c)	0.63m	Depth of borehole available for explosive loading.	$E_c = H - F_s$ = 1.5m - 0.87m 0.63m = 1.3 x carts 55mm MOLANITE. (1 x cart = 420 m long)
8.	Explosive/hole (M_c)	1.48kg	Quantity of explosive in kg to be loaded into each borehole.	1.48kg = 1.3 x carts 55mm MOLANITE. (1 x cart = 1.14kg)
9.	Rock Volume (V)	1.08m^3/ hole	Volume or rock to be removed by each hole.	V = HxBxS = 1.5m x 0.85m x 0.85m
10.	Rock Mass (Rm)	2160kg/ hole	Weight of competent rock each hole was responsible for removing.	Rm = VxSg(coral) = 1.08m^3/hole x 2.0kg. Sg = Specific Gravity, Sg of coral was not known, therefore Sg for limestone was used.
11.	Powder Factor (P_f)	1.37kg/ m^3	Kg of explosive/ m^3 of bank rock.	$P_f = \frac{M_c}{V}$ $= \frac{1.48kg}{1.08m^3}$

b. Borehole Blast Design for 58mm diameter bit, Borehole Depth = 1.0m.

Ser	Technical Term	Measure-ment	Description	Remarks
(a)	(b)	(c)	(d)	(e)
1.	Bit diameter (d)	58mm	See paragraph 215a.	See paragraph 215a.
2.	Borehole depth (H)	1.0m	" " "	" " "
3.	Burden (B)	0.85m	" " "	" " "
4.	Spacing (S)	0.85m	" " "	" " "
5.	Subgrade drilling (S_d)	N/A	" " "	" " "
6.	Find Stemming (F_s)	0.58m	" " "	" " "
7.	Explosive Column (E_c)	0.42m	" " "	$E_c = H = F_s$ = 1.0m - 0.58m 0.42m = 1xcart 55mm MOLANITE
8.	Explosive/hole (M_c)	1.14kg	" " "	1.14kg = 1xcart 55mm MOLANITE
9.	Rock Volume (V)	0.7m3/ hole	" " "	V = H x B x S = 1.0m x 0.85m x 0.85m
10.	Rock Mass (R_m)	1400 kg	" " "	R_m = Vx Sg (Coral) = 0.7m3/hole x 2.0kg
11.	Powder Factor (P_f)	1.6 kg/m3	" " "	$P_f = \frac{M_c}{V} = \frac{1.14kg}{1.07m^3}$

283. Delay Detonators. The above Borehole Blast Designs were effectively employed using delay detonators. The use of the delay detonators and results achieved are explained in paragraph 150. The types and quantities of these detonators are detailed in paragraph 143.

284. Firing on more than one Face. Blast zones and faces at Fakaofo did not allow for extensive use of the advantageous 'more than one face blasting' technique. However, it was employed in areas where the full length of an

existing rock face was not removed by a single blast, (on LHS four large pattern blasts were necessary to blast the existing face). The technique of instantaneously blasting more than one face was used in patterns where a second face had been created by a previous blast, (see drawing at Appendix 6 to Annex P).

285. Infill of Fines. The boreholes at Fakaofo were subject to the same problems of infilling with fines from reef top surge during the period prior to laying the explosives as at Atafu (see paragraph 152). The period before laying the charges could be up to 14 days after the boreholes were drilled, (see paragraph 287, explaining the employment of the handdrifters and the concept of the pattern drilling procedure). No effective method was found to prevent the infilling of boreholes with fines. The technique developed on Atafu, (placing PVC hole retainers, see paragraph 152, and Appendix 5 to Annex P), was not possible due to the PVC external diameter = 60mm, borehole diameter was 58mm. The only procedure adopted for the clearning of blocked boreholes was to 're-drill' the holes with handdrifters just prior to laying the charges, see paragraph for the pattern laying procedure employed. Paragraph 153 states the rate of anticipated infill of the boreholes.

286. Drilling Rules. The Drilling Rules identified during the Atafu task, remained unchanged for the Fakaofo Reef Channel Improvement Task and were consistently adhered to. It was found that very similar results were achieved at Fakaofo and validated the rules. The Drilling Rules are fully detailed in paragraph 153, and likely undesirable results if the Rules were not adhered to, are explained in paragraph 155.

287. Concept of Drilling Procedure. The level of the Fakaofo reef in the AO was found to be @ 0.25m - 0.3m lower than that at Atafu. This meant that the area of the AO on the existing reef edge was subject to a proportionally larger volume of water crossing the reef during the in-going or out-going tides. It was also found that Fakaofo was subjected to larger and more forceful breaking waves on the reef edge. This, apparently, was due to the predominant off-shore currents and the natural draining of high tide water out of the channel at an angle to the prevalent wave motion, (see Appendix 1 to Annex Z). The size of the patterns were calculated by pre-determining the number of boreholes that could effectively be laid during the low tide period.

288. Major problems were encountered when attempting to drill handdrifter patterns on the LHS. The reef top rip, wave surge from breaking waves and (during end Apr 26 - 25 May 86) extremely short duration low tides, meant that there was the potential for the task to suffer due to accumulated down-time. To ensure that the absolute minimum amount of down-time occurred, every possible solution and alternative was considered to allow the maximum rate of drilling/blasting/clearance productivity to be achieved. The following procedure was established:

a. Low tide and any workable conditions; all work effort to concentrate on laying out and drilling of 'pilot holes' on LHS, (see paragraph 289).

b. As conditions became unworkable or early in the low tide period; drill 'pilot holes' down to design depth.

c. When conditions totally unworkable on LHS; drill patterns on LH Inner area.

289. Pilot Holes. The drilling of 'Pilot Holes' in a blast pattern was done during the best sea conditions. This ensured that the lay-out of the pattern was extremely accurate and that the boreholes were drilled in precisely the correct positions. The pilot holes were 58mm in diameter and drilled to @ 0.15m deep. These were rapidly drilled allowing for the further deepening to design depth to be undertaken during rough working conditions. To ensure the accuracy of the pattern layout and borehole locations, a 'drill guide' was locally manufactured. This was an 'L' shaped length of reinforcing rod, each arm being equal to B or S (0.85m long). The 90° corner and strengthening brace accurately displayed the location of the next pilot hole and assisted in keeping the drill bit in the correct place as the hole was commenced, (see Appendix 7 to Annex P).

290. Drilling Anchorages. Due to the rough conditions generally prevalent during the deepening of pilot holes, improvised anchorages were a necessity for the drillers safety during large waves. These anchorages were used in the following ways:

a. As fixed objects for drillers to cling on to as large wave surges swept past, and often over them, leaving the handdrifter safely in the borehole being drilled, (this ensured that the drill was at no risk of being damaged, such as bending the steel, by drillers using the handdrifter as their prevention of being 'bounced' across the reef.

b. To make specific holes or areas of the blast pattern.

c. Preventing the heavy airline lubricator, @ 2.0m from the drill on the air hose, from being washed onto the drillers legs and feet.

These anchorages were very simple and consisted of a 2.2m jumping bar inserted into a borehole @ 1.0m deep, (the borehole used was generally one that was part of the pattern but had been left shallow to allow for the insertion of the anchorage). As the deepening of pilot holes progressed, the anchorage was easily moved accordingly to ensure that it was in close proximity to the hole being drilled.

291. Blasting Priorities. This drilling procedure was sound but, at times, rather slow in terms of completing patterns on the LHS. Extremely detailed planning was required to ensure that the order in which the four patterns on the LHS were drilled, coincided with the necessary order of blasting, (see Appendix 2 to Annex Z). The reasons for this 'ordered' drilling and blasting were:

a. The expected dates of call at Fakaofo of the resupply vessel influenced the location of a blast within the AO. (Patterns on the landward side of the AO were planned for blasting during the period immediately after the ship had called, in case these blasts blocked the channel. This allowed the Team the maximum amount of time to re-open the channel. Patterns on the seaward side were less critical).

b. When proposed blasts are 'side-by-side' as on the LHS, an area of undrilled competent rock is required to act as a 'buffer zone'

between the blast and completed borehole patterns. The buffer zone was necessary to assimilate a majority of the shock waves from a blast and to absorb any resulting fracturing that could damage pre-drilled boreholes. Refer to the following example :

(1) Blast No 1, LHS - Appendix 6 to Annex Z.

(2) Pattern No 2 and 3 drilled on LHS, Pattern No 4 as Buffer Zone - Appendix 7 to Annex Z.

(3) Pattern No 3 blown (due to favourable sea conditions), Pattern No 2 complete, Pattern No 4 on Buffer Zone -Appendix 8 to Annex Z.

(4) Pattern No 4 drilled after blast of Pattern No 2, Pattern No 4 complete for blasting - Appendix 9 to Annex Z.

292. It was found after the first blast on the LHS, that the reef contained large weak cracks. These cracks were particularly difficult to identify and were believed to have been caused by previous blasting done in the channel. These cracks could only have been developed from blasting with excessive amounts of explosive. The first blast resulted in @ 2.0m of back-break as the shock waves travelled back to a major crack severely fracturing the undrilled rock between the rear row of blast holes and the crack. The debris created from this back-break caused a huge clearance task. It was decided that, to prevent this situation from reoccurring, additional boreholes would be drilled in the area between a major crack and the designed rear row of boreholes. These additional boreholes were easily loaded with on 0.5 x 55mm MOLANITE cartridge to assist in the fracturing of the rock into small debris. See Appendix 8 to Annex P illustrating this point.

293. 'Rock Popping'. Handdrifters were employed in the same manner as at Atafu in rock popping tasks for secondary explosive clearance work, see paragraph 158.

294. Coral Structure. The coral structure at Fakaofo did not differ from that encountered at Atafu, see paragraph 159, and Annex N.

295. Charge Make-up. See paragraph 160.

296. 'MOLANITE'. See paragraph 161. MOLANITE was employed in five ways during the Fakaofo task:

a. 1 x 55mm cartridge as total explosive required for the loading of 1.0m deep, 58mm diameter boreholes, (see paragraph 282).

b. 1.5 x 55mm cartridges as total explosive required for the loading of 1.5m deep, 58mm diameter boreholes, (see paragraph 282.a).

c. 1 x 0.5 55mm cartridge as total explosive required for the loading of additional 1.0m deep, 58mm diameter boreholes drilled between the designed rear row of a pattern and major cracks to account for any possible back break.

d. 1 x 29mm cartridge as total explosive required for the loading of 41mm diameter boreholes drilled into rubble for rock popping tasks.

e. 1 x 29mm cartridge as a primer for 10kg AMEX charges.

Due to the smaller diameter handdrifter boreholes, 58mm (compared with 65mm airtrac holes), the tying of the Red Cord to a 55mm cartridge had to be amended to that explained in paragraph 161. The Red cord was 'threaded' lengthwise through the cartridge by use of a locally produced 'needle'. The needle was made of PVC and had a slot at one end for the securing of the Red Cord. Once through the cartridge, a thumb knot was tied in the Red Cord to secure the explosive and the spare end taped. Care was required throughout this messy task, to ensure that the needle passed centrally through the cartridge and that the entry and exit holes of the needle were as small as possible to prevent any loss of explosive or potential for the knot to be pulled through the charge. This proceeding was found to be safe and effective, allowing for an unrestricted insertion of the charge into the borehole. See Appendix 6 to Annex Q.

297. The tying of 29mm MOLANITE to the Red Cord was as stated in paragraph 163. See also Appendix 1 to Annex Q. 29mm MOLANITE was not employed at Fakaofo in the role explained in paragraph 163c.

298 'AMEX'. AMEX charges were made up using the procedure explained in paragraph 164, see Appendix 4 to Annex Q. The employment of AMEX in the clearance of large debris and in dispersing accumulated fines is explained in paragraphs 165 ,166, 168, 169, 170 and 171.

299. 'Red Cord'. All details relating to the use of Red Cord are contained in paragraphs 172, 173a and b(1) and (2).

300. Stemming of Boreholes. See paragraphs 174, 175, and 176. (Note: the stemming funnel used to stem 58mm diameter boreholes was the same 60mm diameter PVC funnel mentioned in paragraph 153, but was modified by grinding the end of the funnel sufficiently to allow for it to fit into the handdrifter boreholes).

301. Blast Pattern Laying Procedure. See paragraphs 177, 178, 179, 180 and 181, (less paragraph 178b).

Clearance of Blast Rubble.

302. See paragraph 182. The damaged assault boats were also employed in the hand clearance operation.

303. D6U Air Winch. See paragraph 183. Winching configurations employed during the Fakaofo task are illustrated at Appendices 3 and 11 to Annex Z. Two winch positions were constructed, one being on top of the 'old sea wall' using the winch anchorage plate described in paragraph 185, (see Appendix 4 to Annex S), and the primary position which was on top of the 'new sea wall', see Appendix 1 to Annex Z. The anchorage of the winch on the new sea wall was very similar to the procedure explained in paragraph 184. The Class 30 Trackway was anchored into the backfill behind the wall using:

a. Four x 2.0m long rock anchors.

b. Two short, (0.59m long) rock anchors placed through the forward edge of the trackway.

c. A further two x 0.59m rock anchors were inserted into the concrete foundations of the Team store and the top of the right hand edge of the sea wall and connected to the trackway by 6.0m long SWR straps.

The SWR straps were tensioned in the same manner as described in paragraph 184b See illustration of the anchorage at Appendix 8 to Annex S. See Appendix Z to Annex S - Rock Anchors (Split Sets). It was not possible to mount the unit further forwards due to the request for the backfilling of areas in the vicinity of the wharf, see paragraph 304.

304. Winching Large Rocks. See paragraph 186. The retrieval of large rocks in a whole state by winching, for the backfill of areas to be reclaimed, was a priority task requested by the local elders. This was a very desirable aspect of the Task for the following reasons:

a. It encouraged the locals to become more enthusiastic about working on the Fakaofo Reef Channel Improvement Task.

b. The potential for creating extensive fines and small sized rubble in the blast zones due to the continuous use of AMEX clearance charges was considerably reduced.

c. The transportation of hand cleared medium sized debris, on the improvised raft and in the assault boats, was not influenced by prevailing sea conditions as all rubble was reclaimed for backfill, (see Appendix 13 to Annex Z).

The winch was effectively employed in pulling large rocks from the position on the new sea wall, (the winch was infrequently used anchored to the old sea wall). See Appendices 3 and 11 to Annex Z for illustrations of the employment of the winch and locations of blocks to enable a pull in a desired direction.

305. Winch Capacity. See paragraph 187 for details of the capacity of the winch when employed with the SWR in various configurations and taskings.

306. Backfilled Areas. The areas backfilled by rubble and reclaimed during the Fakaofo Task were:

a. From the wharf end of the channel for @ 15m, total area = 189m^2, volume of blast debris in backfill = 265m^3. (See Appendix 7 to Annex H and Appendix 9 to Enclosure 1).

b. An area of @ 40m^2, volume = 80m^3, backfilled behind new sea wall. (See Appendix 7 to Annex H).

c. A small area around the ramp from reef top level to the top of the new sea wall, area @ 9m^2 and volume of debris recovered = 13.5m^3. (See Appendix 7 to Annex H and Appendix 13 to Annex Z).

d. Low areas on LHS and RHS of the reef in close proximity to the channel were backfilled with large rocks. These areas were about midway up the channel and, as the high tide receded, caused a funnelling effect of the reef top into the channel and

developed incredibly strong out going rips in the channel. Volume of LHS and RHS backfill areas, total = 65m^3.

307. The chain that was employed is detailed in paragraph 187b.

308. The winch was required to be employed in adverse conditions for this type of machinery. This aspect was illustrated by the rapid deterioration of the SWR. A complete change of the CES SWR, (109m x 8mm) was conducted prior to commencing. The circumstances causing this extensive wear are explained in paragraph 187c. This same deterioration rate, unserviceable after @ three months of continual usage in salt water was also experienced at Fakaofo. No winching of large rocks for disposal in deep water out at sea was undertaken, see paragraph 304, and simplified the winching task so that all debris was recovered towards the wharf.

309. No further modifications were undertaken on the winch, other than those detailed in paragraph 189.

310. Removal of Fines with Dragline. A stated in paragraphs 190, 191, 192, and 193, the dragline operation proved totally unsuccessful in the removal of fines. The dragline employment was attempted at Fakaofo, but was quickly disregarded as extremely inefficient and unproductive.

311. Paragraphs 194 and 195 explain the use of an improvised dragline bucket constructed from a modified 209 litre drum. This was employed at Fakaofo, with only limited success, due to the larger accumulated fines (@ 0.15m diameter average). It was found that rubble of this size created problems for the bucket to 'dig-in' as it was being pulled and failed to self load effectively. Refer to Appendices 6 and 7 to Annex S.

312. The most successful and regularly employed technique used was the operation of the winch pulling a length (3.3m x 0.6m) of Class 30 aluminium trackway 'sled', hand loaded with rubble, see paragraph 196.

313. An improvised winch rope roller was manufactured by the Team and was used in front of the winch to prevent friction damage to the SWR as it wound on to the drum over the edge of the sea wall from reef top level, see Appendices 5 and 8 to Annex S. The roller was a length of mild steel round stock through a length of 50mm diameter galvanised pipe which had two bearings welded at each end. The roller was mounted on a small timber box and proved very successful.

314. Hand Clearance. See paragraphs 197, and 198. Caution was used in the selective laying of AMEX charges to avoid the risk of creating excess 'powder' fines (sand-silt). Powder fines of this nature, as experienced at Atafu, were extremely difficult to remove. See paragraphs 200, 210, 202, and 203, for additional information on relevant aspects concerning the demanding task of hands clearance.

315. It is estimated that @ 425m^3 of accumulated fines, ex-existing channel, and blast debris was hand cleared during the Fakaofo Reef Channel Improvement Task period (May 86 - early Jul 86).

316. During the Fakaofo Reef Channel Improvement Task, the two Pionjar 120 Rock Breakers were effectively employed on the following tasks:

a. Breaking of rubble into manageable sizes.

b. 'Chisel' breaking of overhanging sides of existing channel (see area shown on Appendix 7 to Annex H).

c. Compaction, using tamping pad, of back-filled areas, (see Appendix 7 to Annex H and Appendix 13 to Annex Z).

The employment of the Pionjars, as mentioned above, was effective and productive. It allowed for a lot of flexibility in the manning of the Breakers and the Aumaga were often employed on these tasks that required little or no supervision. Trimming of the overhanging sides of the channel is believed to have removed @ 65m^3 of existing rock.

317. Secondary Explosive Clearance. See paragraphs 207 and 208.

318. Rock Anchors. The Split Silt rock anchors used at Atafu were also effectively and successfully employed throughout the Fakaofo Reef Channel Improvement Task for the anchoring of blocks and winch platforms, (see paragraphs 209, 210 and 211). During the Fakaofo Task, 19 x Split Sets were used and enabled the establishment of all the winching configurations shown at Appendices 3 and 11 to Annex Z.

Technical Overview

319. A brief overview of aspects relating to the suitability of the equipment employed in the Fakaofo Reef Channel Improvement Task is compiled below. This also includes comments on the employment of explosives and records blasting statistics.

320. Equipment Performance Analysis. The following are comments relating to the performance and employment of the equipment used on the Task:

a. 375 cfm Compressor. The Ingersoll-Rand portable compressor proved to be a thoroughly reliable and dependable item of machinery. The compressor was the one essential and extremely critical factor in all work undertaken on both Channel Improvement Tasks. The success of effectively improving either of the Channels totally revolved around the performance of the compressor. The compressor was necessary to power all of the following tools and equipment:

(1) Airtrac (Atafu only).

(2) Winch.

(3) Handdrifters.

(4) Air lights.

(5) Filling of inflatable buoyancy tubes.

No back-up compressor was deployed with either Team due to the @ $36 000 value of a 375 cfm machine. During the deployment,

the compressor did 952 machine hours. It proved to be a most reliable machine with an extremely sound compressor and engine mounting assembly. The 'first' and 'last parades' were simple and straight forward. Nil hours were lost due to down-time of the compressor, (this is disregarding the suspected 'unfair play' which rendered the compressor unserviceable from 22 Mar -25 Apr 86, see Appendix 23 to Annex B). Fuel usage figures are at Appendix 1 to Annex M. The compressor was four wheeled and this permitted an ease of man-portability over rough terrain. Although under-powered for the designed air capacity required to effectively operate the airtrac, the 375 cfm compressor was capable of powering the following combinations of major equipments.

(1) Airtrac and winch (Atafu only).

(2) Airtrac and one handdrifter (Atafu only).

(3) Winch and three handdrifters.

(4) Five handdrifters.

For compressor specifications, see Appendix 3 to Annex M to Reference A. A recommended Deployment Service Kit is at Appendix 1 to Annex AA.

b. Handdrifters. Two types of handdrifters were employed during the deployment. Two light handdrifters were deployed with Team 1 and were in a 'near new' condition prior to the Atafu task. As the work load for the handdrifters increased at Fakaofo due to the RTNZ of the airtrac, (see Appendix 28 to Annex B and Annex Y) these two light drills began to wear rapidly. Up until this stage that had performed very well, but had to have the mufflers removed to prevent the fouling of the exhaust with a build up of fines as was experienced early on. This created discomfort for drillers with additional noise, particularly when drilling underwater in SCUBA equipment. The use of handdrifters on totally submerged tasks was often necessary but extremely inefficient due to the very awkward nature of the work for divers to control the drill. Generally one 1.5m deep, 41mm diameter borehole took divers @ 60 minutes to drill (one x aircylinder). Three medium handdrifters were resupplied to the Team on Fakaofo on 28 May 86 by airdrop. These handdrifters proved to be extremely reliable and far more durable to the harsh working conditions ands constant long periods of work. They were capable of drilling a 58mm borehole to 1.5m in @ 15 mins and, due to better designed shock absorbers, reduced the serious cases of 'drillers knuckles' (swelling and inflamation of all the joints in the fingers and wrist due to the vibration of the drills causing temporary arthritis, see Appendix 1 to Annex BB. The handdrifters were maintained in a highly serviceable condition throughout the deployment by washing each drill in fresh water at the completion of work and then soaking it in an oil bath overnight. The high pressure hose used throughout the deployment with great success was MANTEX hose manufactured by Atlas Copco. This hose is extremely lightweight

(16kg/100m length) and has a lay-flat construction allowing for ease of handling and storage. It proved to be extremely resistant to wear on the abrasive coral but did occasionally require repairing. Leaks generally occurred near connections due to acute angles of the Mantex and were easily repaired, see Appendix 2 to Annex AA. For Mantex specification see Appendix 2 to Annex AA.

c. Pionjars. The two Pionjar petrol drive rock drills proved to be an extremely useful resource and were effective for the following reasons:

(1) Medium/high compactive effort for the tamping of backfill.

(2) Ideally suited to the drilling-in and placing of Split Sets due to the percussion mode being able to be used in isolation of the rotation function. They were, however, found to be of limited use as breakers due to a lack of weight and direct force to shatter solid rocks. On overhanging channel sides, as at Fakaofo, a high degree of success was achieved due to the weakened coral structure. Coral is very similar to limestone and was found to powder easily, therefore it is believed that a heavier breaker would have achieved better results. Pionjars fuel consumption rate is at Appendix 1 to Annex M.

d. D6U Air Winch. The winch was a reliable piece of machinery and, once the exhaust was manifolded, was able to remain outside in all weather. It greatly increased the Teams' ability to clear blast debris in a whole state rather than being forced to resort to explosive clearance. It is believed that a winch of a greater capacity, @ 1134-1814 kg capacity (D6U = 680 - 905 kg capacity), would have significantly benefited the clearance operation and directly effected the completion date of the tasks. Two days of down-time were lost on Atafu when it was discovered that the oil breather plug was permitting moisture to enter into the air motor. The motor was then stripped and the breather was manifolded. The winch was simple to operate and had a manual brake. It did not come complete with an airline lubricator so one was permanently fitted to the winch. For air winch performance capacities see paragraph 187.

e. Split Sets. The only rock anchors used during the deployment were Split Sets and although designed for tunnel roof support, were thoroughly reliable and extremely simple to employ. The 590mm long Split Sets used were adequate for this task, and unless placed in extremely soft or porous coral, remained permanent and stable. They were extremely useful as anchorages for the winch blocks and were used in this way underwater on Anchor Rock (see Appendix 4 to Annex C). The hole in anchorage plate for attaching accessories such as shackles was found to be too small for the shackle pin. This was enlarged by gas cutting equipment and proved satisfactory. Refer to Appendix 2 to Annex S.

f. Assault Boat Raft. The only means available to the Team for the carriage of heavy engineer equipment from ship to shore to ship was by the improvised assault boat raft. The construction of the raft and the design, including the safety precautions are at Appendix 1 to Annex I. Trials were conducted as best as possible in New Zealand during the pre-deployment training on the raft including the loading/off-loading of the raft with the airtrac and compressor. The trials proved to be unsatisfactory as they did not test the raft design in similar sea conditions to those experienced at Tokelau, (to have attempted to trial the raft in extremely rough surf conditions was not viable as the raft equipment used was all that was available to the Team). A dangerous accident occurred on 26 Apr 86 on entering the Fakaofo channel where the raft was caused to overturn 'bow-for-stern'. This incident is reported in full at Annex Y. The raft proved to demand good team work between the raft I/C and the motormen. It was stable but rather slow to react to a change of direction. The OBM's did not have the ability to give the raft the necessary acceleration required for a passage through surf conditions. The construction of the superstructure was sound and it was found that during the accident, the superstructure remained secure while the assault boats aluminium construction was sheared and torn. This improvised type of raft was not satisfactory for the critical, heavy off-loading tasks of engineer machinery necessary at Tokelau.

g. Outboard Motors. Six Chrysler 45hp OBM's were deployed with Team 1 from New Zealand. These were the best available to the Team and were AFNZ 456 to Wksp then to Civilian Repair to ensure that they were in the best condition possible. Throughout the entire deployment the OBM's proved to be:

(1) Totally unreliable.

(2) Constantly requiring major servicing and cannabilising of parts from the least reliable OBM to ensure a fleet of at least four were fully serviceable.

(3) Regularly in demand for spare parts from New Zealand.

(4) Underpowered.

(5) Not suitable for long isolated deployments that necessitated the use of OBM's in a critical role.

The poor performance of the Chrysler 45's on the 26 Apr 86 significantly contributed to the rafting accident, (see Appendix 28 to Annex B and Annex Y). A Mariner 50hp OBM was airdropped to the Team on 28 May 86. This proved to be an outstanding motor that was extremely reliable and powerful. Prior to deploying from New Zealand, the Team Leader requested that four x 50hp Mariner OBM's be loaned to Op Tokelau Reef. No RNZE units were willing to release any of these OBM's. It is believed that the accident of 26 Apr 86 may not have been as serious or perhaps may have been avoided if three x 50hp Mariner OBM's had been employed on the raft.

h. Exploders. Nissan 30 shot and 50 shot exploders were successfully used on the deployment. No misfires resulted from exploder related faults. The exploders proved dependable and adequate for all blasting undertaken. It was found that after a period of @ six months in a moist/hot tropical climate, the shot firing cable terminals began to seriously corrode and the 'D' cell batteries would rapidly drain if left in the exploder for more than two days.

i. Demolition Tester. All detonator, continuity and discontinuity tests were performed using an ICI Atlas Galvanometer. This was a small, robust set that worked effectively. It recorded readings in gradients of Ω.

321. Explosive Employment See paragraph 214.

322. Blasting Statistics. The following is a statistical analysis of all the drilling, blasting and explosive work undertaken during the Fakaofo Reef Channel Improvement Task:

a. Total Blasts = 30 (includes : 1 x PR task
2 x school display
10 x excess explosive)

a. Pattern Blasts :

(1) Handdrifter -largest Blast 1) = 133m^2, expl = 130kg
- average = 77m^2, expl = 75kg

c. Clearance Blasts :

(1) AMEX - largest (Blast 19) = 43 x charges expl = 430kg

- average = 11 x charges expl = 110kg

(2) Rock Popping : - largest (Blast 214) = 12 x holes expl = 2.04kg

- average = 10 x holes expl = 1.7kg

d. No of Blastholes Drilled:

(1) Handdrifter - average blast = 75 x holes
- time/1.5 hole = 15 mins

(2) Total for entire task @ 550 x holes

e. Total Metres Drilled :

= 690m

f. Total Explosive Used:

(1) MOLANITE 55 mm = 835kg (732 carts)

(2) MOLANITE 29mm = 19. kg (113 carts)

(3) AMEX = 1120kg

(4) Detonators = 52 .

(5) Red Cord = 3100m

(6) Overall Total Explosive used = 1974kg.

g. Total Explosive Dumped or Destroyed :

(1) MOLANITE 55mm = 1284kg (1126 x carts)

(2) MOLANITE 29mm = 344kg (2022 x carts)

(3) AMEX = 905kg

(4) Detonators = 242

(5) Red Cord = 4500m

(6) Overall Total Explosive = 2533kg.

h. Total M^3 Existing Rock Blasted = 750m^3 (500 m^2)

i. Distance from Firing Point to:

(1) Closest Blast (No 1 LH Inner) = 60m

j. Total Use of Sandbags = @ 400

k. Total use of Nitropril Bags = @ 250.

Local Labour Work Force (Aumaga).

323. See paragraph 216.

324 On arrival of the Team at Fakaofo (26 Apr 86), it was discovered that no preparatory work at all had been undertaken by the Aumaga on the channel by removing the accumulated infill. The village had however constructed a timber and 6 x 209 litre drum raft, which proved to be only capable of supporting its own weight in the water unloaded.

325. The employment of local labour was agreed to, through Reference A, and the arrangements of the detailed manning was established by the Team Leader with the Fakaofo Toeaina. It was agreed that a work force of 20 men/day would assist the Team for 4 hours/day, 6 days/week. This was increased on 16 Jun 86 to 40 men/day for 6 hours/day. On nine occasions the entire Aumaga @ 80 men worked a three hour shift in the channel.

326. Command and Control. See paragraphs 222, and 223 for an identical situation to that on Fakaofo.

327. Administration of the Aumaga. The same procedure for administering the Aumaga as used on Atafu was effectively employed on Fakaofo, see

paragraphs 200, 201, 203, and 204. The Fakaofo Aumaga were also paid at the same rate of $2NZ/hour.

328. The problems identified in paragraph 230b and 230c, equally apply to Fakaofo.

329. Work Output Constants.

No of days worked (Aumaga)	= 51 days.
Average number Men/shift	= 24 men
No of man hours worked/day (average)	= 120 hours
No of man hours worked entire task	= 6120 hours
Approximate total volume of blast debris and accumulated fines removed	$=525m^3$
Volume of blast debris and accumulated fines removed/man/hr	$=0.75m^3$
Volume of blast debris and accumulated fines removed/man/4hr shift	$=2.25m^3$

Storage on Fakaofo

330. Stores and Equipment. All Team stores and equipment, (less catering/household and personal stores) were stored in the 'store' near the task site. The store was situated @ 20m from the wharf, next to a large copra shed, on a newly reclaimed area bounded by a 2.0m high seawall. The store was on a raised concrete pad and had timber and galvanised iron walls which opened as shutters, with an open interior roof to the galvanised roofing iron. The store was the Public Works store shed and was divided into three areas by timber/reinforcing mesh walls. The Team had two of these areas with lockable interior and exterior doors. The Public Works Department had timber machinery and cement in the third area. Floor area for the team = $100m^2$ and, although rather cramped, was adequate for the Teams' requirements.

331. Explosives. All explosives, including detonators, were stored in the same store explained in paragraph 330, due to no other suitable sites being available.

332. POL. All POL was stored in the shade between the store and the large copra shed. See Appendix 2 to Annex M for the types of POL used on the deployment.

333. See paragraph 235.

Diving

334. See paragraph 237.

335. Equipment. See paragraph 238 and 239.

336. Spare Parts. See paragraph 240 and Appendix 1 to Annex T.

337. Additional Equipment. See paragraph 241 and Appendicies 2 and 3 to Annex T.

338. Dive Times. The following is a record of dive times/diver, during Fakaofo task:

a. Skinner: 919 minutes, (1707 minutes total deployment).

b. Darroch: 736 minutes.

Resupply

339. The Team was resupplied at Fakaofo by two means:

a. Airdrops from RNZAF aircraft.

b. By sea from a chartered ocean-going cargo vessel ex Apia.

340. Airdrops. RNZAF airdrop resupplies included:

a. Engineering stores.

b. 1 x OBM.

c. General stores.

d. Medical stores.

e. Welfare items.

Three airdrops were received by an appreciative Team at Fakaofo, one ex P3 and two ex C130. These are explained in detail in Annex U.

341. Ship. The chartered M.V. Wairua called at Fakaofo once, with a further visit made by M.V. Kali for urgently required construction materials for the administration. The Apr 86 ship brought the Team to Fakaofo and the Jul 86 ship took the Team on return to Apia. The Team was able to demand for the resupply of:

a. Fresh Food.

b. POL.

c. Minor general stores.

d. Small quantity of beer, (paid for by personal funds).

Survey

342. The ability to be able to readily conduct x-section and longitudinal reconnaissance, confirmatory or progressive surveys of the channel was a valuable asset to the Team. Team II was fortunate to have, included in the Team as a Combat Engineer, a trained RNZE surveyor. He was of benefit during the execution of these surveys and in compiling the final survey drawings.

343. a. The equipment used throughout the deployment was:

(1) One NK-10 level.

(2) A three extension, 4m wooden staff.

(3) A magnetic mls prismatic compass.

(4) A 30m fabric tape.

(5) Abney level (ex-C130 airdrop on 7 Apr 86).

b. Although this equipment permitted an extremely accurate survey to be conducted, the shortfalls were:

(1) The wooden Army staff proved too old and out-dated. Continual problems were encountered whilst using the staff in salt water conditions as the wood became swollen and rotted. It was also extremely heavy to move around on uneven blast zones in surf conditions. Modern survey staffs are constructed of aluminium and weight @ ½ weight of a wooden staff. (See Conclusions and Recommendations in Reference A paragraphs 54 b (5), and 55 m (1). Paragraph 55 m (1) of Reference A identifies a suitable replacement staff for the current out-dated ones held in service by the Army. The staff deployed was AFNZ 37 in Tokelau on 8 Jul 86 as being beyond economical repair.

(2) A 100m fabric/steel tape was a requirement to ensure the accuracy of linear measurements. The Team had to borrow a tape from the Tokelau Public Works Department (PWD).

(3) An Abney Level was necessary to allow for an accurate survey of the outer channel mouth areas due to the rough working conditions. The airdrop on 7 Apr 86 resupplied the Team with an Abney level. This provided the Team with a dependable back-up instrument and an alternative method of attaining survey information.

(4) The NK-10 level was found to be inferior to the NK-2 used for the reconnaissance during Feb/Mar 85. The NK-10 proved to be less robust, more difficult to operate in brilliant sunlight and does not have a swivel locking screw.

344. See Appendix 1 to Annex CC for list of suggested Survey Kit items and Appendix to Annex CC for list of suggested Draughting Kit.

345. When drawing the final survey drawings, (see Appendicies 1, 2, 7 and 8 to Annex H and Enclosure 1), it was discovered that some discrepancies had occurred between the original survey drawings (see Annexes I and K to Reference A) and the final survey drawings. These discrepancies were of a minor nature and are believed to have resulted from the following circumstances:

a. The horizontal distance may not have, in all cases, been measured accurately due to prevailing sea or wind conditions

b. No permanent survey marks to indicate the location of X-sections on the Survey Control Line (SCL) were able to be placed during

the reconnaissance for future reference, (see Reference A, paragraph 13).

c. The bearing off-set from the SCL may not have been a consistant 90° in all cases. This may have given a distorted width of the channel.

346. See Appendices 1, 2, 7 and 8 to Annex H and Enclosure 1 for the plan drawings of the final survey of the Fakaofo Reef Channel Improvement Task. As Enclosure 1 to this report, the full range of detailed X-sections and plans are compiled.

Note: A mistake is believed to have been drawn on Appendicies 7 and 8 to Annex H, the drawing displays the information gained from the survey but when comparing the drawing to the ground, X-section P is believed to be 1.5m further to the LHS than drawn.

347. The Survey Sheets used to record the survey information from which the drawings were taken, are compiled as Enclusre 2 to this report.

Reporting and Recording.

348. The Fakaofo Reef Channel Improvement Task was reported to 1 Fd Sqn by:

a. Daily radio schedules (see paragraph 408).

b. Weekly Sitreps; transmitted by radio, (see Annex B).

c. Progress Charts; sent by civilian mail on the resupply vessel, (see Annex Z).

349. See paragraph 250 and Appendices 1, 3 and 4 to Annex X.

350. The completed RNZE Reef Blasting Logs for the Fakaofo Reef Channel Improvement Task are compiled as Enclosure 3 to this report.

Public Relations Tasks.

351. PR tasks were undertaken at Fakaofo on a "when available" basis. The following tasks were completed as PR activities to benefit the village and atoll as a whole:

a. Dismantling, by gas cutting, a wrecked tracked vehicle in the vicinity of the wharf (ex-1963 Army deployment).

b. Construction of two 1.0m high, 60.0m long, wire 'pig-retaining fences' parallel to LHS and RHS of channel.

c. The blasting of four large coral heads in the lagoon obstructing a major boating passage, (each @ 3.0m x 3.0m x 10.0m).

d. X-Section survey of Fale Island for Toeaina and used by a visiting archaeologist.

Move off Fakaofo.

352 10/11 Jul 86. The ship arrived at Fakaofo ex-Atafu and Nukunonu at 100600 Jul 86. The whole day of 10 Jul 86 was devoted to the off-loading of the Fakaofo cargo, visiting UN and MFA representatives and the two other respective Toeaina.

353. The Team commenced the on-load of the engineer equipment at 110630 Jul 86 and had all of the Team stores complete on board by 111100 Jul 86. Sea conditions were excellent and this was due, claimed the locals, to the fine job the Army Team had completed.

354. 12 Jul 86. The Team departed Fakaofo at 121900 Jul 86 for Apia, via Atafu and Nukunonu (to return the respective atoll delegates). Remaining on Fakaofo were the following major equipments:

a. 375 cfm portable compressor.

b. D6U air winch, including 8 m chain, shackles, spare 109m x 8mm SWR, 2 x dragline buckets.

c. Three x assault boats.

d. 10 x 6.5m lengths 50mm diameter galvanised pipe.

e. PVC guttering erected on Team Store.

f. Water reticulation system including shower/shaving facilities at ex-Team accommodation.

g. Quantity of assorted POL (see breakdown at Appendix 1 to Annex DD).

355. Items listed in paragraph 353a and 353b were left on direction from OTA/MFA. Paragraph 353c records the assault boats as remaining on Fakaofo. This is verified by Appendix 2 to Annex DD, and the boats were left in the care of the Director of Public Works to oversee the subsequent repair of the boats and desirable further distribution, one boat/atoll. (It will be seen that Appendix 2 to Annex DD is not signed by the Director of Public Works, this is due to his adamant rejection of any form of responsibility for the boats, although he was greatly in favour of these remaining in Tokelau).

PERSONNEL MATTERS

Welfare

356. The well being of the soldiers on this long deployment away from home, in an isolated location overseas, was of paramount importance to ensure the successful completion of each of the channel tasks.

357. The following factors and aspects effected the morale and welfare of the Team:

a. Allowances.

b. Type of work undertaken.

c. PR tasks.

d. Command and control of Team.

e. Fresh food.

f. Alcohol available.

g. Team functions.

h. Video and TV.

i. Communications to/from New Zealand, including next-of-kin.

j. Team compatibility.

k. Mail.

l. Local lifestyle.

358. **Allowances.** The Team were paid the following allowances:

a. Incidental Allowance : $7.15/day.

b. Laundry Allowance : $0.50/day, on the understanding that this money was to be spent on employing a local woman to do the Team's washing.

All Team members understood that the allowances were only paid to allow the servicemen a live a lifestyle which was similar to the New Zealand standard of living. However, it is believed that since this New Zealand style of life could not be achieved in Tokelau, and the incidental allowances were subsequently reduced to a minimum, some sort of allowance should be made available to compensate for the long period of work in extremely restrictive and trying conditions. This would also indicate to the soldiers that the Army was concerned with this 'hardship'.

359. The Team Leader and Team II 2IC, who were in Tokelau for the entire duration of the deployment, applied for Location Allowance on RTNZ (in

accordance with AFAD No 3, Section 5, Paragraph 2). The application was refused with the claim that this was because there was no opportunity to live a New Zealand lifestyle in Tokelau!

360. The application for Tropical Clothing Allowance prior to deploying from New Zealand was also refused when Personnel staff believed that there was no requirement for decent civilian clothes to be worn on Tokelau. This judgement proved to be totally incorrect, as the Team were constantly required to attend formal and informal functions and expected to participate in Church services each week. The wearing of uniform to these occasions was often not desirable.

3691. The payment of the $7.65 total man/day advance was confused in Sep 85 as both Ministry of Defence and the Ministry of Foreign Affairs attempted to pay the individuals. The correct government department responsible for the payment must be nominated prior to the individuals receiving the cash advance.

362. Due to the prolonged nature of Op Tokelau Reef and the completion date of the deployment being extended, the allowance advance for all Team II personnel was exceeded. An advance was forwarded to the Team at Fakaofo, but was such that a standard figure of $443.70 was paid to each individual regardless of entitlement. This meant that six Team members received too much, and subsequently had to reimburse a large amount of money on RTNZ, and was insufficient for the Team Leader and 2IC who had to reclaim the amount owing on RTNZ.

363. Type of Work Undertaken. The type of work on which the Team members were employed had a large bearing on overall Team morale. Generally the work undertaken at Atafu and Fakaofo proved to be challenging, interesting and satisfying for all those involved. A slump in Team morale occurred during the extremely frustrating period encountered at Atafu during late Mar and all of Apr 86 when major mechanical breakdowns limited the Team to mundane hand clearance tasks, (see paragraph 123, serials 27 to 33). One day/week was allowed as a rest day (Sunday) and was necessary for recuperation.

364. PR Work. Tasks of a PR nature were undertaken when suitable. These helped to boost Team morale and cohesion as a sense of good will was conveyed to the locals, (see paragraph 387).

365. Command and Control. Generally sound directions were received from New Zealand and a feeling of concern for the Team in the latter stages, from higher headquarters in New Zealand, was felt. Daily 'O Groups' were held at the completion of the day's work and it is believed these promoted group cohesion.

366. The continued month long extensions to the project adversely affected Team morale, however these were unavoidable.

367. During the changeover of the Teams in mid Feb 86, it was found to be extremely advantageous for the Team Leader and one other person to remain insitu for the purposes of continuity. This situation meant that previously gained experience could be discussed and ideas criticized when considering the task concept and employment of new, inexperienced personnel. The 'moral support' of having another person who had been away from home for the same period was also beneficial.

368. Fresh Food. The monthly resupply of fresh food was a great boost to the Team. This added greatly to the variety of food available to the Team cook and was essential for continued good health and overall welfare. The 24 live chickens taken to Tokelau as a source of fresh eggs and meat were an excellent welfare activity as they were named and cared for.

369. Alcohol Availability. Alcohol could not be purchased on Atafu and was of such a limited quantity on Fakaofo that the Team organised for the resupply of personal beer on each ship from Apia. It is firmly believed that the provision must be made for Team members to have access to beer. The resupply from Apia and payment of bills through the local Administration required considerable planning and detailed control but was believed justified to preserve and foster good Team spirit and the morale of individuals.

370. Video and TV. The video cassette recorder and television, supplied from Army sources were of considerable value as welfare items. Radio reception was extremely poor and TV could not be received. A grant was allocated to the Team from the Central Welfare Fund for the purchasing of video cassettes. 42 tapes were bought by Team 1 personnel on RT Apia and forwarded to Tokelau. These supplemented several personal tapes that belonged to various Team members. This equipment was essential.

371. Prior to leaving New Zealand, attempts were made to borrow an Army video camera but proved unsuccessful. The aim of taking a camera was to allow the Team to compile technical work related videos of task progress periodically throughout the deployment which could then be sent back to New Zealand for viewing. It is believed that, had this camera been made available, an extremely beneficial method of progress reporting and future reference would have been achieved. (One video was able to be made of the Atafu channel task on 18 Jan 86, using a visiting locals' camera, and is included as Enclosure 5 to this report).

372. Communications to/from New Zealand. The Defence radio link between Tokelau and Papakura Camp was of great benefit for Team members to talk to their Next of Kin (NOK) at pre-arranged timings. This, for most individuals, was a highlight and assisted in maintaining high spirits. See paragraph for details of scheds and communications equipment employed.

373. Team Compatibility. Op Tokelau Reef proved to be demanding for those involved who were required to live extremely close together with little or no privacy. Fortunately, all but one of the personnel on the deployment were ideally suited to working as part of a small Team in an isolated location. Personality conflicts of an extremely minor nature occurred, as could be expected, but were all satisfactorily 'defused' or settled by those involved with no outside help. (One extremely undesirable situation occurred in mid Apr 86 resulting in the RTNZ of one Team member, see paragraph 386).

374. Airdrop Resupply. The frequent airdrops were always eagerly awaited and any welfare items/personal mail were greatly received by the Team. After any airdrop, many of the Team members would comment that it made them feel 'not so far away from home'. Much gratitude was always felt by the Team for those in New Zealand responsible for the planning and organising of the airdrops. 1Fd Sqn did a fine job in keeping NOK informed of task progress and future airdrops.

375. Accommodation. The standard of Team accommodation had a great bearing, initially, on the overall Team morale. The house occupied on Atafu was adequate for the Team, although two personnel were required to sleep outside. At Fakaofo, the Team accommodation was by far substandard in New Zealand terms. See paragraphs 448 and 449 on Accommodation.

376. Mail. Mail was always keenly awaited and rapidly read. RSA Christmas Welfare Packs were received in Feb 86 and added a welcomed variety to food and drinks. No mail at all was received in Atafu on the first visit of the ship. It was believed that this became misplaced in Apia. Some letters were received after being sent via Nukualofa, Tonga, and others, sent in Dec 85 were received in Feb 86. It became frustrating for most of the Team when personal bills etc., were received in Tokelau unable to be actioned. All individuals were extremely keen to be kept 'in-the-know' as to news, promotions and personnel movements within their parent units. More information from unit SSM's would have been appreciated.

377. Local Lifestyle. The local lifestyle of Tokelau played a significant role in the morale of each individual. All Team members had to adjust to the slow pace of life and the restrictions placed upon the Team by the Toeainas (such as no work on Sundays, house was 'out of bounds' to all locals when a formal invitation was issued). The limited privacy that the Team managed to create was often destroyed by numerous locals who, from a distance, would watch the Teams activities continuously. It was not unusual to wake in the morning and see several pairs of eyes outside observing us. The locals also tended to look upon the Team as a huge charity organisation and occasionally, children were sent to the house asking for money. Any form of assistance available by the Team was always offered and this generated a feeling of good will amongst the locals. It was believed that the Team were on large allowances. Village cricket was a key village activity and would often take precedence over priority work required in the channel. When this occurred several days in a row, some bad feeling was felt by some of the Team, particularly when locals would refuse to do any voluntary work but would instead sit for hours watching the Team in the channel. The females were found to be extremely friendly and their affection for the Team could have lead to conflicts with the local men, had the Team not conducted themselves in a mature manner. Pressures from the village to attend numerous social functions did cause some individuals to become withdrawn, particularly if these were during work time.

378. The Team as a whole found it extremely difficult to accept the way the locals would neglect and continuously beat their children if they were found anywhere near us. Women were generally treated as second class citizens and were often publicly beaten-up by men using sticks and fists.

379. It became evident that emphasis had to be placed upon ensuring the Team continued to live a 'self-sufficient' existence relying as little as possible on island resources. This meant that the locals demands and requests had less 'leverage'.

380. The local cleaning/washing woman was of value. She also managed to provide some form of security around the house during work at the channel, although personal equipment and clothes did vanish from the house.

Team Selection

381. The selection of the correct type of serviceman to participate as part of a small team, working for a long period in trying conditions, overseas in an isolated location, was essential. Emphasis during the pre-deployment administration was placed upon identifying the best suited personnel. This was critical to ensure that group cohesion was promoted to enable the success of the deployment.

382. **Qualities.** The following qualities are believed to be of paramount importance when selecting individuals for a long overseas deployment involving working in water:

a. Maturity.

b. Leadership qualities.

c. Trade skill and knowledge.

d. Sound and stable home and personal life in New Zealand.

e. Ability to communicate.

f. Initiative, including an ability to improvise.

g. No adverse qualities (such as a heavy drinker, is racially prejudiced or is a loud snorer when asleep!).

h. Sense of humour.

i. Confident swimmer, (Government Diver qualified or civilian diver preferably).

j. Physically fit.

k. Loyal.

l. Trustworthy and honest.

m. Even temperament.

n. Reliable and dependable.

o. Ability to work in a small team.

p. Personality.

q. Age, suggest > 21 years old.

383. The following are points to consider :

a. In the Pacific Islands, church plays a large role in village life. All Team members must be prepared to attend church from time to time and respect the locals christian beliefs.

b. In addition to the primary trades selected, it is handy to have personnel cross-trained as:

(1) Surveyor.

(2) Carpenter.

(3) Plumber.

(4) Blacksmith.

(5) First aid.

(6) UEO/air cargo handler.

(7) Maori culture.

(8) APTI.

c. All personnel must be thoroughly competent in their primary role and must not be on the deployment to learn their trade. The deployment was excellent for developing skills and allowed individuals to use their initiative.

384. The Team 2IC must be selected with all of the above qualities, plus :

a. Man-management skills.

b. Understanding of all the trades involved on the deployment,

c. Comprehensive knowledge of Field Engineering.

d. Ability to 'forward-plan' activities.

e. Government Diver qualified.

Discipline.

385. The Team Leader was granted 'Powers of Detachment Commander' for the period 19 Oct 85 - 21 Mar 86. This was renewed in early 86 and extended until 31 Jul 86.

386. One major breach of discipline was encountered during the total of nine months overseas. This was on 16 Apr 86 and involved several team members. A civilian policeman became involved and disciplinary action resulted in one Team member being RTNZ on the Apr 86 ship. This incident was later dealt with by the Commanding Officer at 1TF.

Public Relations.

387. Every possible effort, without detracting from the primary channel task, was made to undertake as many tasks as possible of a PR nature.

388. The following tasks and activities of a PR nature were undertaken during the deployment.

a. Atafu:

(1) Upgrade of water supply, involved re-diverting roof top water direct to large holding, avoiding the damaged intermediate tanks. Used 25m of 50mm alkathene pipe and assorted connections. Increased efficiency of water catchment and storage @ 300%.

(2) Assistance in demolishing outdated Administration Building using Team tools. Surveying location and levelling new AO building foundations.

(3) Dismantling damaged Braithwaite water tank and salvaging usable material.

(4) Transportation from ship to shore of light 2 tonne tractor using Team assault boat raft on 13 Feb 86 (see Appendix 2 to Annex K.)

(5) Cooking numerous (@15) Christmas cakes for locals in Dec 85.

(6) Giving cooking lessons to interested women on alternate ways to cook or prepare local food.

(7) A large barbeque (BBQ) for @ 60 locals on a remote islet at the southern end of the atoll.

(8) Organising and running 'disco's' at the local meeting house.

b. Fakaofo:

(1) School lecture and presentation of various engineering tools and equipment including explosives, and an explosives display in the nearby lagoon of 10 x 10 kg Amex charges, one length of 800m det cord, and @150 kg of excess Molanite explosive.

(2) Destruction of four large coral heads which were destructing a heavily trafficked boat route from Fale to Fanua Fala. Each coral head was @ 5m x 5m x 10m and were reduced to small mounds < 3m high using 10 x 10 kg Amex charges on each.

(3) Constructing two pig fences parallel to the channel (one on each side) 1m high and 60m long requiring the drilling in of standards, concreting and fixing of wire mesh.

(4) Gas cutting and disposal of wrecked tracked vehicle (ex-1963 Army deployment) from wharf area.

(5) X-section survey of Fale island for reference by the Toeaina.

389. The following minor PR activities took place at both atolls:

a. Organising and running raffles for the benefit of the schools or churches.

b. Conducting 'Village' video nights, generally on Saturday, at the local meeting house using Team equipment.

c. Hosting weekly BBQ at the Team accommodation, entertaining @ 25 - 40 locals each time.

d. Adopting the role of 'Official Photographer' using the Team Polaroid Instamatic camera, at various weddings, birthday parties and funerals.

e. Supplying the local schools with books for the library obtained from Papakura Camp Library.

f. Providing the local Doctors with urgently required expendable type medical stores, if possible.

g. Fixing of various local equipment and appliances (for example, boats with holed hulls, house roofs, radio cassettes, sunglasses, sandals, OBMs etc...).

h. Storing locals' fish and meat in available space in the Team refrigerators.

Medical

390. Team I deployed to Tokelau with an extensive range of controlled and expendable medical stores including technical surgery instruments. The Team Medic position was filled by the RNZSigs Rad Op who had received relatively comprehensive training in New Zealand. RNZAMC were not able to provide a Medic, but with the local resources available in Tokelau (a qualified Doctor and hospital at each atoll) the Team did not suffer medically through the lack of a specialist.

391. Training. The respective Team Medics were each given @ six weeks medical training through the Papakura Camp Hospital. This involved some detailed study of basic first aid and also included the treatment of MIR patients regularly at each morning parade for several weeks. This proved to be of value in treating 'real' casualties, however when compared with the ailments and injuries received during the deployment, (see Appendix 1 to Annex BB), the medic should have concentrated on and had far more experience in dealing with skin infections such as boils, septic cuts, sores and rashes. It is believed that it would have been beneficial for the Medics to have had a short (1-2 weeks) TOD to an Accident and Emergency Unit in one of the local public hospitals. The hospital facilities in Tokelau were limited and extremely restricted in the drugs

available. The Doctors would often run out of expendable pain killers such as Panadeine, Panadol, Solprin, and Amoxil. Several times the Team 'repaid' the hospital staff for their services to the Team by providing a quantity of those drugs for their use. Team members were only referred to the Doctors on the Medic's direction and this was generally for the treatment of unusual tropical illnesses such as soft tissue infections or comprehensive injuries such as infected ears and eyes. Each Team Medic spent time at the local hospital observing the methods used by the locals for the treatment of common ailments. Team Medic must have completed Basic Medical Course.

392. Atafu was recovering from a recent Hepatitis epidemic on arrival of the Team and during the deployment time the epidemics occurred on the islands.

393. Ailments. See Appendix 1 to Annex BB for a detailed list of all ailments and illnesses contracted. The most common ailments affecting the Teams were:

a. Coral cuts.

b. Divers Ears (middle and outer ear infections).

c. Heat exhaustion.

d. Diahorrea.

e. 'Drillers Knuckles' (short term arthritis caused by operating hand drifters).

f. Shaving rash (salt water rash).

394. Treatment. The effective treatment of coral cuts was critical in ensuring that as many team personnel as possible were fit for work in the water. Coral cuts often began as mere scratches in the skin caused by jagged coral rocks. The small coral particles which were unable to be cleaned out of the wound with Savlon would cause it to become septic and 'ulcerate'. Some scratches often opened up into wounds 20mm wide and up to 10mm deep. The adopted treatment was to clean with Savlon immediately after leaving the water and apply Methiolate to prevent secondary infection setting in. An unavoidable aspect of working in the water constantly was that dressing would not remain on a wound and the numerous flies would eat out any new or developing tissue. As the skin began to develop over a coral cut, antiseptic cream was used if required. It was found that Methiolate was an excellent treatment and inhibited flies. Unfortunately the stock of Methiolate did not last for the entire deployment, and the Medic was forced to rely more heavily on Penicillin. Penicillin was generally only used for large cuts that showed slow or no improvement. Due to the high occurrence of coral cuts, it was found that some individuals became slightly immune to Penicillin through over exposure. The usage rate of Methiolate for an eight man team = 1 litre/month.

395. 'Divers Ears' were caused by the Team divers having to work for long periods underwater in murky conditions, generally caused by previous blasting, with a high degree of minute coral fines in suspension. This was particularly hazardous for the Demolition Safety Officer who was required to inspect blasts sites for blinds immediately after a blast. All cases of infected ears were referred to the Doctor.

396. Several cases of heat exhaustion occurred causing the patient to feel cold, tired, have sore joints and an intense headache. Body temperature was generally @ 40°C. Treatment consisted of the taking of Solprin tablets and rest.

397. Most personnel on the deployment suffered at some stage from diahorrea. This was considered an 'occupationasl hazard' and was adequately treated with Lamotil tablets or Trisul.

398. The only treatment for 'Drillers Knuckles' was rest. This, unfortunately, was not always possible due to the requirements of the task and drilling priorities. But, although rather uncomfortable, no serious disabilities resulted from excessive handdrifter drilling. Drillers were generally rotated @ every 1½ hours for a ½ hour rest.

399. Salt water rash on the face was prevented by not shaving.

400. Prevention. The prevention of job related ailments such as coral cuts was not adequately solved, but improvised pads of neoprene wetsuit material taped around the shins were useful, as were wet suit vests to protect the upper body. Once familiar with the type of treatment necessary for a particular ailment, Team personnel were able to administer their own first aid. Daily hygiene checks were conducted of the toilet/ablution area and cleanliness of the kitchen area including utensils and tea-towels. One 209 litre drum each of washing-up detergent and 'Jay-Pine' disinfectant were deployed with Team 1, this quantity was found to be far too much and a suggested usage of disinfectant for a six-month deployment = 1 x 60 litre drum and detergent = 2 x 60 litres.

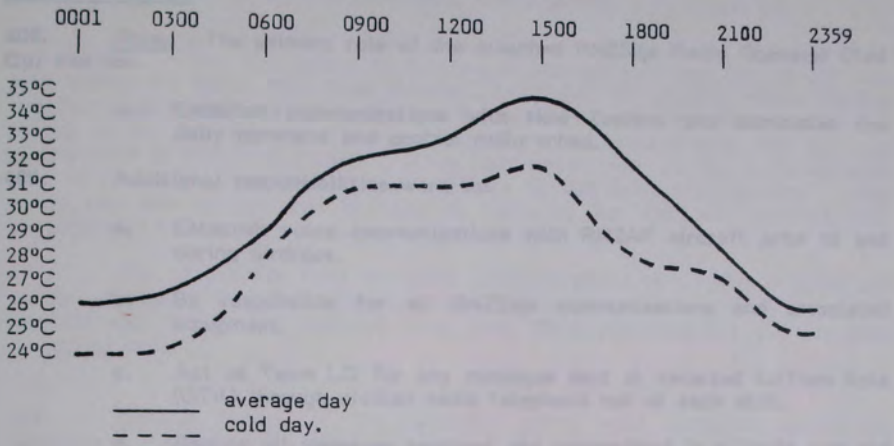
401. It was found that ear plugs (foam rubber type) were far more satisfactory for use in rough seas. They were not washed off the head and lost, and also prevented further infection setting into the ear. All Team Members also preferred the ear plugs for comfort. The full wetsuit 'jump-suits', which were used sporadically depending on the danger of the task or wind chill factor, were rapidly disregarded as a health hazard due to the expected transferral of infections from the previous wearer, as the material rubbed on any open wounds. The Team Medic was required to keep a Medical Log Book on individual's ills and this acted as a good reference for further treatment, or for the most successful method found to tackle an injury.

402. Overall, the Medic training was excellent and excellent support was received from Papakura Camp Hospital staff. It is believed that a minimum of six weeks intensive training is required to prepare a non-RNZAMC serviceman to fulfil the role of a Team Medic on this type of deployment.

403. Dental. No dental problems were encountered, although most Team members had minor complaints concerning their teeth by the end of the deployment.

404. Meteorological. It was arranged during the pre-deployment training to provide the Ministry of Transport Head Meteorological Office in Wellington with data once daily on the radio scheds which reported weather conditions at first and last light. The form 'Met 694' was used. Due to the Team receiving no feed back at all from New Zealand on anticipated approaching weather patterns and due to a lack of time, these were stopped in late Dec 85.

405. The following is a generalized temperature chart : (all temperatures are in the shade).



406. The prevalent heavy seas during the hurricane season of November to March each year did not cause any serious periods of downtime. However, the seas were extremely unpredictable during this period and the use of 'Tide Tables' would have been of great benefit had they been available. Generally the tide stayed high for a long period then suddenly receded to low tide with large waves and irregular swells.

407. Rainfall was very irregular and occurred only if a storm happened to pass overhead. On numerous occasions, when extremely low on fresh water, rainstorms could be seen passing the atoll only a couple of km away. Generally, some form of substantial rainfall (10mm - 25mm) could be expected once a week, with intermittent showers in between. The longest period with no significant rainfall was eight weeks. The Team had limited water storage facilities (total = 14000 litres) and was sufficient for the Teams' demand, see paragraph 452.

LOGISTIC MATTERS

Signals (RNZSigs)

408. Role. The primary role of the attached RNZSigs Radio Operator (Rad Op) was to:

a. Establish communications with New Zealand and administer the daily command and control radio sched.

409. Additional responsibilities were to:

a. Establish voice communications with RNZAF aircraft prior to and during airdrops.

b. Be responsible for all RNZSigs communications and associated equipment.

c. Act as Team LO for any messages sent or received to/from Apia (OTA) through civilian radio telephone net at each atoll.

d. Record all messages received and transmitted in a Radio Log and keep copies of message sent on civil net to Apia.

410. Equipment. The equipment used for transmitting and receiving messages direct to/from New Zealand was:

a. Primary Means. One x AN/GRC-106 voice/CW. (Some equipment used in New Zealand as Rear link back-up during deployment).

b. Back-up. One x AN/PRC 47.

c. Antenna. One x ANGRA 4 with AS12 diapole.

d. Power Source. One x 1.5 KVA generator through five x 12 volt wet cell batteries.

All RNZSigs equipment deployed to Tokelau is listed at Appendix 2 to Annex EE.

411. The 1.5 KVA generator was used as the only power source for the radio. It was necessary to start the generator one hour prior to a sched commencing to 'warm-up' the set. The five 12 volt batteries were used to prevent damage to the radio that could have been caused if the generator had 'surged' during as transmission. During Dec 85, the generator began to perform poorly, providing erratic outputs of power. It also began to demand constant servicing and was consuming huge amounts of engine oil @ 600 ml/3 hours of running). On advice from the Team Vehicle Mechanic, a replacement 1.5 KVA generator was requested from New Zealand and was resupplied by sea in Mar 86.

412. Problems were also encountered with a faulty module in the RF Amplifier section of the 106 set. The fault was temporarily repaired by the Rad Op but he was not confident of the set remaining fully serviceable for a

further four or five months insitu. A back-up 106 set was requested from New Zealand and received ex-P3 airdrop on 20 Jan 86. The 47 set was found to be inadequate for transmitting or receiving from/to New Zealand. See paragraph 417. for recommended back-up equipment, also Appendix 3 to Annex EE.

413. A period of limited communications occurred on arrival at both Atafu and Fakaofo. This was caused by the loss of battery acid from the 12 volt wet cells during the moves from Apia to Atafu, and Atafu to Fakaofo. Whilst loading the Team stores at Apia in Nov 85, the battery box containing the batteries was loaded on its side causing the loss of most of the battery acid, (the box was clearly marked "THIS WAY UP"). After four weeks in Atafu the batteries were able to hold a significant charge and allowed for full scale transmissions. Only minor loss was encountered en-route to Fakaofo, and this was replaced with concentrated battery acid supplied on request from Apia in Apr 86.

414. The 47 set was used for voice communications to aircraft prior to and during airdrops. Communications could generally be established while the aircraft was @ 160 km from the Drop Zone (DZ), providing the aircrew were willing to talk.

415. General Points. The following points were identified during the deployment and are worth noting:

a. A primary and alternate power source is necessary to ensure flexibility and an efficient back-up is available when one becomes unserviceable. Suggest one 1.5 KVA generator also have a 'Redfern' step-down transformer to allow the 106 to run direct from the generator, by-passing the batteries.

b. The 47 set was suitable as a back-up radio for direct communications to New Zealand, suggest also a AN/PRC 104 set be taken for use with airdrops. (See Appendix 4 to Annex EE).

c. The use of Communication Operating Instructions (COI's) became a time consuming and pointless exercise as security was consistently breached by conversations with NOK and by young inexperienced operators manning the rear-link. Designators were also compromised in this manner. It is believed that Designators should only be used in formal messages.

d. Confusion often occurred, particularly early in the deployment, when New Zealand based Rad Ops did not man the rear link at a pre-determined sched timing due to them incorrectly interpreting 'Zulu' time. This resulted in down time for the Rad Op in Tokelau.

e. It became evident that on a task such as Op Tokelau Reef, which had limited manpower resources and critical role priorities essential to be coincided with weather and sea patterns, that the 'control station' must be the work site, not the rear link. This would allow the Team to ensure that the scheds occurred during the most suitable period of the day, (taking account of atmospheric conditions also). New Zealand based Rad Ops often argued that the desired sched timings were 'too early' or 'too late'.

f. If a 47 set is deployed for use in the airdrop role and as a back-up for a 106 prime means, it is suggested that a total of six 12 volt batteries are taken. This would avoid the frustrating situation that occurred from time to time when airdsrops coincided with a sched timing. (Two 12 volt wet cell batteries are necessary to operate a 47 set and a minimum of four are required for the 106).

g. Inter-atoll moves proved to be extremely unpredictable due to various factors such as weather and mechanical performances. It was rather frustrating when a planned move was not actioned and as wet close-down period of several days had been agreed to, meaning that there was no way, other than to rely on the temperamental civil radio telephone system to pass a message to New Zealand via Apia. The most desirable situation would have been the close-down of the task site radio during the nominated period while the rear link remained manned during the normal sched hours in case of a last minute change of plans or date requiring immediate notification to New Zealand.

h. It must be remembered that Rad Ops are not trained in the repair of radio's, but can identify faults. It would be advantageous if the Rad Op prior to deploying from New Zealand spent a period of several weeks with a Radio Technician gaining experience on routine/minor repairs of the prime and back-up means.

i. During the predeployment training, a short presentation to those Rad Ops, designated to man the rear link, on 'Engineer Terms and Abbreviations' would have been beneficial for accurately and efficiently receiving messages from the task site.

416. The AN/GRC 106 set proved to be a very reliable and suitable radio for the Tokelau deployment. Had a larger range of frequencies been allocated for the deployment (through the range of 11.001 - 16.499 Mhz), workable frequencies would have been more easily identified. This would have reduced down time experienced while atmospheric conditions altered not permitting the use of the limited range of frequencies allowed on the deployment, (see Appendix 1 to Annex EE). This also would have reduced the large proportion of transmissions that had to be sent by Morse, the average SITREP (see Annex B) could take up to four hours to send if voice comms were unworkable.

417. Suggested radios to be deployed from New Zealand on future tasks of this nature are:

a. Prime means, AN/GRC 106.

b. Back-up, AN/PRC 47.

c. Spare, AN/PRC 104 (including use with airdrops).

Vehicle Mechanic (RNZEME).

418. Role. The role of the Vehicle Mechanic (VM) during the task was critical to ensure that all the Teams equipment and tools were kept in a fully serviceable state.

419. All equipment deployed to Tokelau was familiar to both VM's, less the winch, airtrac and compressor. To ensure that the Team I VM had some degree of competence with the servicing and repair of these new equipments, a short (one week) Tour of Duty (TOD) to the Ingersoll Rand workshops was organized during the predeployment training phase. This was found to be an excellent arrangement and ensured that the VM was confident of his responsibilities. Unfortunately, the same could not be organized for the Team II VM prior to his deployment.

420. No major mechanical problems were encountered during the deployment (less the compressor breakdown, refer to Appendix 23 to Annex B). When machinery became unserviceable the VM either:

a. repaired the item with locally available spare parts, including cannibalisation from other unserviceable equipment,

b. requested resupply of spare parts, or

c. improvise.

421. The VM's on the deployment proved to be extremely competent and diligent.

422. It was found, when assembling the Team stores at Papakura during the pre-deployment administration phase, that a majority of the mechanised equipment allocated required some form of servicing either locally or AFNZ 456 action. It would have been beneficial for the VM to have had sufficient time with the Team to have conducted detailed inspections of each item to identify their suitability for deployment and to anticipate likely faults. All six OBM's were sent to 'Civil Trade' to ensure they were thoroughly serviced.

423. The VM's found that all equipment required more frequent checking and servicing during the task then in normally expected in less extreme conditions (New Zealand). As the equipment was worked for a long period in the tropical conditions, common or regular faults occurred with particular items. This helped to reduce the time required for the diagnosis of the fault and indicated that a 'Preventative Maintenance' routine was required, to ensure the tools and equipment remained in as best a condition as possible. The diagnosis of more complex faults and demanding of the correct spare parts, if necessary, was relatively easy for the major equipments, 'Workshop Manuals' were available for the airtrac and the compressor. The Spare Parts catalogues with the Team were useful, but did not assist the VM in identifying faults. The request for resupply parts for other mechanical equipment, such as the handdrifters, OBMs and generators was more involved as no Spare Parts or Workshop Manuals were available. These, if taken to Tokelau, would have increased the speed of diagnosis and ensured the spare parts required were accurately demanded for.

424. Preventative Maintenance. A routine of preventative maintenance was established. This was;

a. all tools and equipment were washed in fresh water after work each night,

b. then either sprayed with a corrosion preventative solution (airtrac), of CRC and oil or submersed in an oil bath overnight (handdrifters, shackles, SWR blocks etc ...).

This simple routine proved highly effective, although was not entirely satisfactory for the airtrac, which required painting on the under chassis with an oil based gloss paint due to serious metal fatigue and corrosion. Essential equipment used by the VM is listed at Appendix 1 to Annex FF.

425. A suggested list of VM stores, tools and accessories required for the support of a Team on this type of task is attached as Appendix 2 to Annex FF. Common machinery faults and spares required are listed at Appendix 3 to Annex FF.

Catering (RNZCT).

426. Consideration. The following factors were taken account of when considering the catering requirements for Op Tokelau Reef:

a. Minimal local fresh food resources in Tokelau.

b. Small team (< 10 men).

c. Long work hours on the task.

d. Possibility of monthly fresh food resupply.

e. Limited catering appliances in Tokelau.

f. Can not rely on local store for purchasing 'dry rations'.

g. Deployment was planned for a long duration.

h. Require a healthy diet.

i. Aim to be self-sufficient.

j. Climate.

427. Three major purchases were made to assist the catering for the Team:

a. 1 x LPG oven (domestic type), 4 x gas rings, with racks, grill plate, roasting tray and baking sheets.

b. 2 x LPG/electric refrigerators, $4ft^3$.

c. 2 x LPG/electric freezers, $2ft^3$.

428. The following requirements were decided, that the food must be:

a. Appetising.

b. Nutritional.

c. Easy to prepare.

d. Provide little or no wastage.

e. Capable of being stored easily and hygienically for long periods.

f. Robustly packed.

g. Able to withstand the hot tropical climate.

429. The following types of food were considered:

a. Local fresh food in Tokelau.

b. Processed foods from New Zealand.

c. Fresh food resupply from Apia.

d. 10-man composite ration packs.

e. Live domestic poultry.

430. Local Fresh Food in Tokelau. The main diet in Tokelau consists of fish, breadfruit and coconuts. This is supplemented with coarse taro (Pulaka), pandanas, lu (a green broad leaf shrub) and a few bananas. Alternate food sources were considered because of the limited local variety available.

431. Processed Foods from New Zealand. A large range of canned meats, fruits, vegetables, milk, cheese and butter was readily available in the Papakura area. This food could be complimented by packaged dehydrated foods such as curries, stews, Vitamin C drinks, milk powder, onions and potato flakes, hot drink mixes and noodles. Condiments such as baking powder, sauces, flour, rice, raisins, biscuits and cereals were also easily obtainable from warehouse outlets.

432. Fresh Food Resupply from Apia. An allocation of @ $1000 NZ was provided for the Team to order fresh food from Apia, through OTA, for resupply on the ship (@ every five weeks). This allowed for the provision of fresh citrus fruits, vegetables, meat and cheese.

433. 10 - man Composite Ration Packs. This type of rationing was only considered as an 'emergency' source of provisions.

434. Live Domestic Poultry. A quantity of live chickens were considered, to provide the Team with fresh eggs and, when required, fresh meat.

435. It was decided to adopt the following catering plan:

a. Purchase a large quantity of processed canned and dehydrated foods in New Zealand prior to commencing the deployment.

b. Periodically purchase as much fresh food from Apia as necessary which could be adequately stored, (see requirements and orders at Annex B).

c. Deploy with ten x 10-man composite ration packs for emergency use.

d. Purchase 24 x laying hens (battery type) in Apia for transportation to Tokelau.

e. Supplement the Team's diet in Tokelau with local fresh produce as desired.

436. Menus. 28 day menus were prepared by the Team I chef prior to deploying. In practice it was found that these menus were irrelevant for the following reasons:

a. Individual preferences for types of food.

b. Change in personal eating habits (entire Team ate less than in New Zealand).

c. A snack type lunch was more practical than a prepared meal. This was eaten on the task site often at irregular timings depending on sea/weather conditions and work priorities.

d. Fresh food resupply was unreliable.

e. Dinner became the main meal of the day, less desserts. Breakfast was on a 'self-help' basis and generally consisted of cereals, fruit juice and hot drinks.

f. Team members preferred quick, easily prepared basic meals which were filling and simple to clear-up afterwards, allowing the maximum time available on the task.

g. Not all the food desired by the Team was of a 'typical tropical' nature (such as cold drinks, cooked cold meat and bread). This was due to eating habits being affected by temperature fluctuations once acclimatized. Often hot soups and casseroles were provided on wet, windy days.

h. Quick grill type meals were preferred on Friday and Saturday nights for hospitality barbeques and Team Happy Hours.

437. Budget. The Team's budget for the purchase of pre-packed processed canned and dehydrated rations was:

Scale = Small Mess Ration @ $3.50/man/day.

438. It was found that the fresh food resupply budget of @ $1000/eight men/five weeks was sufficient. This accounted for approximately 33% of the food ordered arriving rotten or inedible and @ 15% of requested items being either unobtainable or out of season.

439. Storage and Packaging. All food taken to Tokelau from New Zealand was generally removed from the cardboard box 'outers' and collectively placed inside a tough plastic bag, then inside a metal 'Cabin Bread' tin(@ 20 litre capacity). The lids were then 'spot' soldered in place and labelled with the contents.

440. This type of storage had the following advantages:

a. Food was not damaged by rough handling, pests or water.

b. Items in glass containers were not broken (these were packed in rags old).

c. Easy handling.

d. Assisted in preventing pilfering in transit and in storage.

e. Efficient storage in transit and on the respective atolls, as the square cans could be neatly stacked.

441. The corresponding disadvantages were :

a. Often too many food items of a particular type had been placed in the same tin. This meant that to obtain a large range and selection of food, several tins had to be opened.

b. The spot soldering often meant that in attempting to open a tin, the tins were rendered useless for future storage.

c. The exterior labelling of the contents may have caused the pilfering of attractive items that occurred enroute to Atafu from Apia.

d. All tins had been labelled in New Zealand prior to commencing the deployment. After @ six months exposure to sea air, the writing became difficult to read.

See Appendix 5 to Annex F for weights of food deployed from New Zealand.

442. Four 'Tuff Boy' containers were used during the task and proved useful for the storage of bulk dry goods, such as chicken mash and flour. The containers were also used for storing cordial bottles when the cardboard boxes became unserviceable.

443. Refrigeration. A $6ft^3$ fridge freezer was provided for the Team at both Atafu and Fakaofo. The refrigeration units mentioned in paragraph 360 were all used at Atafu to supplement the local fridge freezer. At Fakaofo, due to a lack of space only the small freezer units were used. These dual powered fridges and freezers were excellent. They were capable of keeping frozen goods frozen and prolonged the life of fresh fruit and vegetables. When adequately packed with 'honey comb' cardboard, the units travelled well. See Appendix 1 to Annex M for LPG consumption rates.

444. Catering Equipment. See Appendix 1 to Annex GG for a suggested list of deployment equipment, also Appendix 2 to Annex GG for expendables required for this type of deployment.

445. Role of the Chef. The role of the Team Chef was to provide food of a sufficient quantity and quality so as to satisfy the Team members. The food must aim to be nutritious, appetising and, where possible, have variety. Desirable Chef personal qualities are, to be :

a. Qualified with 'City and Guilds 706/1 and /2'.

b. Flexible.

c. Imaginative and display initiative in his food preparation.

446. General Points. The following is a list of general points related to catering :

a. The large quantity of canned and dehydrated food taken to Tokelau from New Zealand provided a wide variety of nutritional food.

b. A 'fail safe' pre-mixed bread mix was purchased from New Zealand Bakels called 'Hercules Bread Roll Mix'. This was time saving and efficient. Usage was @ 100 kg mix/eight men/three months.

c. Vitamin C based fruit drinks were found to be extremely beneficial to assist the rapid healing of wounds, (after the period of acclimatization, the standard 'Tip Top' cordial squash syrup became unpopular amongst the Team).

d. All tins, cartons and packets of food were of a small to medium size to ensure that the food that was opened was eaten and not wasted.

e. Several 10 - Man composite ration packs became water damaged and insect infested due to the cardboard packaging.

f. The live chickens proved a worth while venture. Providing they were fed 'Chicken Mash' feed, (resupplied in 40 kg bags from Apia with the fresh food), the average 'egg-laying'rate' was one egg/chicken/two days. When they failed to lay, the chickens became a Sunday roast dinner.

g. The meals provided by each Team chef were at all times excellent.

h. Team members should meet to discuss their 'likes' and 'dislikes' with the chef prior to him purchasing the food in New Zealand.

i. On long deployments, such as Op Tokelau Reef, attempts could be made to grow 'fast growing' vegetables.

Accommodation

447. At each location, the Team aimed to be totally self-sufficient for such things as :

a. Power.

b. Lighting.

c. Linen and bedding.

d. Refrigeration.

e. Cooking facilities.

448. Atafu. The Team accommodation at Atafu was of an excellent standard. The house was constructed on a concrete basement, part of which was a rain water tank. The external walls were of concrete block and had numerous louvre type windows, covered with permanent fly screens, and the roof was iron. The internal rooms were three 2 x man bedrooms, a small bathroom/shower/toilet, a lounge and kitchen equipped with cupboards, stainless steel bench and sink, running cold water and a linoleum floor. The Team's gas oven and refigerators/freezers were able to be suitably installed. Power for the house was supplied by the nearby school generator that ran for part of the day. This was supplemented by the Team's 3.5 KVA generator. Permanent lighting was reticulated throughout the house. Six European style beds were provided, the other two Team members were required to sleep outside on Army beds. All linen was provided from Team resources. An old-fashioned electric washing machine was also supplied and used by the washing woman. Due to a lack of space indoors, all eating was done outside. The house was generally easy to keep clean and required little maintenance.

449. Fakaofo. On Fale Islet, Fakaofo, the accommodation used by the Team was extremely limited and cramped. The decision to live on Fale was made by the Team Leader after considering an offer by the administration to accommodate the Team in a guest house (similar style to that used at Atafu) on Fenua Fala Island. It was considered that myriads of administrative and logistic problems would have occurred had the Team lived on Fenua Fala whilst working on the Fale channel due to the distance across water. See Appendix 4 to Annex A.

450. The Fale house was iron-roofed and had poured concrete walls. It was well ventilated by adequate louvre windows on all four walls. There were no internal walls or fixtures, but it did have a lined ceiling and a small lino covered wooden bench. The dimensions of the floor area were @ 10 m x 6 m. Once all seven beds, catering appliances (such as the freezers and gas oven) and a dining table were inside, the Team Cook had a very limited space in which to work. The Team constructed an outside shower and ablutions area. To the rear of the house, was an outdoors toilet which was topped up with water from the nearby lagoon. There was no water reticulation internally. An improvised water delivery system from water tanks to the ablutions was constructed by the Team. A permanent concrete tank @ 5000 litres capacity was adjacent to the house but was in a poor state of repair. The Team supplemented this tank with water catchment equipment improvised from Team resources (see paragraph 452). There was little storage space for food and cleaning chemicals, the floor of the house was cracked, uneven concrete which caused a rapid accumulation of dirt

and proved difficult to clean. Ants and cockroaches were in abundance. The cleaning woman would use a scrubbing board and basin to wash the linen and clothes. Due to the dense population of Fale, (islet = 200 m x 200 m with @ 350+ people!), the house was often filled with smoke from nearby local cooking fires, rendering it impossible to remain inside the house for several hours.

451. It became evident that the standard of accommodation had a bearing on individual morale, particularly when it was difficult to gain any form of privacy, (as at Fakaofo).

Water Supply

452. Fresh water was a rare but essential commodity for the Team. Rainfall on Tokelau is extremely unpredictable and, as such, droughts of several weeks are not unusual. To compensate for the irregular rainfall, the following water supply equipment was taken :

a. Two x aqualite pumps.

b. One tarpaulin, 5 m x 5 m.

c. @ 250 m x 50 mm diameter alkathene piping.

d. @ 200 m x 25 mm diameter alkathene piping.

e. Assorted alkathene fittings and G.S. plumbing accessories.

f. Two x 'Para' swimming pools, capacity 7000 litres each, (no in-service water tanks were available for the deployment.

g. 10 m of PVC roof guttering and mounting accessories.

h. One x Pool Chlorine, Poison S4, 2 kg net weight.

453. Atafu Requirements. The following water supply equipment was established at Atafu :

a. House. The Team accommodation had, as permanent fixtures:

(1) 2500 litre header tank on a 7 m tower.

(2) 69120 litre Braithwaite tank.

(3) 68400 litre capacity in house verandah tank.

As a daily task, the two holding tanks were 'dipped' to determine the volume of water. The header tank was refilled by an aqualite pump as required from the Braithwaite. It was soon discovered that the verandah holding tank was unhealthy and breeding mosquito lavae, so all roof-top water was re-directed into the Braithwaite tank. The verandah tank was then only used in emergencies. The average quantity of water held at any one time was @28000 litres, during a drought it dropped to @12996 litres. This allowed for each individual to have one shower per day and did not restrict the cook or cleaning/washing woman in

their tasks. The header tank water was chlorinated by adding the chlorine through the pump and was kept between 1.0 parts per million (ppm) and 1.5 ppm. This was sufficient to ensure the water was drinkable, without an extremely unpleasant taste.

b. Work Site. Water catchment and storage at the work site consisted of the team employing :

(1) One 7000 litre tank (Para pool).

(2) 10 m of guttering.

(3) One aqualite pump.

The 7000 litre tank was used as a source of fresh water for spraying the airtrac and tools down each night, by use of the aqualite pump and for submerging small tools and diving equipment to remove salt water. 10 m of guttering was erected on the store to direct roof top water into the tank. The quantity of fresh water held at any one time was @5000 litres.

454. Fakaofo Requirements. The following water supply equipment was established at Fakaofo :

a. House. The Team accommodation had, as a permanent fixture, an enclosed concrete water tank fed by roof top water. This was beginning to deteriorate and leaked through cracks. On arrival, the entire roof top catchment was diverted into this tank, which held @5000 litres maximum. The Team erected one 7000 litre tank nearby and 50% of the roof top catchment was rediverted into this tank. The need for a shower and some sort of ablution area was evident, so two x 209 litre drums (empty and cleaned) were mounted on a timber platform above the concrete tank, @ 3.0m high. Water was then reticulated by gravity feed through 25 mm diameter alkathene into the improvised shower box and tapped to the ablution bench. Two galvanised wash basins were permanently mounted on the bench and connected to the 50 mm diameter alkathene drain pipe from the shower. This disposed of foul water into the lagoon. The two 209 litre 'header' tanks were filled by aqualite pump from the 7000 litre tank as required (general usage rate for one shower/man/day (including shaving and washing teeth) = 19 litres, that is 400 litres/7 man team/3 days). Water in the 7000 litre tank was used in the following ways :

(1) Showering, shaving and washing.

(2) Washing of meal plates and pots.

(3) Washing of linen and clothing.

The concrete tank was used entirely for cooking and drinking. To increase the catchment area for water supply to the 7000 litre tank, a 5 m x 5 m tarpaulin was erected over the tank using an 11 x 11 tent frame. A hole was cut in the centre of the tarpaulin and a gauze filter inserted to trap dirt and leaves. This worked extremely well and also prevented any growth

of algae in the pool by negating any direct sunlight. This water was also chlorinated to @ 2.5 ppm - 3.0 ppm.

b. Work Site. The same water supply equipment was used at the Fakaofo work site as that explained in paragraph 453b.

455. General Points. The following is a list of general points :

a. The storage of water for domestic purposes in open tanks required a cover to prevent contamination and inhibit the growth of algae.

b. One x 7000 litre tank was of ample size for the work site requirements.

c. Domestic grade chlorine would be more suitable than the swimming pool chlorine used for the sterilizing of drinking water. Pool chlorine was found to be extremely concentrated and this meant that occasionally the drinking water was over chlorinated making the water relatively unpalatable.

d. Due to the intensity and quantity of rain water collected during a storm, additional mounting brackets for the guttering are required to ensure the gutter sections withstand the run-off, (approximately twice the number recommended for New Zealand conditions).

Financial Expenditure

456. The following is an analysis of overall expenditure incurred by resupply requests (ex-Apia) from the Team during Op Tokelau Reef, period Nov 85 - Jul 86, (Resupply from Apia was accounted for in the task budget. See Annex A to the document at Annex E to this report) :

a. POL

(1) Diesel. Total = $ 7558.02 NZ.

(2) Petrol. Total = $ 4726.08 NZ

(3) LPG. Total = $ 4108.57 NZ

(4) Oxygen. Total = $ 566.14 NZ

(5) Acetylene. Total = $ 488.92 NZ

b. Fresh Food. Total = $ 5463.32 NZ

c. Minor General Stores. Expenditure on minor general stores, such as welding electrodes, battery acid and live chickens :

Total = $ 132.00 NZ

d. Overall Total. Total expenditure on POL, fresh food and minor general stores :

Overall Total = $23043.05 NZ

457. See Appendix 1 to Annex HH for a monthly breakdown of expenditure whilst in Tokelau. Expenditure as at 1 Oct 85 on general stores is at Appendix 2 to Annex HH.

458. Throughout the entire deployment, the Team received extremely poor quality fuel. This would have been regarded as totally substandard in New Zealand terms. The excessive sediment and corrosion found within each drum caused the Team to waste up to one-third of a 209 litre drum.

General Stores

459. 1Fd Sqn provided @ 60% of all stores required for Op Tokelau Reef from local resources. The remaining 40% of stores were acquired in the following ways :

a. Major purchases necessitating the importing of goods from overseas. This required direct liaison with civilian companies.

b. "Local Purchase' through 1 Sup Coy, RNZAOC.

c. Other Corps (RNZSigs, RNZEME, RNZCT, and RNZAMC specialist equipment).

d. Other RNZE units (SME and 25 ESS).

e. Issue and Loan equipment (from Welfare Sect and DSS, RNZAOC.).

460. Accounting. All stores and equipment taken out of New Zealand as part of the deployment were accounted for in a MD502. Further accounting was conducted during the following periods :

a. 1 Sep 85 - 10 Oct 85; concentration, manifesting and packaging of all stores and equipment at 1Fd Sqn, Papakura.

b. 31 Oct - 4 Nov 85; checking of explosives and stores in Apia during transit.

c. 11 - 15 Nov 85; checking of stores against manifests and MD 502 during unpacking at Atafu.

d. 19 Mar 86; periodic stock-check of MD 502.

e. 21 - 24 Apr 86; compilation of manifests and stock-check of MD 502 for move to Fakaofo.

f. 28 Apr - 2 May 86; checking of stores against manifests and MD 502, during unpacking at Fakaofo.

g. 7 Jul 86; periodic stock-check of MD 502.

h. 8 Jul 86; Board of Survey, AFNZ 37 conducted at Fakaofo.

i. 9 - 11 Jul 86; compilation of manifests for move to Apia.

j. 16 - 17 Jul 86; check of stores in Apia during transit for C130 loading.

k. 23 - 25 Jul 86; 'Class A' Application for Write-off, Ty 311, conducted at Papakura Camp.

461. Budget. The budget allocated for the entire task is detailed as Annex A to the document at Annex E to this report. It will be seen that no provision was made for the purchasing of :

a. Expendable stores (see Appendix 7 to Annex F).

b. Spare parts.

c. Necessary accessories, (such as drill steels and air hose for the airtrac).

This allocation was made without any consultation with the Team Leader or Mounting Unit.

462. Expendable Stores. Usage rates of major expendable items are recorded in Appendix 2 to Annex M. These are included in this report because none were available to the Team during the acquisition of stores prior to deploying from New Zealand.

463. Packaging of Stores. All stores, less bulky/large items and food, were packed in kit-set timber boxes. These boxes were constructed by the Team, using staples, and measured @ 1.2 m x 0.6 m x 0.6 m. They were packed in such a way as to ensure that the heaviest were no more than a 'two-man-lift'. In the course of the nine month deployment, the timber boxes were subjected to 14 'major moves' and a large amount of intermediate handling. (A 'major move' is considered one of the following types: on and off the aircraft, on and off the ship, storage during transit through Apia). It was found that the majority of these boxes remained fully serviceable for @ 10 major moves. The return move to New Zealand from Tokelau would have been significantly easier to control if additional kit-set boxes had been resupplied to the Team when requested. This would have reduced the amount of equipment that had to be transported loose or bound with wire. An alternative to the requirement of resupplying kit-sets would have been the use of stronger, more robustly constructed boxes prior to deploying.

464. Bulky Stores. Bulky stores were generally bound with wire or remained individual units. (Such as the assault boats, compressor and airtrac). Delicate large items, such as the freezers and refrigerators were adequately prevented from damage by being packed in 'honey comb' cardboard.

465. Food. See paragraph 439.

466. Unnecessary Stores. The following stores were found to be unnecessary on the deployment.

a. Airlift pumps, these were totally unproductive on the removal of fines encountered in the channels, due to the majority of fines > 0.03 m diameter.

b. OPH sets (although the pins were extremely useful for various tasks and the plates were used as boat anchors).

c. Sump pump.

467 Additional Stores. The following is a list of stores not taken to Tokelau that would have been of significant benefit :

a. Lancer inflatable boat, for use as a safety boat due to its ability to work in virtually any sea conditions.

b. Lovidbond Comparator, for accurate water analysis and diagnosis, including Alum and Acid for pH adjustment.

c. Domestic household fans, to cool living areas and inhibit flies and mosquitoes.

d. Coloured smoke cannisters for airdrops.

e. AN/PRC 104 set or hand-held 'walky-talkies' for detailed control of airdrops.

f. Typewriter.

468. General Points. The following is a list of general points relating to stores :

a. The shelf-life of expendable stores must be noted prior to deploying to ensure the expiry date is after the task completion date, (such as glue and sealants).

b. Attention must be continually paid to the storage and handling of POL to prevent contamination through damage to the containers.

c. Natural fibres in cordage, tentage and clothing rots rapidly in the damp warm climate if not regularly aired when in storage.

d. Sandbags are extremely useful and can always be employed in one way or another, this causes a high usage rate.

e. The best available equipment 'Army wide' must be provided for this type of isolated deployment, due to the limited resupply and repair facilities available.

Clothing

469. All Team members received the following new issue of clothing prior to deploying from New Zealand :

a. Two x PTR's.

b. Two pairs black shorts, cotton.

c. Two x green T-shirts.

d. One pair sandshoes.

470. The following additional clothing was locally purchased for each Team Member :

a. Two pairs Rockhoppers, (hard-soled neoprene wetsuit boots, ankle high).

b. Two pairs double palmed leather gloves.

c. One x wide brimmed denim hat.

d. Two pairs 'KD' plastic sandals, (issued through RNZN).

471. The most commonly adopted dress for daily work was black shorts, Rockhoppers and/or sandals, gloves, shirt and hat. Under-pants were generally not worn to avoid causing heat/moisture rashes.

472. Analysis. The cotton black shorts issued were rapidly disregarded by all of the Team. It was found that the cotton material deteriorated and rotted quickly, and that excessive chaffing was caused to the groin. These shorts were also found to be heavy when wet and a burden when a task required long periods of swimming. Nylon shorts were worn by all individuals with no adverse results.

474. Overalls and wet-suit vests were worn for warmth and to protect divers from excessive cuts to the upper body when diving.

474. 'Velcro' binders were sown on to the wrists of the leather gloves to provide added security when using them for hand clearance work in water. The gloves were cut relatively quickly, (@ one pair/month depending on usage) due to the extremely sharp nature of coral. Gloves that were unserviceable for hand clearance work had the fingers cut off and were used when handdrifting to provide a 'non-slip' grip of the drill handles' (handdrifters expel a high proportion of oil out of the exhaust from the air line lubricator).

475. Rockhopper boots were excellent for the following reasons:

a. Protection from cuts to the feet and ankles.

b. Did not hinder movement when swimming.

c. Comfortable.

The sole was extremely durable but was prone to tear-away from the neoprene material, which wore quickly when continuously rubbed on jagged coral. The most suitable footwear found was the wearing of 'KD' sandals around the Rockhoppers. This provided stability to the ankle and protected the neoprene from excessive wear.

476. It was not necessary to wear wetsuits to keep warm when diving, but they were often a necessity when working on the reef in rain and strong winds.

Airdrops

477. General. Airdrops were a welcomed resupply activity and were considered as 'something-to-look-forward-to'. The dates and timings of the airdrops received at Atafu and Fakaofo are recorded in paragraphs 123 and 261. In total, nine airdrops were flown, six at Atafu and three at Fakaofo. Four were by C130 Hercules and five by P3 Orions.

478. Drop Zone. All drop zones (DZ) were marked by a yellow and pink 'T', (due to limited panels) constructed in the centre of the DZ and was six panels anchored to the reef by stones or galvanized pipe couplings. Smoke, from coconut husks and diesel/2-stroke oil, was provided if possible, (depending on the tides, some DZ's were underwater during the airdrops). A further three yellow panels were laid at either end of the DZ in line with the DZ in the direction of the wind. Coloured smoke cannisters would have been of benefit to indicate to the aircraft wind direction and velocity. Ground to aircraft communications were monitored by the Team Rad Op using a AN/PRC 47 set. At least one boat was always manned in the lagoon to retrieve any loads that may have landed away from the DZ.

479. DZ Locations.

a. Atafu. In centre of small island Ulugagie, @ 500 m due South of Atafu Village, see Appendix 3 to Annex A and Appendix 1 to Annex U.

b. Fakaofo. On the reef, @ 400 m N.West of Fale Village, see Appendix 4 to Annex A and Appendix 2 to Annex U.

480. Airdrop Reports. Airdrop reports were sent to New Zealand via daily scheds detailing :

a. DZ Location and how marked.

b. Number of loads received and location of each drop.

c. Serviceability of resupplied stores.

d. Time of each drop.

e. Backload details of airdrop accessories to New Zealand.

Several reports are included in Annex B.

References.

481. The following references were used prior to and during the deployment :

a. AA MLW Part 2, Engineer Training, Vol 3, Pam 1, Basic Field Engineering.

b. AA MLW, Part 2, Engineer Training, Vol 3, Pam 4, Demolitions.

c. AA MLW, Part 2, Engineer Training, Vol 3, Pam 10, Water Supply.

d. Reconnaissance Report

e. REPB.

f. P158, Shallow Water Diving Regulations.

g. Decompression time-tables.

h. Characteristics of Coral and Coral Dredging, Schlapak and Herbich, Jun 1978, Report No 213, Texas A and M University.

i. Quarry Blasting Manual, 1985, ICI NZ Ltd.

j. Pacific Islands Year Book.

482. Additional References. The following additional references would have been of benefit :

a. Local phrase book.

b. Tide tables.

ATAFU SHIP WRECK

483. A brief resume of all known information and data relating to the Atafu ship wreck and the various options available for possible disposal of the wreck, has been compiled in this section of the report.

484. Location. The remains of a wrecked Taiwanese fishing vessel, now in three sections, is grounded on the reef at the eastern side of Atafu. The approximate position of the wreck is S 8° 34.4, W 172° 28.6, (see Appendix 3 to Annex A.).

485. Reconnaissances Conducted. Two detailed reconnaissances were conducted by the Team. These were :

a. 30 Nov 85; from the landward side (Matalia). This reconnaissance determined the dimensions of the stern section and bow section. It involved snorkelling work for two individuals who, to get onto the bow section, had to be taken out to sea with the rip off the reef and swim in on the breaking waves, to the rear of the bow. The only possible way off the bow was to jump the 5.0m, timing this with a large surge of water across the reef.

b. 28 Dec 85; diving in SCUBA equipment, off boats out at sea. This reconnaissance determined:

(1) The slope gradient of the reef from the bow section to deep water.

(2) The plan of the end of the natural channel that the wreck is obstructing.

(3) The existence of a large, submerged mid-ship section of the ship, in close proximity to the bow that had not been seen previously.

486. See Appendix 1 to Annex JJ.

487. Reports. A report from the 30 Nov 85 reconnaissance was submitted and suggested three courses for explosive disposal of the wreck, (two for the bow section and one for the stern). See Appendix 2 to Annex JJ.

488. The additional information gained during the 28 Dec 85 reconnaissance is recorded in detail at Appendix 3 to Annex JJ.

489. All photos showing measured dimensions of the bow and stern sections are also included as Appendix 3 to Annex JJ.

490. No dimensions were measured of the mid-ship section due to the fierce surf conditions experienced in that area (see 'Surf Zone' on Longitudinal Section and Plan at Appendix 1 to Annex JJ). It will also be seen that no reef top measurements were recorded in the 'surf zone', again this was due to the dangerous conditions which the divers were subjected to.

491. Further Considerations. It became evident that the task of dispensing of the Atafu ship wreck would be extremely complex, expensive, and involve a large amount of 'high risk' (danger to divers), work. The additional information gained on 28 Dec 85 would indicate that :

a. Unless the mid-ship section was completely removed, disposal of only the bow section would not open the channel for use by boats.

b. Disposal of the mid-ship section would be extremely difficult due to it being firmly seated into the coral and its location in relation to the huge breaking waves.

c. A sea-going tug would be essential for the pulling of wreck debris after destruction by explosives.

d. All work in and around the bow and mid-ship sections will be extremely hazardous and dangerous for divers, particularly after the initial blasting where further jagged steel segments would be created in the 'surf zone'. Serious injuries to divers would most definitely result.

e. The bow section is extremely difficult to get on to, and would be increasingly so when carrying tools and explosives.

f. The location of the wreck is @ 6000 m from the Atafu Village. This distance is across the lagoon and can only be traversed during daylight hours due to the treacherous coral heads that grow throughout the lagoon up to the water surface level. These have not been marked, therefore all navigation in the lagoon relies upon 'local knowledge'.

g. The lagoon side of 'Matalia' is bounded by an extremely shallow shelf which travels for 500 m from Matalia to the deep water of the lagoon. Water across this shelf ranges in depth between 0.1 m - 0.5 m depending on the tide. This restricts boat movement, particularly if carrying a load, and generally travelling by foot across the shelf is the only feasible option. The shelf is 'coral mud' and extremely soft (one generally sinks @ 0.2m into the mud when walking unladen). This would cause problems for the transportation of any amount of stores or large equipment to the wreck site, (see Appendix B to Annex A).

h. The bush on Matalia is extremely dense and has only one narrow footpath which runs perpendicular to the reef from the ship wreck to the lagoon, @ 200 m in length. No other paths are in the nearby vicinity, ruling out the possibility of avoiding the coral mud and walking down the island to the wreck, (see photo at Appendix 3 to Annex JJ).

i. Matalia is not a commonly visited island on Atafu due to the huge abundance of mosquitoes and prolific insect life. When at Matalia, <u>all</u> areas of exposed flesh must be totally covered to avoid the mosquitoes, (including hands, faces and feet).

j. There are no clear areas on Matalia in close proximity to the wreck that would permit the establishment of any sort of camp or

stores dump. To clear such an area would require the permission of the Toeaina, the land owners and the provision of some sort of monetary compensation.

k. The locals at Atafu do not appear particularly concerned with a rapid removal of the shipwreck as they understand that there are no polutants from the wreck endangering their fishing from that area. In the 5½ months that the Team were on Atafu, the topic of the wreck was not raised nor was there any requirement in all that time to use the channel which the wreck is obstructing.

CONCLUSIONS

492. The following are conclusions:

a. General

(1) Op Tokelau Reef proved to be an excellent professional experience for personnel of all ranks who deployed in both Teams.

(2) Work undertaken at Atafu significantly improved the channel.

(3) The Fakaofo channel was considerably improved by the work undertaken.

(4) Any further work undertaken on the RHS of the Fakaofo channel will not greatly improve its present state.

(5) The piles of loose rocks on the sides of each channel help to prevent reef top water draining into the channel at high tide and creating a strong 'out-going' rip.

(6) The rubble piles contribute significantly to the infill of each channel with fines, as waves erode the rubble.

(7) Local people believe that all work associated with the maintenance and improvement of the coral reef channels is not their responsibility.

(8) The locals at each atoll must establish a routine maintenance programme, which should be conducted progressively, to ensure that each channel remains fully trafficable.

(9) All future teams deploying on this type of task must aim to be totally self-sufficient, with regards to:

(a) Accommodation; including bedding and linen.

(b) Water supply; including storage and treatment.

(c) Catering; including cooking, refrigeration and rations.

(d) Communications.

(e) Work related tools and equipment, less local labour assistance.

(f) Power supply.

(g) Medical.

(10) Guidance on reef channel improvements by an experienced Civil Engineer would have been beneficial.

(11) There was previously no depth of skill of coral blasting techniques within the Corps.

(12) The length of a deployment of this nature should be up to six months, but more than four months, out of New Zealand to warrant the huge logistic and administrative arrangements necessary.

(13) Deployments of greater than six months to isolated areas, such as Tokelau, may prove to be less than 100% productive, due to the personal demands imposed on the Team Members by the isolation.

b. Reconnaissance.

(1) The reconnaissance for the Op Tokelau Reef deployment was undermanned and conducted at the wrong time of year.

(2) A reconnaissance for this type of task must be manned in such a way as to accurately identify all the work required to achieve the desired aim of the task, and to correctly address the myriad of associated administrative, logistic and non-RNZE details.

(3) Any future reconnaissance must allow for a test drill of the proposed AO, to determine the coral structure and if possible, allow series of trial blasts to indicate the reaction of the coral to explosives.

(4) The short falls in the reconnaissance conducted for the Op Tokelau Reef deployment were due to:

(a) Lack of specialist reconnaissance equipment.

(b) Minimal manning.

(c) The reconnaissance was not conducted at the same time of year as the proposed commencement of the task.

(5) Had a confirmatory reconnaissance been conducted, these 'shortfalls' would have been overcome.

c. Mounting.

(1) The RNZE Mounting Unit must be nominated as soon as the reconnaissance is complete.

(2) Mounting Orders and Administration Instructions from higher headquarters, must be promulgated as early as possible to ensure that the selected personnel are released from their parent units for the pre-deployment administration phase, at the Mounting Unit.

(3) Representatives from all Corps involved with supplying personnel for the deployment must be included at all pre-deployment planning conferences and meetings.

(4) A pre-deployment administration and training phase is essential and should be a period of at least eight weeks, prior to departure, at the Mounting Unit.

(5) The Team Leader must be released from his parent unit to the Mounting Unit at least two months prior to the pre-deployment phase.

(6) All personnel, who are part of the Team, must be released from their parent units to the Mounting Unit for the entire pre-deployment phase.

(7) A storeman is required to be attached to the Team for the entire pre-deployment phase, to action and receipt stores demands from numerous sources.

(8) Thorough trials in similar anticipated conditions, of all equipment, is essential prior to the deployment.

(9) No planning figures of usage rates of expendables were available for planning purposes during the pre-deployment phase.

(10) Essential financial expenditure for items such as;

(1) spare parts,

(2) expendable stores, and

(3) CES type equipments,

must be allowed for in the overall task budget.

d. <u>Task.</u>

(1) The need to continually improvise, is a fundamental aspect of Pacific Island tasks.

(2) The clearance of blast debris and fines is a major factor in the overall task. This must be addressed in detail prior to leaving New Zealand to ensure that several methods of clearance are available on site.

(3) Coral structure changes significantly from location to location and is often composed of several contrasting layers.

(4) The blast designs adopted by the Team on Op Tokelau Reef proved to be sound for use in the type of coral encountered in Tokelau.

(5) The conduct of confirmatory cross-sectional surveys are required at each task site prior to the commencement of any work. This would enable an accurate validation of the reconnaissance results and would allow for periodic quality control checking throughout the work period.

(6) The task established comprehensive survey grids at both the Atafu and Fakaofo channels, which can be readily used, by the locals, for periodic checking of changes in channel depth and width.

e. Assistance

(1) New Zealand High Commission, Apia, displayed a concern for the Team and were willing to assist, when possible, in resolving loose administrative arrangements made by OTA.

(2) The support provided to the Team by OTA was generally sub-standard.

(3) 1Fd Sqn provided an excellent service to the Op Tokelau Reef Team in keeping the NOK regularly informed of future airdrops and task progress.

(4) All RNZAF support received via airdrops and aerial photographs was appreciated by all Team members.

(5) Apia Haulage Ltd provided a reliable,punctual and friendly service to the Team.

(6) The LO in Apia proved to be ineffectual and unreliable.

(7) Arrangements must be made for the Team to have the opportunity to express their desires for the loading procedure of cargo on to the ship. This would ensure that all stores remained undamaged and would be efficiently off-loaded at the destination.

f. Local Lifestyle

(1) Future Teams must be prepared for, and rapidly learn to live with, respect and understand the local customs, attitudes and 'way of life' on remote Pacific Islands.

(2) The local work force provided as labour assistance to the Team must be well-managed, controlled and directed on the task by the Team, but administered by the Local Administration.

(3) To encourage the locals to establish and conduct a periodic Routine Maintenance Programme, the provision of surveying equipment for local quality control would be advantageous.

g. Personnel

(1) Team Members must be carefully selected, taking into account the following criteria:

(a) Maturity.

(b) Leadership qualities.

(c) Trade skill and knowledge.

(d) Sound and stable home and personal life in New Zealand.

(e) Ability to communicate.

(f) Initiative, including an ability to improvise.

(g) No adverse qualities; (such as a heavy drinker, is racially prejudiced or is a loud 'snorer' when asleep).

(h) Sense of humour.

(i) Physically fit.

(j) Loyal.

(k) Trustworthy and honest.

(l) Even temperament.

(m) Reliable and dependable.

(n) Ability to work in a small team.

(o) Personality.

(p) Age, suggest > 21 years old.

(2) The Team Leader and Team 2IC must be Army Divers.

(3) This type of deployment requires the following non-RNZE trade supplementations:

(a) RNZCT Cook.

(b) RNZEME Vehicle Mechanic.

(c) RNZSigs Radio Operator.

(d) RNZAMC Medic.

(4) On this type of deployment, all Team members must be confident swimmers, preferably all RNZE personnel to be Government Diver trained and non-RNZE servicemen to be civilian divers.

(5) It is extremely advantageous in a small team to have a broad range of secondary skills such as :

(a) Carpenter.

(b) Plumber.

(c) Surveyor.

(d) APTI.

(e) Blacksmith.

(f) UEO/air cargo handler.

(g) Maori culture knowledge.

(h) First Aid.

(6) All personnel selected for Op Tokelau Reef, including RNZE servicemen, would have benefited from receiving refresher type instruction prior to or during the pre-deployment phase, on:

a. Explosive handling, (Demolition Handlers Course for non-RNZE personnel).

b. Small boating and watermanship skills; including knots and lashings.

c. Snorkelling, diving and safety in water, (Pre-Dive Course type training).

(7) The long deployment was personally and professionally demanding.

(8) It was difficult for the Mounting Unit and higher headquarters to understand the living and working conditions on Tokelau, due to no 'base' pesonnel being familiar with the area.

(9) The manning of a deployment of this nature should be nine personnel.

h. <u>Welfare.</u>

(1) In isolated locations with no recreational facilities, such as Tokelau, the following are important welfare aspects :

(a) Video and T.V.

(b) Beer supply.

(c) Fresh food.

(d) Highest possible rate of allowances paid.

(e) Personal privacy.

(2) The best possible standard of accommodation for the team is required.

(3) The ability for Team Members to talk to their NOK and loved ones, via the Defence radio net to Papakura, was extremely beneficial for individual wellbeing.

(4) Servicemen are keen to hear news from their parent units.

(5) Airdrops were an excellent welfare aspect.

(6) The visit of OC and SSM 1Fd Sqn during Jun 86, was a worthwhile venture and assisted in promoting the Team morale.

(7) If a changeover of personnel occurs with a small team, such as during Op Tokelau Reef, it is extremely beneficial for the Team Leader and one other RNZE serviceman to remain for continuity and support.

(8) A period of about one week is necessary for post-deployment administration. This should be conducted as soon as possible on return to New Zealand, prior to any personal leave commencing.

i. Engineer Equipment.

(1) The best available equipment must be released for use on this type of deployment.

(2) RNZE has no suitable rafting equipment necessary for the landing of medium-heavy engineer equipment, through surf conditions, on to coral reef beachheads that have had only minor development.

(3) Chrysler 45 hp OBM's are totally unsatisfactory for this type of deployment.

(4) The LM-100 airtrac drill was a durable, efficient and effective item of drilling equipment that greatly increased the Team's productivity.

(5) The D6U air winch did not have a large enough capacity for the work required of it.

(6) An air winch with a capacity of @ 1500 kg line pull would have been more suitable, and effectively employed on this type of deployment.

(7) A 'purpose built' dragline bucket that could have been effectively employed, would have greatly increased the Team's ability to remove existing and blast fines from the channels.

(8) The Corps, at present, has very limited resources of medium capacity water storage and catchment equipment.

(9) In-service, wooden Army survey staffs are not suitable for extended periods of work in tropical salt water conditions.

(10) The efficiency and safety of underwater work would have been enhanced had the divers been able to employ a civilian

type of 'work harness' for the attaching of lifelines and tools to.

j. Support Trades.

(1) Daily radio scheds were essential for allowing the flow of routine and priority messages to and from New Zealand.

(2) The use of COI's is impractical, when the same radio net is also used for Team to NOK welfare transmissions.

(3) An AN/PRC 104 set would allow the Rad Op to talk direct to the aircraft during an airdrop from the DZ.

(4) Hand-held 'walkie-talkie' type equipment would have benefited the Team during airdrops and significantly improved the control and reporting of loads dropped, from the DZ via the static defence radio to the aircraft.

(5) The Team medic must be competent in the diagnosis, treatment and prevention of tropical illnesses and ailments.

(6) Although the Team was adequately supported by the Team Medic/Rad Op; a RNZAMC Medic is required as a team member on this type of deployment.

(7) Fresh food resupplies can not be relied upon and must be considered as a 'bonus'.

(8) Food consumed during the deployment must be :

(a) nourishing,

(b) appetising, and

(c) have variety.

(9) Processed packaged food obtainable in New Zealand is durable to tropical conditions, can be easily packed and has a diverse range.

(10) The cooker and LPG/electric refrigerators and freezers were reliable and essential catering stores, which performed exceptionally well.

(11) The Medic provided to support this type of deployment must be as proficient in the diagnosis and treatment of 'diver-ills' as he is in tropical and routine type medical ailments.

k. Stores.

(1) All stores, equipment and accessories must be accurately manifested to the smallest detail when packaging for an intended move.

(2) Periodic, 100% stock checks of all Team stores are essential to ensure accuracy in accounting and justify resupply requests.

(3) Daily reconcilliations are mandatory for all controlled, hazardous, and rapidly expended stores such as :

(a) Explosives.

(b) Fuel, (consumption rates).

(c) Expendable task stores, (sandbags, insulation tape, medical resources etc...).

(4) A Lancer inflatable boat would have been extremely useful as a safety boat.

l. Clothing.

(1) Issue black cotton shorts are unsuitable for wearing on tasks in hot tropical conditions which require a high degree of in/underwater work.

(2) The wearing of nylon shorts was popular and these were found to be far more comfortable and durable than issue cotton shorts.

(3) Hard-soled wetsuit boots (Rockhoppers) worn with plastic 'KD' sandals was a sound and practical type of footwear for work on the reef and amongst rubble.

m. Public Relations.

(1) Any assistance and advice able to be offered, by the undertaking or supporting of local development schemes or charitable organisations, significantly contributed to the promotion of sound public relations between the Team and the local population.

n. Command and Control.

(1) Rank structure within the Team must be managed to ensure that the Team 2IC is the only Team member that holds his particular rank.

(2) The Advance Party must arrive prior to the Team stores, when transitting through an intermediate country, to allow for the checking of administrative arrangements.

(3) It was essential for sound command and control of the task, that the OC of the Mounting Unit and Team Leader had frequent discussions on the Defence radio net.

(4) The recording of task progress and working conditions by video is an effective way of reporting to New Zealand.

(5) A Team on this type of deployment required a competent and dependable LO for the organisation of 'base' type administrative arrangements. In the case of OP Tokelau Reef this LO would be in Apia, and should be a RNZE JNCO Storeman/clerk.

(6) MFA or associated representatives must not have any influence over the command of the Team or their movements.

(7) On the arrival of the Advance Party in Apia, MFA and OTA were unfamiliar with the basic principles of the deployment such as :

(a) Movement of Team 1 from Apia to Tokelau.

(b) Requirerment for dedicated ship sailings.

(c) The volume of Team stores.

(d) Requirements for explosive storage.

(8) A changeover of Teams on long deployments is a sound practice.

(9) The Op Tokelau Reef deployment proved that the Army 'System' works.

RECOMMENDATIONS

493. The following points are recommended :

a. General.

(1) RNZE continue to undertake deployments of this nature, on a regular basis, to avoid any loss of knowledge or experience from the Corps.

(2) No further widening work be undertaken on the RHS of the Fakaofo channel.

(3) The locals be encouraged to remove all the loose piles of rubble on the sides of each channel to avoid further infill of fines.

(4) Each channel be enclosed on both sides by firm rubble walls, incorporating gabion baskets filled with large coral debris. These would be locally constructed and prevent the drainage of reef top water into the channel.

(5) A programme of routine maintenance, involving monthly hand clearance, be established on each atoll; overseen and directed by the local Public Works Department. This would then cause all channel work to become an 'official' task and would subsequently receive a monetary allocation in the atoll's budget as a Public Works responsibility.

(6) Future RNZE teams be fully equipped with all the necessary stores and support facilities to enable the Team to live a self-sufficient lifestyle, causing as little disruption as possible to the local way of life.

(7) When major construction or blasting tasks are planned, guidance from a civil engineer experienced in coral work be obtained to determine the effective design parameters for the task.

(8) Deployments of this nature be between four - six months for a single team operation.

(9) Extended deployments for greater than six months duration have team change-overs at four monthly intervals.

(10) Comprehensive post-deployment reports, for this type of overseas task, be submitted to ensure a reliable source of reference is available for the planning of future deployments.

b. Reconnaissance.

(1) All future reconnaissances for this type of task be manned by the following personnel :

(a) OC Mounting Unit.

(b) Team Leader of the deploying team.

(c) Team Leader from the most recently completed RNZE deployment of a similar nature to the Pacific Isands.

(d) RNZE SNCO, preferably the deployment team 2IC.

(e) RNZE surveyor.

(f) Storeman of the Mounting Unit, who will act as the Teams' base logistics NCO in New Zealand during the deployment or as the LO in the intermediate country.

(2) The time of year when the initial reconnaissance is conducted be the same as the proposed task commencement date.

(3) All necessary equipment and tools, required to conduct a thorough inspection of all task related concerns, be permitted on the reconnaissance, to include test drills and, if possible, trial blasts of the coral.

(4) A further confirmatory reconnaissance must be conducted after the initial reconnaissance, to ensure that the necessary administrative arrangements are being actioned in the task location and to check on the provision of support services required from other intermediate/outside agencies, such as OTA. The Mounting Unit 2IC should be included on this reconnaissance.

c. Mounting.

(1) A period of at least eight weeks be allocated for all team personnel to concentrate at the Mounting Unit for pre-deployment administration, training, trials of equipment and logistic arrangements.

(2) The Team Leader be released from his parent unit two months prior to the pre-deployment phase, to commence detailed planning at the Mounting Unit.

(3) Arrangements be made, through the early promulgation of authorities, for all team members to be released from their parent units for the entire pre-deployment phase.

(4) All Corps that are to be involved with the deployment, be represented at all planning conferences and meetings.

(5) A reliable and competent NCO storeman from the Mounting Unit be attached to the Team for the entire pre-deployment

phase, deployment period, and the short post deployment phase.

(6) An allocation of finance be made in the overall task budget for the purchasing of spare parts, expendable and CES type stores.

d. Task.

(1) A validation of reconnaissance information be conducted prior to the task commencing, (during the confirmatory reconnaissance).

(2) Considerable attention, prior to deploying, be given to establishing several sound and efficient methods of the disposal and clearance of blast debris and fines.

(3) Periodic quality control checks are undertaken throughout the task.

e. Assistance.

(1) LO's for future tasks of this nature, involving an intermediate foreign country, be provided by Army. Suggest a JNCO storeman/clerk from the Mounting Unit.

(2) Supporting outside agencies be fully briefed on the Teams' support requirements for the deployment and be committed to providing a reliable service. This would be checked on during the confirmatory reconnaissance.

(3) Apia Haulage Ltd be used on future Army tasks requiring the transportation of cargo around Western Samoa.

f. Local Lifestyle.

(1) The Team, prior to deploying, receive comprehensive and detailed presentations on, the local;

(a) customs,

(b) language,

(c) protocol,

(d) social stratification,

(e) religious beliefs,

(f) food, and

(g) attitudes.

(2) Detailed specifications and a 'Terms of Reference' for the employment of the local work force assistance, be established

on site to allow the Team to control and direct the taskings without becoming involved with the administration of the workers.

(3) OTA purchase survey equipment for each atoll in Tokelau, to enable the locals to conduct regular checks of the channels to determine any undesirable changes.

g. **Personnel.**

(1) The criteria listed in paragraph 492 g. (7) be adhered to when assessing the suitability of a serviceman for this type of deployment.

(2) All Team members be confident swimmers and, as many as possible, be diver trained.

(3) The manning of future teams involved on this type of task be :

(a) Team Leader (RNZE Diving Officer)

(b) Team 2IC (RNZE SNCO Diver)

(c) Three Combat Engineers (Divers)

(d) Cook (RNZCT NCO, Cpl minimum)

(e) Vehicle Mechanic (RNZEME NCO, Cpl minimum)

(f) Radio Operator (RNZSigs NCO)

(g) Medic (RNZAMC NCO).

(4) Training for all selected team personnel, prior to deploying, involve :

(a) Small boating and watermanship skills, including knots and lashings.

(b) Snorkelling, diving and safety in water (Pre-Dive course type of training).

(5) Non-RNZE personnel receive training in explosive handling (Demolition Handlers course).

h. **Welfare.**

(1) Emphasis be placed upon providing the following :

(a) High standard of accommodation.

(b) Fresh food.

(c) Beer supply.

(d) Video and TV, including a camera for personal and work related tapes to send home.

(e) Means for Team members to talk to their NOK.

(f) Frequent news relating to the Teams' parent units and peers.

(g) Welfare items via airdrops.

(h) A liaison visit to the task site by the mounting unit OC and SSM.

(i) An efficient mail delivery system.

(j) High rate of allowances.

(2) When a change-over of teams occurs, the Team Leader and one other RNZE serviceman remain insitu.

(3) The minimum possible post-deployment period, at the mounting unit on return from the task site, be administered.

i. Engineer Equipment.

(1) Priority loan of the Corps equipment and stores be given to the conduct of this type of deployment.

(2) RNZE develop the capacity for the safe landing of medium-heavy engineer equipment, through surf conditions, on to coral beachheads that have had only minor development, by the acquisition of comprehensive rafting equipment.

(3) Chrysler 45 hp OBMs not be used for this type of deployment.

(4) The Corps procure the following equipment for future deployments of this nature :

(a) Light, compressed air driven airtrac drill with the capacity to drill 65 mm diameter boreholes to a depth of 3 m and complementary portable compressor, suggest the Ingersoll-Rand LM-100 airtrac and P375 compressor.

(b) Man portable air winch with a line pull capacity of @ 1500 kg, suggest the Ingersoll-Rand HU winch.

(c) Dragline bucket, compatible with the air winch capacity, designed for the removal of blast debris and fines for use in and under water.

(d) Open and enclosed medium capacity, @ 7000 - 10000 litres, water tanks.

(e) Modern, lightweight aluminium survey staffs to replace the outdated, cumbersome wooden staffs, currently in service. Suggested replacement is :

(i) 5 m aluminium three extension 'Mizoguchi MFG' Co Ltd Japan survey staff which comes complete with a nylon carrybag. This item is currently used by the Ministry of Works and Development.

j. Support Trades.

(1) A Defence radio net is established between the task site and the Mounting Unit.

(2) An AN/PRC 104 set is deployed on similar tasks that involve airdrops.

(3) COI's are not used if the net is used for welfare/NOK conversations.

(4) The majority of all food to be consumed during the deployment be purchased and packaged in New Zealand and deployed to the task site with the Team.

(5) The gas cooker, two LPG/electric refrigerators and two LPG/electric freezers purchased for Op Tokelau Reef remain at 1Fd Sqn for future deployments to the Pacific Islands.

(6) The Team Medic undertake a course of instruction in the diagnosis and treatment of 'diver-ills'.

k. Stores.

(1) Whenever a task involves dangerous work in heavy seas, as did Op Tokelau Reef, a Lancer inflatable boat be deployed for use as a safety boat.

(2) Routine, thorough stock checks of all Team stores be conducted throughout the deployment.

(3) Detailed manifests be compiled for all moves.

l. Clothing.

(1) Nylon shorts, in lieu of cotton, be issued for overseas deployments.

(2) Hardsoled wetsuit boots (Rockhoppers) and plastic 'KD' sandals be worn on tasks involving work on coral reefs.

m. Public Relations.

(1) At every opportunity, future Teams undertake as many public relations type tasks as can be managed, without detracting effort from the primary deployment task.

n. Command and Control.

(1) The rank structure within a Team be such that the Team 2IC is the only serviceman holding his particular rank.

(2) The Team Leader and OC Mounting Unit have regular discussions via the Defence radio net.

(3) A video camera be provided for all deployments to allow for accurate recording and reporting of task progress and working conditions, when forwarded to New Zealand, and for future reference.

(4) The deployment of an Advance Party precede any movement of task stores out of New Zealand.

(5) Supporting Government organizations fully understand that the command and control, including employment, of the Team is an Army responsibility.