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POLLUTION SOURCES SURVEY OF THE KINGDOM OF TONGA

South Pacific Commission

Noumea, New Caledonia

November, 1984

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SOUTH PACIFIC REGIONAL ENVIRONMENT PROGRAMME

Noumea, New Caledonia

TOPIC REVIEW

POLLUTION SOURCES SURVEY OF THE KINGDOM OF TONGA

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South Pacific Commission
Noumea, New Caledonia
November 1984

P R E F A C E

Twelve years ago, the United Nations Conference on the Human Environment (Stockholm, 5-16 June, 1972) adopted the Action Plan for the Human Environment, including the General Principles for Assessment and Control of Marine Pollution. In the light of the results of the Stockholm Conference, the United Nations General Assembly decided to establish the United Nations Environment Programme (UNEP) to " serve as a focal point for environmental action and co-ordination within the United Nations system " (General Assembly resolution XXVII of 15 December 1972). The organizations of the United Nations system were invited " to adopt the measures that may be required to undertake concerted and co-ordinated programmes with regard to international environmental problems ", and the " intergovernmental and non-governmental organizations that have an interest in the field of the environment " were also invited " to lend their full support and collaobration to the United Nations with a view to achieving the largest possible degree of co-operation and co-ordination ". Subsequently, the Governing Council of UNEP chose " Oceans " as one of the priority areas in which it would focus efforts to fulfil its catalytic and co-ordinating role.

The Regional Seas Programme was initiated by UNEP in 1974. Since then, the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans.

The Regional Seas Programme at present includes eleven regions (1) and has over 120 coastal States participating in it. It is conceived as an action-oriented programme having concern not only for the consequences but also for the causes of environmental degradation and encompassing a comprehensive approach to combating environmental problems through the management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of the marine and coastal environment. The action plans promote the parallel development of regional legal agreements and of action-oriented programme activities (2).

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(1) Mediterranean, Kuwait Action Plan Region, West and Central Africa, Wider Caribbean, East Asian Seas, South-East Pacific, South Pacific, Red Sea and Gulf of Aden, East Africa, South-West Atlantic and South Asian Seas.

(2) UNEP : Achievements and planned development of UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies. UNEP Regional Seas Reports and Studies No. 1, UNEP, 1982.

R E S U M E

Sont présentés dans ce rapport les résultats d'une étude des sources de pollution au Royaume de Tonga. Les risques écologiques les plus aigus sont dus aux rejets des eaux usées des installations touristiques et aux techniques de pêche destructives qui causent la mort des coraux. Les risques chroniques sont dus à l'utilisation de peintures au plomb dans les canalisations d'adduction d'eau, à l'usage croissant des pesticides, à l'envasement des ports et à la construction de chaussées san systèmes de drainage.

Les mesures proposées pour prévenir tout risque futur de pollution sont notamment des restrictions aux importations de produits chimiques dangereux, l'amélioration de la gestion des déchets solides, la prévention des déversements d'hydrobarbures et des études d'impact sur l'environnement.

La semaine nationale de l'evironnement, le projet d'installation de fosses septiques, le plan de création d'un centre des petites industries, l'operation "vanille", l'amélioration de la raffinerie de coprah, la législation relative à la protection de l'environnement sont des mesures positives allant dans le sens de l'amélioration de la qualité de l'environnement.

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INTRODUCTION

1. The Kingdom of Tonga, in its 1980 summary of environmental conditions (SPREP Country Report 13), indicated its need to review ecological conditions and possible sources of pollution, to create "a working foundation of knowledge" with which the Government could safeguard its natural resources and public health.

2. The South Pacific Commission, through its South Pacific Regional Environment Programme agreed to provide assistance with an inventory of Pollution Sources within the Kingdom and Dr. Richard Chesher of the Marine Research Foundation was funded to conduct the survey.

3. A pollution sources survey is a tool developed by the United Nations Environment Programme (UNEP) and the World Health Organization (WHO) to facilitate environmental management. It results in a document which contains an inventory of discharges of pollutants into the sea, rivers, or estuaries of an area. The document provides a single location for important information about discharges as well as maps showing their location and the nature of the environment where the effluent is discharged.

4. An inventory of pollution sources has a wide range of uses for environmental protection. For example:

Obtaining the location, characteristics and expected impact of existing discharges.

Establishing which sources need monitoring programmes and where to locate sampling sites, measurement frequencies, and assessment of environmental effects of the discharges.

Definition of pollution control programmes and formulation of pollution control laws and regulations.

Preparation of preliminary environmental impact assessments.

Finding essential information for quick pollution control action in the event of severe environment-related public health problems.

Discovering links between pollutants and diseases.

Improving future site selection and construction practices for discharges.

5. In general, pollution sources surveys are useful for formulation of environmental protection policies in national development plans, and in allocating resources and setting priorities for environmental health and pollution control programmes.

DEFINITIONS

6. STUDY AREA: Coastal areas of the Kingdom of Tonga from Tongatapu north to Vavau, and including Nomuka, Hifaava, Lifuka, and Foa.

7. POLLUTION: The Intergovernmental Oceanographic Commission defines marine pollution as:

> "The introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources; hazards to human health; hindrance to marine activities including fishing; impairing the quality for use of seawater and reduction of amenities." (UNESCO, 1982).

8. HEALTH HAZARDS: Pollutants which directly endanger human health through contamination of food or water, including:

> Microbial Pollutants including viral, bacterial, fungal, and parasitic organisms generally from sewage discharges.
>
> Organic Chemicals including pesticides, medicines and drugs, industrial dyes, petroleum products, and PCB plasticizers used for road surfacing, electrical transformers, newspaper print, etc.
>
> Metalic Poisons such as lead, mercury, cadmium, and arsenic, which may accumulate in foods.

9. ENVIRONMENTAL HAZARDS: Pollutants which endanger the health and productivity of marine and terrestrial ecosystems. These are also hazardous to humans because of the resultant loss of essential life-support functions including food, shelter, and circulation of nutrients. Economic loss may also result from ecosystem degradation when valuable plants or animals are lost.

10. In addition to the pollutants listed above as dangerous to human health, environmental hazards include:

Destructive fishing techniques such as poisons or coral breakage.

Siltation

Thermal discharges

Pesticide residues

Blockage of water flow and/or migration routes

Land fill activities

11. ENVIRONMENTAL CAPACITY: The rate of introduction of a pollutant which will not result in major adverse ecosystem changes.

12. CRITICAL TARGETS: Key organisms, processes, or conditions which, if killed or altered through pollution, will result in far ranging degradation of the ecosystem.

Stony Corals, for example, are vital to the productivity of the Tongan marine environment and, if these are destroyed, the productivity and stability of coastal areas will decrease.

13. Critical Targets and environmental capacities are often not known and difficult to discover. Ideally, however, when standards are set for various pollutants, the most sensitive critical organism which might be killed or injured must be the one on which minimum discharge rates are set.

14. Critical Targets can also be conditions such as aesthetic quality. An example might be degradation of a scenic beach by litter, garbage, or oil spills.

15. ACUTE HAZARDS: Cases in which pollution has already exceeded critical levels and action is required immediately. In terms of human health, this would indicate pollution which is of immediate danger. In cases of environmental hazards, this indicates conditions in which the environmental capacity has been exceeded and critical targets are in rapid decline.

16. Acute condition also refers to poisoning or illness which may result in death.

17. CHRONIC HAZARDS: Cases in which pollution is causing long-term degradation. In terms of human health, this would include low level poisoning from lead in paints and pesticide build-up. In environmental hazards it refers to trends in environmental degradation such as siltation of harbour areas and subsequent ecosystem decay. In general,

chronic conditions are less obvious and require longer periods of treatment.

18. Chronic condition also refers to levels of poisoning or illness which do not result in death but may lower growth rates, reproductive ability, resistance to other stresses, or slowness of response.

METHODS

19. Pollution Sources Surveys are designed to provide an inventory of industrial and municipal sources of pollution. WHO/UNEP methodologies were derived for large-scale analysis of continental, industrialized land masses. In general, the first stage of these surveys is to list the industrial activities and consider their probable discharge of pollutants based on existing information.

20. Because most Pacific Islands have little industrial activity, SPREP decided to take the pollution sources survey to the second stage: examination of the discharges and the coastal and marine environment. Thus, a more field-oriented approach was used in Tonga as a model for future SPREP Pollution Sources Surveys.

21. A team was assembled with the Ministry of Lands, Survey and Natural Resources, the Ministry of Health, and the SPREP project director. The team was comprised of:

> SPREP Project Director: Richard Chesher, Ph.D. Marine Ecologist.
>
> Project Co-ordinator: Taniela Tukia, Physical Planner, Secretary to the Energy Committee, Ministry of Lands, Survey & Natural Resources.
>
> Public Health Inspector: Lelea Tuitutou, Senior Public Health Inspector of the Environmental Section of the Ministry of Health.
>
> Economic Impact Inspector: Viluila Mafi, Land Evaluator, Ministry of Lands, Survey & Natural Resources.
>
> Surveyor: Fredrick Wolfgramm, Ministry of Lands, Survey & Natural Resources.

22. Following a two-day discussion on the goals and methods of conducting a Pollution Sources Survey, the team drew up a list of activities which might be causing pollution (Table 1). Data sheets were designed and printed to record specific information about each pollution source during the progress of the survey (Figure 1).

TABLE 1

ACTIVITIES INVESTIGATED FOR POLLUTION SOURCES

AGRICULTURAL AND LIVESTOCK INDUSTRIES:

Feed Factory (Under Construction: Discharge to treatment plant and Drainage field).

Chicken Layers (All wastes used for fertilizer or feed. Smell reported to be disturbing in one of the three examined).

MANUFACTURING:

Slaughter Houses (2) (Wastes used as feed or fertilizer, washings to septic tank and drainage field).

Poultry Processing (No discharge).

Sausage Packing Plant (No discharge, washing to septic tank).

Milk Plant (No discharge, washing to drainage field).

Fruit Canning (Small Industries Center, Under Construction).

Fish Market (Washings into sea).

Coconut Oil Refining (No discharge).

BEVERAGE INDUSTRY:

Two soft drink bottling factories (wash water to drain field).

INDUSTRIAL CHEMICAL MANUFACTURE:

Paint Mixing (solid waste, container, and lead problems).

Soap Manufacture (no discharge, solid wastes used for fuel).

POWER PLANTS:

Tongatapu (discharge of thermal effluent, oil & detergent)
Lifuka (no discharge).
Vavau (no discharge).

TABLE 1: ACTIVITIES INVESTIGATED (Continued).

SEWAGE PLANTS:

Primary treatment with effluent pumped to drainage ponds; no discharge into marine or river environments.

Vaiola Hospital

Liahona High School

Tukutonga

HOTELS AND PUBLIC BUILDINGS:

Dateline Hotel (Discharge of septic tank overflow onto reef).

Friendly Island Motel (No discharge)

Good Samaritan Inn (No discharge but solid waste disposal problem).

Paradise Hotel (Septic tank overflow onto reef).

Public Toilets in Neiafu Harbor (Septic tank seepage onto reef).

Public Buildings (Septic tanks to drainage fields).

Stowaway Motel (Septic tanks for each duplex, drainage fields).

Vavau and Lifuka Hospitals (Septic tanks with drainage fields).

GROUND WATER RUN-OFF FROM URBAN AREAS:

Street drains in Nuku'alofa and Neiafu.

SOLID WASTE DISPOSAL:

Litter (generally not a severe problem except Neiafu waterfront).

Tukutonga (Mangrove fill).

Makeke (Ocean dump).

Fangaeva (Mangrove fill).

Sludge Drying Beds (Tukutonga, Vavau, no problems observed).

TABLE 1: ACTIVITIES INVESTIGATED (Continued).

QUARRIES AND LAND FILLS:

Nuku'alofa waterfront and Queen Salote Wharf (Lagoon siltation).

Neiafu wharf (Lagoon siltation)

Lauaki Quarry (Lagoon siltation)

Tukutonga Quarry (No discharge)

Vaina Quarry (no discharge)

Causeways in Vavau (2) and Ha'apii (1) (Water circulation stopped).

GROUND WATER RUN-OFF FROM AGRICULTURAL LANDS:

Pesticides and Fertilizers in Tongatapu, Lifuka, and Vavau.

Experimental farms (Tongatapu, Lifuka, Vavau).

Farm areas (Tongatapu, Lifuka, Vavau).

FISHING ACTIVITIES:

Poisons, coral breakage.

Figure 1. Data Sheets for Tongan Pollution Sources Survey.

STATION NUMBER MAP REF

NAME AND LOCATION

MEANS OF DISCHARGE

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE

(Indicate: Wind Direction, North, Currents, Wave Action)
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE
AMOUNT OF WASTE
PERIODIC DANGERS

DILUTION AT DISCHARGE POINT Good: Fair: Poor:
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:

HEALTH HAZARD

ECOLOGICAL HAZARD

USES OF STATION AREA: Fishing Swimming Tourism
Food Gathering (List kind of food taken)

OTHER USES

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION

INSPECTOR DATE

PHOTOGRAPH: Taken at location marked "P" on the chart.

23. Previous studies done in Tonga on the subject of pollution and environment were reviewed (see References). It was noted that such studies were not readily accessible and it is recommended that:

> RECOMMENDATION 1: A central library be established containing all reports, studies, documents relative to pollution and environment conducted within the Kingdom of Tonga. This reference library should be indexed according to subject and author and kept in the Department of Lands, Survey, and Natural Resources.

24. Such a library is essential to the quality and quantity of work produced by anyone working in the environmental field in Tonga.

25. All of the places listed in Table 1 were visited by the team and, data sheets filled out for those activities which had a discharge into the marine environment or which might indirectly contribute to marine pollution.

26. In addition, a general inspection of the marine communities was conducted by the Project Director at locations indicated on Figures 2 through 7 and Table 3 (see Atlas page 49).

27. The survey was primarily an examination of potential pollution sites and a visual, qualitative inspection of discharges and their apparent impact on the marine communities. Possible pollutants normally associated with specific activities are itemized in the data sheets or in the discussion of findings. Samples were analyzed in two instances: Sewage discharge from the Dateline Hotel (Station 102A Tongatapu) and Lead in Paint.

28. Color photographs of the discharge sites were taken which will provide base-line information on the abundance and distribution of organisms in the vicinity of the various discharges.

ACUTE HAZARDS:

SEWAGE DISCHARGE FROM TOURIST FACILITIES (Stations 102A Tongatapu, 101 and 108 Vavau).

29. The Dateline Hotel, Paradise Hotel, and the Public Toilets on the Neiafu Wharf receive wastes from thousands of tourists each year. These people come from all over the world and may carry a wide range of communicable diseases including cholera, typhoid, hepatitus, as well as numerous parasites.

30. These, and other, ailments can be transmitted by sewage to marine organisms such as clams, and thus into the Tongan community if these organisms are eaten.

31. The Dateline Hotel discharges up to a million gallons of effluent per month onto the reef flat immediately adjacent to the fish market.

Shellfish are often stored or washed in the water which is directly down-current of the hotel effluent. People were observed collecting shellfish to eat within 20 meters of the discharge pipe.

32. The discharge pipe originally extended to the reef edge but has been broken and discharges onto the reef flat itself. Samples from the pipe showed no chlorine ions and coloform bacteria counts higher than could be counted.

> RECOMMENDATION 2: Put signs surrounding the reef area between Yellow Pier and the Vuna Wharf written in Tongan indicating the water is polluted and forbidding swimming or fishing or washing of food in the water. Repair and activate the chlorinator on the septic tank storage tank. Build appropriate drainage fields for the septic tanks.

33. The existing system assumes the chlorination will work continuously, which it obviously does not. It also fails to allow for short, but perhaps deadly, lapses of operation during which shellfish might become infected and remain contaminated for days.

34. The Paradise Hotel has septic tanks (see data sheet 101 Vavau) and a drainage field on the north end of the hotel grounds. Bathroom drains in the hotel began backing up several years ago and the management decided the drainfield, which is on a steep slope above a cliff, was inadequate. A trench was dug from the septic tank overflow through the drainage field and a pipe laid to allow the septic tank effluent to flow over the cliff.

35. The flow was observed at a moderate rate over a period of several weeks, beginning when the hotel was fully occupied and continuing even when the occupancy rate dropped.

36. The overflow runs down a heavily vegetated slope and then over a rocky beach and into the Neiafu Lagoon. The survey team suggested that the management contact a competent septic tank expert to expand the system and repair the drainage field.

37. The hotel is in the process of expanding its capacity. There is reason to believe the existing septic tank facility will not be able to handle this increased load.

38. It was also noted that trash was thrown over the cliff by the hotel staff littering the lagoon coastline.

> RECOMMENDATION 3: Test the effluent from the drainage field at the Paradise Hotel and insist on adequate sewage facilities before allowing further expansion of the hotel capacity.

39. The public toilets on the main wharf at Neiafu have a septic tank with a very small drainage field (data sheet 108 Vavau). At low tide, seepage was observed from the bottom of the wall streaming over the tidal flat into the lagoon. This flow should be sampled and tested and, if required, a larger drainage field installed.

RECOMMENDATION 4: Sample seepage from the base of the Neiafu waterfront seawall to see if it is from the public toilets and take corrective action if necessary.

40. Cruise ships, fishing vessels, merchant ships and yachts present a somewhat different problem. Some ships discharge sewage directly into the water while others have holding tanks and discharge these at sea. A questionnaire was prepared and observations made to determine how many yachts had sewage holding tanks aboard and how many people from yachts utilized public or hotel toilet facilities ashore. These questionnaires have not yet been received from the Tongan Government and so no conclusions can be made at this time. However, the most serious dangers may be avoided if health officials check the international vaccination certificates of passengers and crew for cholera, typhoid, smallpox, and other diseases of epidemic concern.

DESTRUCTIVE FISHING TECHNIQUES AND CORAL REEF DEATH

41. During the Pollution Sources Survey and the related Black Coral Assessment Project, the project director noted many dead and dying coral reefs. Figures 2 to 7 (see Atlas, page 49) show which reefs were examined, and Table 3 (Page 58) lists conditions found at those reefs. The geographic distribution, depth of coral kill, species involved, and relative time of coral reef death, judged from the level of coral breakdown, indicate a slowly developing problem with multiple causes. The matter deserves a more complete analysis but, one major cause of coral mortality was identified as destructive fishing techniques during subsistence and commercial fishing.

42 Men and women were observed killing coral during of their food gathering activities. In the past, when women and children walked the reefs at low tides, they went bare-foot and carried sticks or nothing at all. Today most reef walkers are shoed, some booted, and they carry bush knives, crow-bars, iron poles, and even hammers.

43. The reef-walkers use these new tools to pry loose and break up the living coral. They walk through the small branching coral thickets leaving a trail of smashed coral behind.

44. Rocks and corals which are turned over are not replaced in their original position, thus leaving the eggs and smaller encrusting sea creatures to die.

45. Octopus, which formerly were caught with lures or by hand are now often broken out of their nesting sites, destroying the habitat as well as the nesting females and their eggs.

46. Men also break the coral during fishing activities. I witnessed fishermen breaking coral while taking vasua from the reef. It is a common practice to put a net across a lagoon entrance and, as the tide falls, break the coral and turn over rocks in the lagoon to chase the fish into the net.

47. Coral thickets are sometimes battered to rubble to chase the smaller reef fish into encircling nets.

48. Poisons are also used to catch fish. Some of these are toxic to corals and small invertebrates and kill all the fish including juveniles. Both natural toxins and artificial poisons (including sodium hypochlorite and pesticides) can create long term coral destruction.

CORAL INFECTIONS AND PREDATORS

49. When the coral is broken, especially the more fragile Acropora corals, it becomes infected with a blue-green algae; probably of the genus Oscillatoria (Antonius 1977). The algal infection spreads from the wound to kill the whole coral colony (Figure 8).

Figure 8. Coral infected with bluegreen algae dying on the reef edge.

50. Numerous infected, but unbroken, colonies were observed in areas where coral breakage was common. The distribution of the infected specimens indicated that the algal infection could spread from damaged corals to undamaged ones. There are several possible ways this can happen including transmission by water-borne filaments.

51. Each coral colony has numerous small crabs, shrimp and fish which live in the protective branches. When the coral dies these associates move elsewhere. I observed that a crab from a partly dead colony had small strands of the blue-green algae on its leg hairs. I also observed that if the crab was put into another coral colony the crabs already there fought with the intruder. It is likely that during the

fight the fragile coral tissue could be damaged and infected.

52. When the coral colonies are broken loose and thus damaged and infected, they roll around in the surf and damage adjacent colonies, infecting them at the same time. These may be washed into the lagoonal areas or out the reef cuts into deeper water, damaging and infecting corals in the deeper water.

53. In addition, the battered, infected corals and increasing areas of dead reef tends to force coral predators into smaller areas of live coral. Thus I observed coral colonies with huge numbers of predatory snails, and a large population of crown-of-thorns (Acanthaster planci, fig. 9) and Cushion (Culcita sp.) starfish.

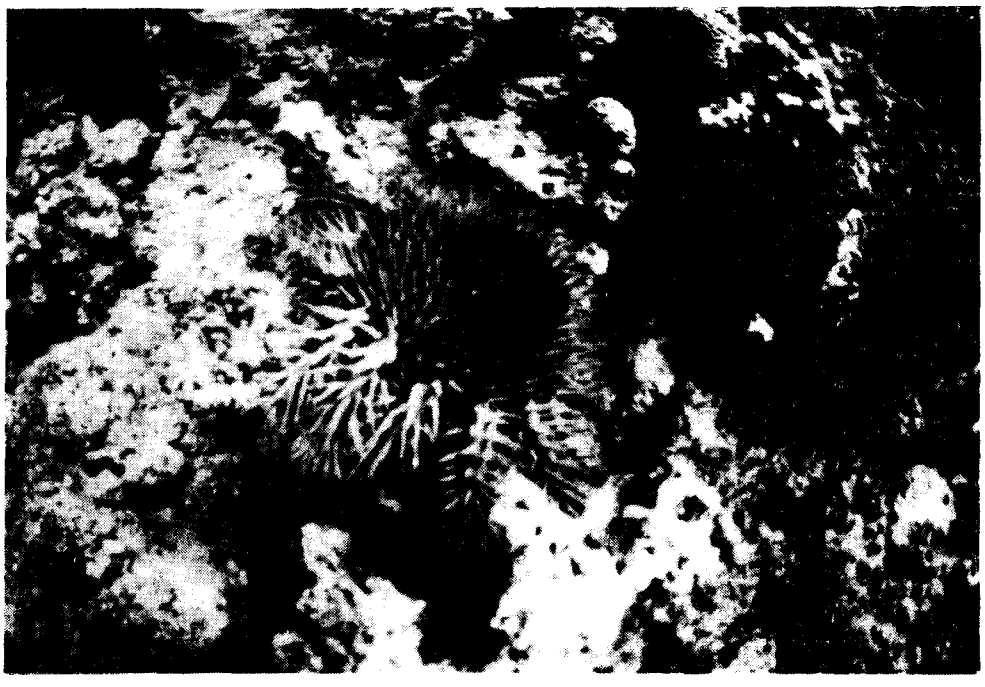

Figure 9. Acanthaster planci, the Crown of Thorns starfish eating coral at the edge of a damaged coral reef.

54. As these coral predators are forced together they experience increased breeding success as well as decreased predation from their predators (which are collected for food or sale) and their populations increase(Chesher, 1969).

55. The end result is a spread of dead and dying coral from the shallow water into the adjacent, deeper water.

CATASTROPHIC CORAL DEATH VIA S.D.R.

56. When corals are subjected to stress, such as abnormally high or low temperatures, fresh water, excessive siltation, pesticides, phosphate starvation, breakage or abrasion results in the rapid death of the whole coral colony. This reaction was named Shut-Down-Reaction

because the coral colony seems to stop some critical physiological reaction and the tissue comes off the skeleton in long strings.

57. If these strings of dying tissue come in contact with other corals which are also under stress, the other corals begin to undergo the same S.D.R. and die. Thus, it is possible for coral breakage at extreme low tides or in the rain to result in a massive death of corals over a large area.

58. All of the above factors probably have contributed to the large number of dead coral reefs we observed. The project director witnessed destructive fishing on several reefs and found numerous coral colonies which were infected by blue-green algae. Populations of Acanthaster planci, the Crown of Thorns Starfish and of Culcita sp, the Pin Cushion Starfish (both coral predators) were abundant on many reefs, especially near dead reefs.

59. David McLean, a long-time resident of Vavau, observed the destruction of a reef over a 9 year period and wrote a report on this for the Governor of Vavau.

LOSS OF A CRITICAL HABITAT

60. The coral reef ecosystem produces fish, clams, oysters, lobsters, octopus, and many other protein rich foods for the people of Tonga. These are wild foods and are dependant upon the living reef habitat for survival. When a coral reef is reduced to dead rubble the yield of sea food is likewise reduced. When a coral reef habitat is destroyed, especially when fishing pressure continues, it may never recover. Figure 10 compares a live reef area with an area which has been destroyed by fishermen.

61. In areas where coral destruction has been complete the people have shifted their search for the larger reef creatures to smaller, less appealing organisms like tube worms and chitons. To extract these they apply their steel and iron impliments with a great deal of energy. It is unlikely corals could regrow with such continued activity.

WHAT CAN BE DONE?

62. I interviewed several people about the issue of coral breakage. They all said that the Tongan people did not consider coral as being "alive" or as being important to fish or lobsters they hunted. As one Pollution Sources Survey team member remarked after interviewing fishermen about the coral reef degradation, "The fishermen know nothing about coral, just how to catch fish."

63. The women do not know that there are eggs of many fish and invertebrates under the rocks they turn over; they don't know they SHOULD turn rocks back the way they found them.

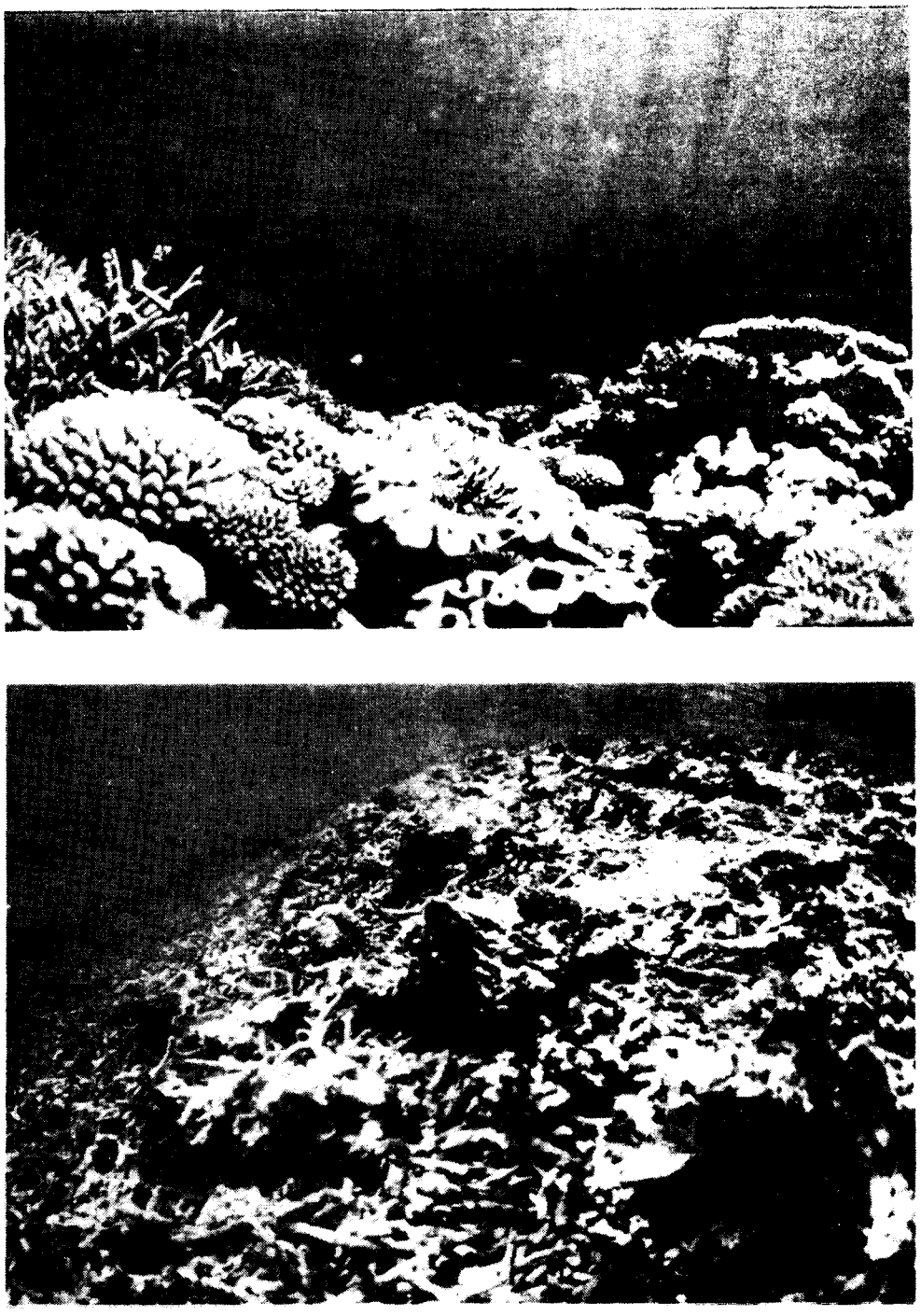

Figure 10. A living coral reef in Vavau (top photograph) contrasted with a dead coral reef nearby (lower photograph). Local residents say fishermen broke the coral to frighten fish into their nets.

64. Two educational thrusts are required to reduce coral damage during subsistence and commercial fishing activities. The first involves preparation of educational materials to be incorporated in the Radio Tonga Educational Programme and into the school system.

65. The second involves production of an educational video and is aimed at the adult public who, after all, are creating most of the problem and who are least likely to be willing to abandon their fishing methods without a major revision in their thinking.

66. The first step requires the preparation of educational materials on the following topics:

1. Why coral is important.

2. Dangers to the Living Coral Reef.

    a) Breakage

    b) Infections

    c) Poisons

    d) Predators

    e) Shut-Down-Reactions

3. Why reef-top rocks must be turned back to their original position.

4. Reef Improvement

67. Several approaches to delivering this information are available:

1. Environmental Radio

2. Educational Radio

3. Newspaper articles

4. Classroom Posters

5. Educational Video

68. The information must be presented in Tongan and be highly illustrated. A suggested work plan for this program might be divided into four phases:

Phase 1. SPREP prepares educational information with photos and illustrations on the above mentioned topics.

Phase 2. SPREP delivers materials to Tonga and holds a government meeting with officials from the Department of Lands, Survey & Natural Resources, Fisheries, Radio, Newspaper, and Education.

Phase 3. Tongan officials prepare translations and presentations of the materials as they find appropriate.

Phase 4. When materials are in the field, SPREP to return and prepare educational video to show how the Tongan people respond to the material and adjust their fishing behavior to protect and improve the coral reefs.

69. This last phase is probably critical to the success of the project as it not only provides information on the relative success of the various types of information dissemination but it is a direct incentive for the people who are being filmed to actually change their behavior.

70. When complete, the video could be utilised in the educational system of Tonga, made available at the numerous video rental stores, shown publicly, and (if the system is complete) broadcast nationally.

71. Some villages are more destructive in their fishing habits than others. Because some of these villages are known as "fishing villages" they might be approached to help with development of new and non-destructive fishing techniques, thus adding a contest to the spirit of the programme.

72. The "rules" of the contest would include finding ways to fish without breaking the coral or destroying habitats, burrows, or rocks, and identifying ways of reef fishing which might improve its general health.

73. The video, played back to the villagers as it is being made, could include a comment from the National Government on the importance of the project, a comment from the local governor on willingness to cooperate and the response to these comments by the village elders and the fishermen.

74. When non-destructive systems of fishing have been filmed, the villages would have neccessarily committed themselves to protect their coral reefs with appropriate behavior. This commitment, viewed publicly and in the educational system, would provide continued support for the ideas.

75. Productive new, non-destructive fishing techniques might be developed during the exercise, and at least some of the older fishing techniques such as the use of lures to capture octopus, can be revitalized. It is most important, however, that constraints on destructive fishing techniques be imposed as quickly as possible. Since it is probably impossible to do this with legislation, it must be accomplished with the willing help of the Tongan public.

RECOMMENDATION 5: Prepare

1. Educational materials on the importance of and dangers to the coral reefs and what needs to be done.

2. Posters on "Don't Break the Coral" and "Turn the Rocks Back Over".

3. Educational Radio programme on Coral Reefs.

4. Newspaper Articles on Coral Reefs and the danger of their death.

5. Environmental Radio and Talk-Back Radio on Coral Reefs and Fishing techniques to save them.

6. A fact-sheet covering all aspects of the problem.

7. A video for public and educational use showing Tongans working to improve their coral reef environments.

CHRONIC HAZARDS

LEAD IN PAINT.

76. Lead is a cumulative, poisonous, heavy metal which can cause far-reaching health and environmental problems. Its most hazardous use has been as a paint additive. As the paint film breaks down the lead is distributed into the island ecosystem along a variety of pathways. It can accumulate in plants, animals, and people.

77. There are strict regulations on lead use in most countries. During the Pollution Sources Survey it was discovered that the Asian Paint Company was importing a lead additive to be used in its paints. Formulae for their paints, mixed at the factory at the Small Industries Centre, indicated many of their products contained lead in amounts which represent health hazards.

78. The Golden Yellow and Canary Yellow paint, which might be used on interior surfaces or even on toys, contain lead additives which would require warning labels in most countries.

79. Rooforite paints were sold in cans labled "Lead Free" and are widely used for rain catchment surfaces. The formula for this paint included "0.913% Lead Napth" hardener and tests of the paint product by Dr. Morrison of the University of the South Pacific showed it contained enough lead to ban its use around children or on interior surfaces in New Zealand. It exceeds the permissible level of lead content for any water catchment surfaces.

80. In addition, raw Lead Napthate hardener was observed spilled on the floor of the factory and at least one empty drum containing this toxic chemical was sold to the public for uses unknown.

81. Lead free paints are manufactured in most countries because of the wide-spread health problems associated with lead and children. The extent and seriousness of this problem has received wide-spread attention during the 1970's.

82. Many cities in the United States have active programmes to eliminate this hazard through repainting, wall-papering, and paint stripping. Testing blood samples from children on a large scale, called Lead Screening, is common to identify areas of high contamination.

83. The most serious danger from lead poisoning is its low-level damage to brain tissue. The symptoms may be vague, including aggression, weakness, clumsiness, loss of intelligence. Its most common target is children under age 6.

> RECOMMENDATION 6: Label all paint containers containing leaded paint with clear health hazard warnings in both English and Tongan. As soon as possible ban the import of lead chemicals into Tonga except for critical needs. Shift to the use of non-leaded paints, especially in public buildings, schools, interior use around children, and on water catchment systems.

TABLE 2

PESTICIDES FOUND IN THE TONGAN ENVIRONMENT

Samples taken by Niels von Keyselinpk, 1980

Analyzed by Pesticide Analytical Laboratory, B.P.1, Manila, Philippines

SAMPLE	T LINDANE	HEPTACHLOR	T ALDRIN	ENDOSULFAN	T DDT
CABBAGE	0.08	0.01			
BANANA	0.05		0.09		0.02
CUCUMBER	0.02		0.03		
TOMATO	0.01				
WATER 101	0.21	0.16	0.09	0.06	0.04
WATER 102	0.15	0.23	0.08		
WATER 103	0.23	0.18	0.11	0.01	0.05
WATER 104	0.07	0.03			0.02
WATER 105	0.40	0.23	0.13	0.09	0.07
WATER 106	0.06	0.01	0.04	0.04	0.02
WATER 107	0.30	0.17	0.08	0.10	0.04
WATER 108	0.06	0.01			
WATER 109	0.14	0.01			
MILK	0.02-0.1	0.03-0.05	0.01-0.07		0.09-0.43
HUMAN FAT					1.4-4.2

Vegetables, milk, human tissues as mg/kg. Water as mg/litre.

PESTICIDES: A CHRONIC ENVIRONMENTAL HAZARD

84. The danger of pesticides to human health is well known and warnings appear on pesticide product labels and in the Pesticide Handbook prepared by the Ministry of Agriculture, Fisheries and Forests (MAFF).

85. Discussions with the research division at the Experimental Farm in Tongatapu indicated that the Ministry is sensitive to, but largely uninformed about, long-term environmental hazards of pesticide use to wildlife, soils, and especially marine ecosystems.

86. Tonga imports and uses an increasing amount and variety of pesticides. The long-term effects of these are often unknown, especially with respect to coastal and marine ecosystems. Many pesticides or their break-down products are toxic and long-lasting. Many of them, including all the chlorinated hydrocarbons, build-up in living systems, especially in the higher predators such as birds, predatory fish, and humans.

87. Pesticides enter the marine environment by rain water run-off, aerial overspray, burning of pesticide coated plants, washing of pesticide containers, disposal of used pesticide dips, and intentionally as fish poisons. Corals are especially sensitive to a wide spectrum of pesticides (Chesher 1971) and the evident decay of coral systems in Tonga may be related to pesticide use. Other organisms, such as molluscs, shrimp, lobsters and fish have been shown to be pesticide sensitive. The extent of pesticide intrusion into the Tongan coastal waters has not been measured, but should be.

88. MAFF conducted a survey of pesticides in well water, vegetables and people. The results are summarized in Table 2. The health implications of these findings are not known, and the samples are extremely limited. The data clearly show, however, how DDT is accumulated in human tissues. Although not tested, other predators would show a similar accumulation of DDT. Birds, reptiles, fish, and many invertebrates suffer reduced reproductive capacity, neural disorders, and if the levels are sufficiently high, death from such accumulation.

89. Figure 11 shows the increased water use by the people of Tongatapu over the past 13 years. The problems associated with water recharging and the possible increase of contamination of the water lens with increased flushing rates is a subject of great concern.

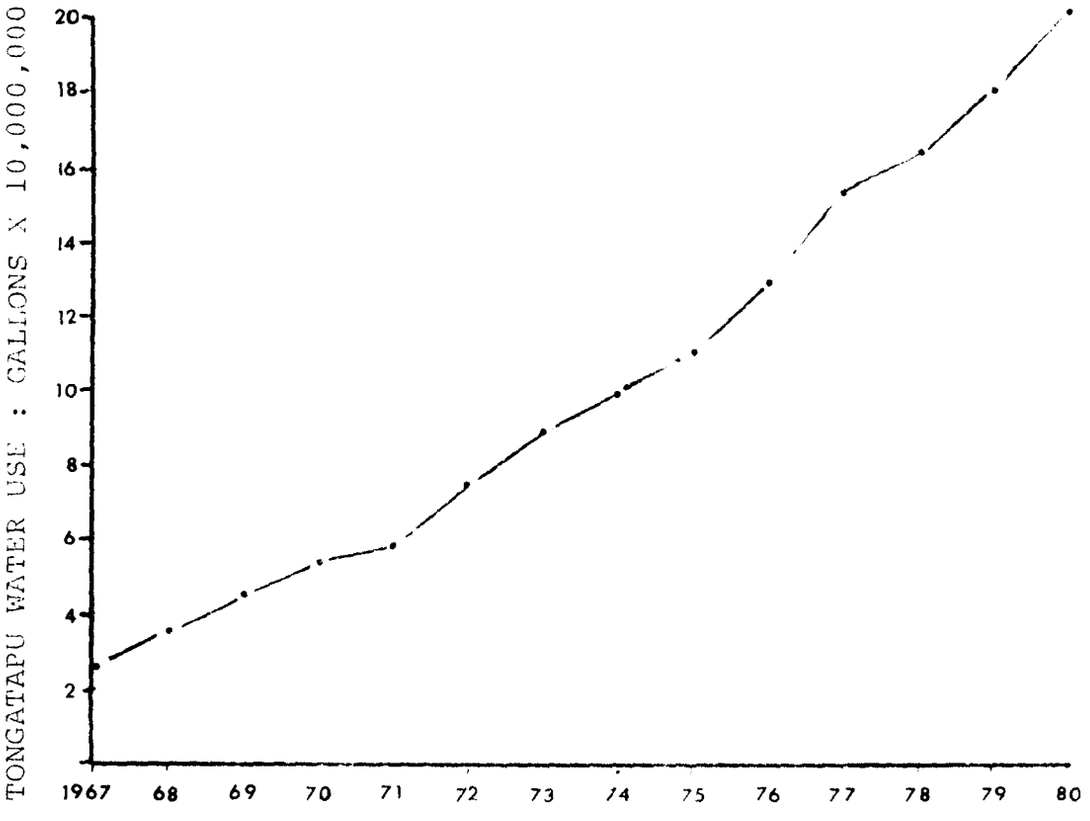

Figure 11. Increase in fresh water use on Tongatapu.

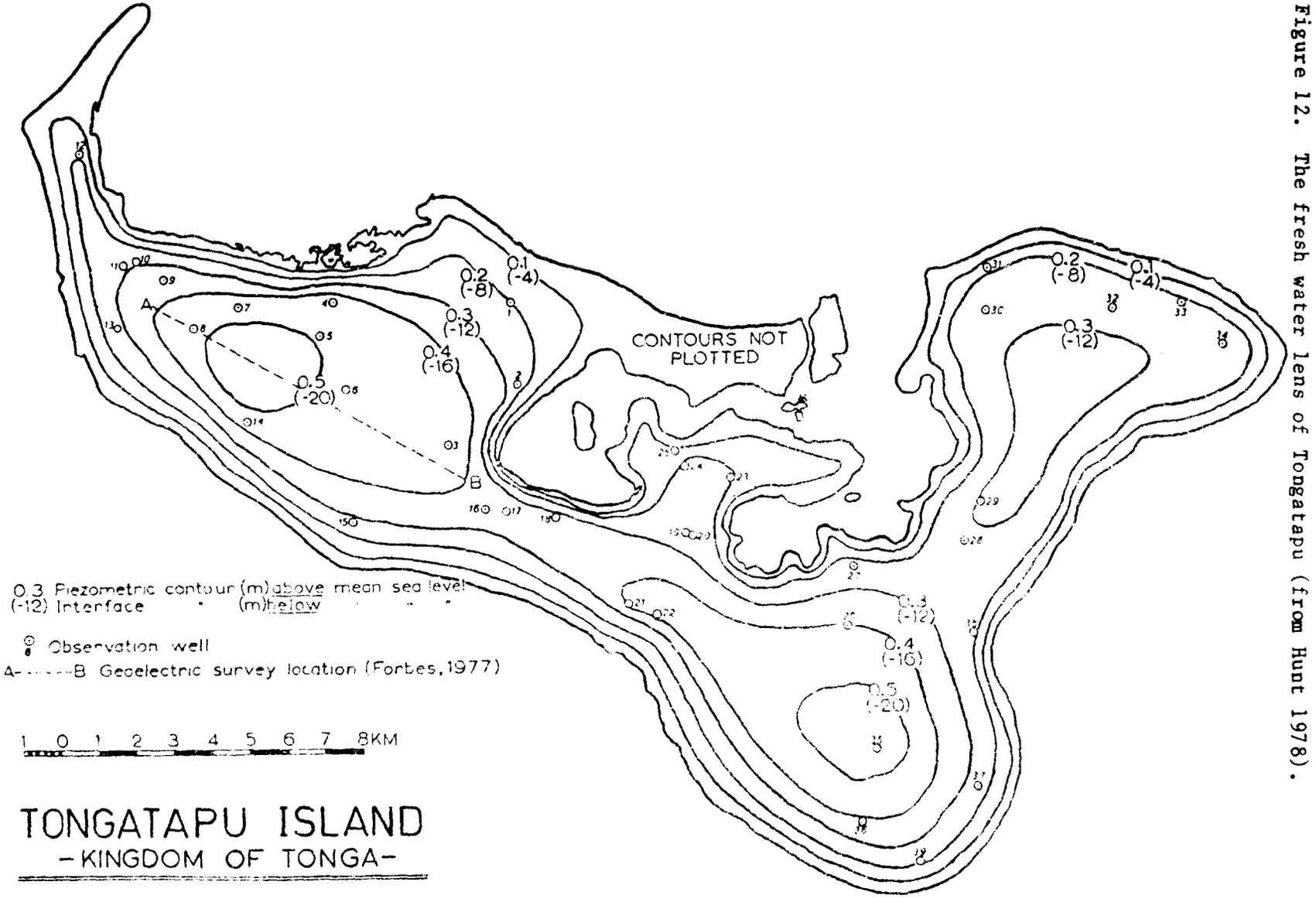

Figure 12. The fresh water lens of Tongatapu (from Hunt 1978).

Measured piezometric contours, observation well locations and calculated interface contours.

90. Poisoning of the watertable with pesticides or their residues is a considerable risk. The water lens of Tongatapu (Figure 12) underlies agricultural areas and while the depth contours of the water lens seem deep enough in the central areas of the island to filter out the pesticides there are areas on the edge of the aquafer and perhaps rock outcroppings through which water containing pesticide residues could reach the drinking water. The more water soluble compounds may even move directly into the aquafer through the soil.

91. The most serious danger, in addition to contaminating the water and food supply, health effects, the impact on marine ecosystems, and the destruction of important insects (like bees), birds, and other wildlife, is the danger of poisoning the soil and thus destroying the productivity of garden land.

92. This has been a serious problem in many places in the world. Recently, for example, the build up of copper from long term spraying of coffee plantations in Africa reached a point where no crops at all would grow in the soil.

93. Once soil is poisoned, it may be unsuitable for growing crops until (and if) the soil is reconditioned. In many cases, the soil cannot be saved and becomes permanently barren.

94. There should be an investigation into the question of soil degradation from pesticides in Tonga. The team found some evidence that this may be a problem.

95. Compare the two graphs in Figure 13. The first shows the rapid increase in pesticide imports. The second shows agricultural exports from Tonga.

96. The exports were divided into crops which were grown without pesticides and those crops which "required" the use of pesticides. The crops which did not have pesticides applied increased markedly in export value over a 13 year period while those crops which were treated with pesticides declined in total export value.

97. Does this decline in production reflect decreasing soil fertility due to pesticide poisoning of the soil ecosystem?

98. The experimental farm in Vavau has several tracts of land which have declined in productivity to the point where crops, especially vanilla, grow poorly. Production rates from land which was once part of the experimental farm are far below those from land further away, and vanilla plants grown there were observed showing signs of stress (B. Davis, J. Dequaire, and personal observations).

99. It is of interest that the most valuable crops of Tonga, including coconuts and vanilla, do not need pesticides. The low value (in terms of money) banana crops and (in terms of nutrition and money) watermelon crops are the largest pesticide users. From a biological viewpoint, it would seem reasonable to reduce pesticide use and concentrate on crops of high value for export and high nutritional value for local consumption.

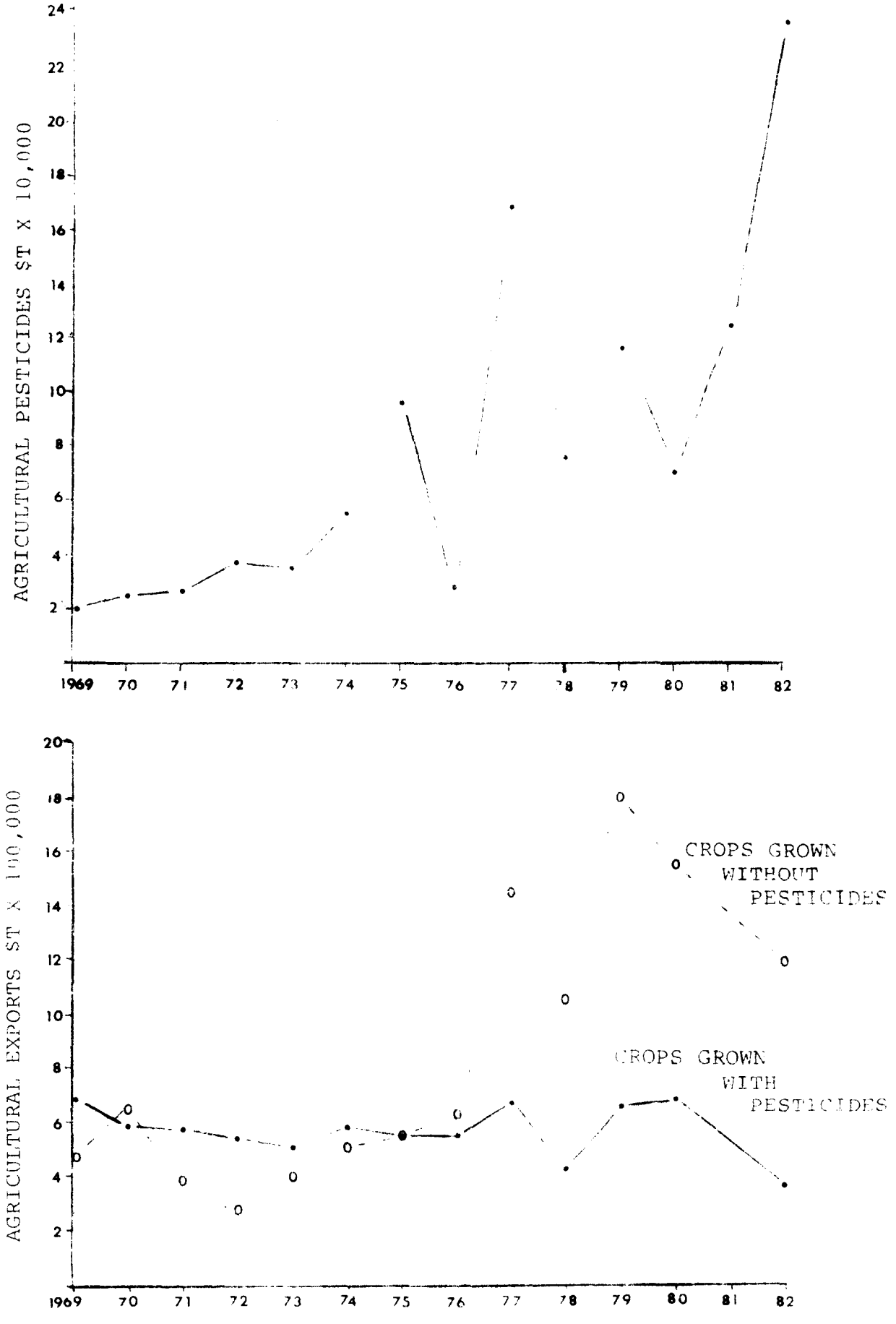

Figure 13. Are pesticides poisoning the soil? Despite increased pesticide use (top graph) crops grown with pesticides have decreased in value compared to crops grown without pesticides (bottom graph).

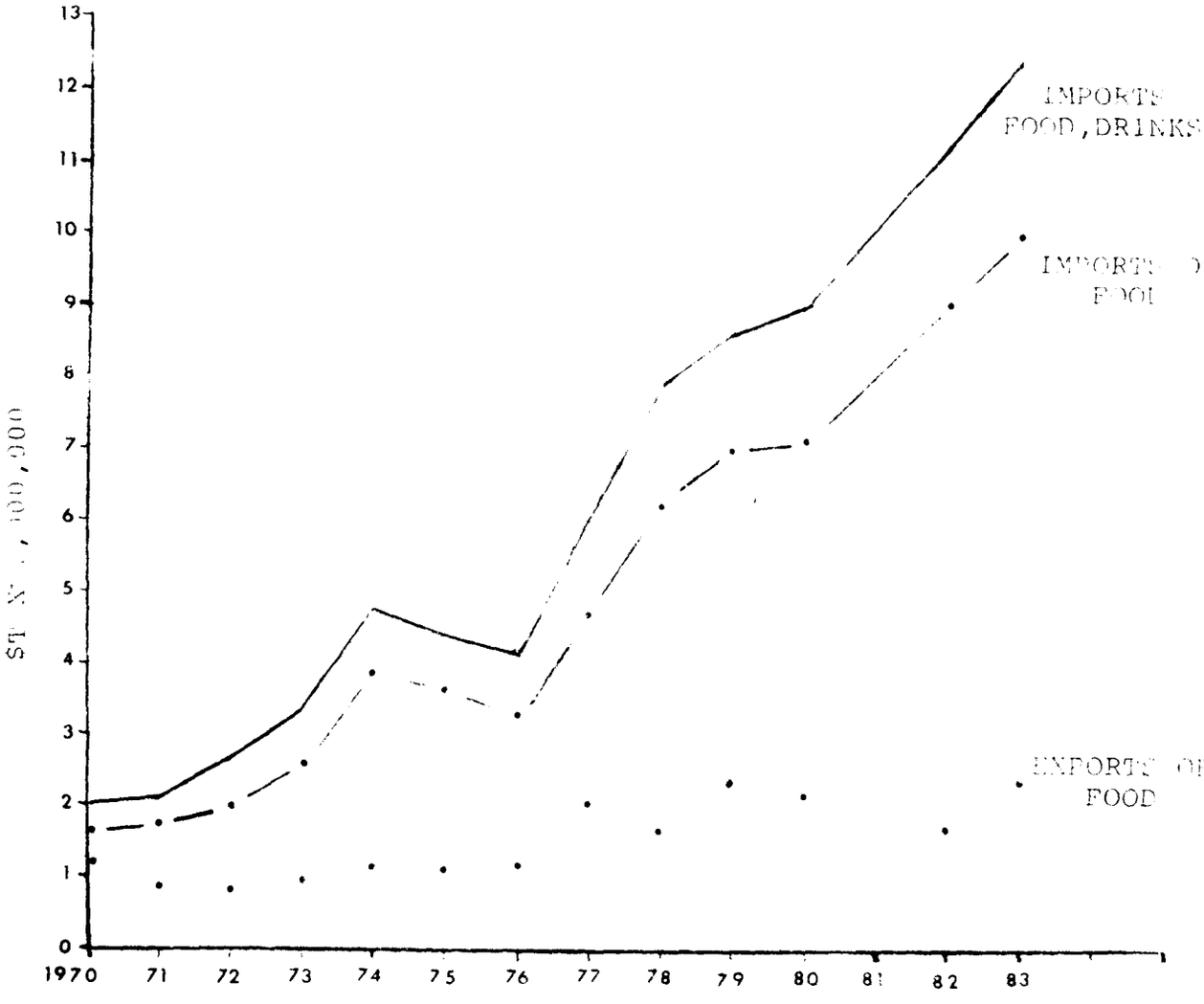

Figure 14. Compare the increase in imported food to exports of food. Economically as well as ecologically, growing nutritional food for local use is better. Vegetables grown for local consumption in small mixed gardens need less pesticides and are better suited to organic farming.

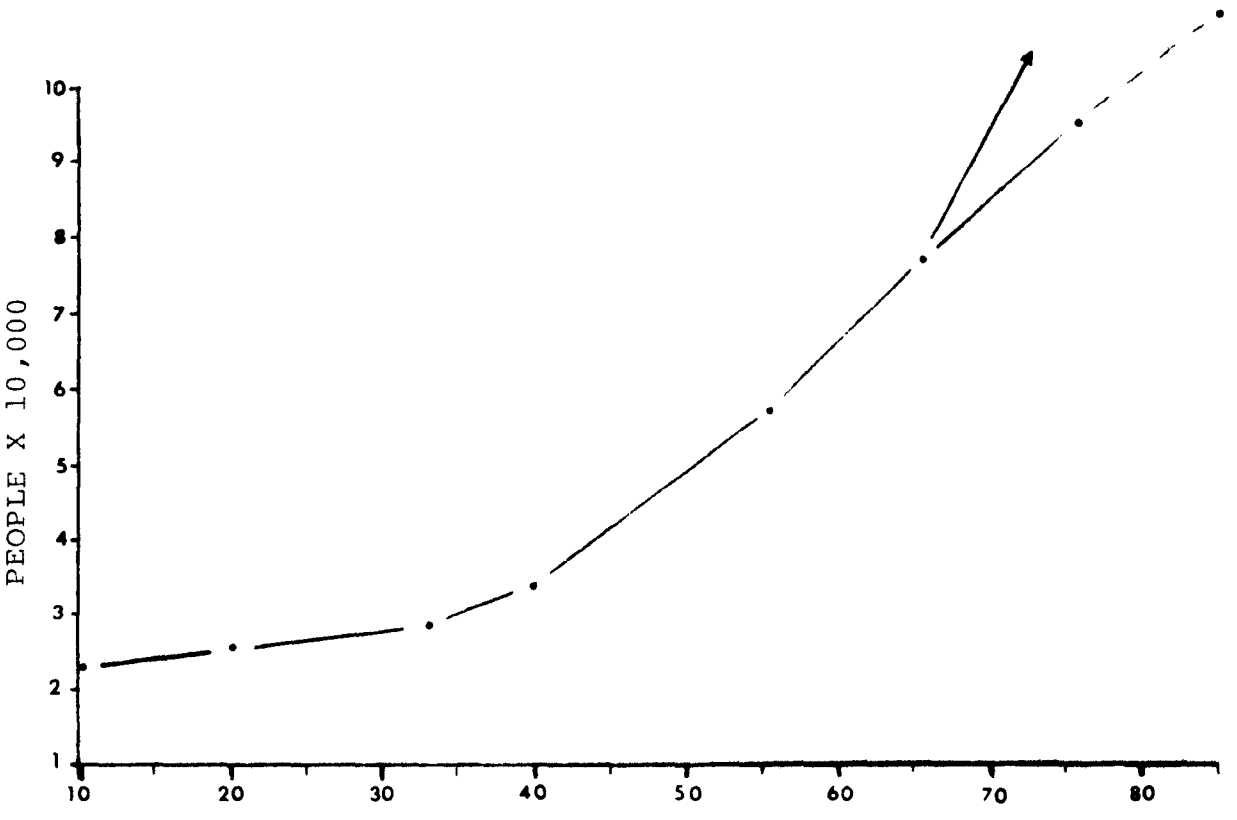

Figure 15. The graph of the population increase in Tonga is identical to a graph of the need for additional land for food production, living space, and support services. The arrow leading upwards from 1966 represents the true population growth. Migration of Tongans to other countries results in the number of people counted in the 1976 Census.

100. Figure 14 shows that the export value of agricultural products is falling far below the increasing cost of importing food to Tonga. This clearly demonstrates the increasing value of Tonga's Garden land for nutritional cropping.

101. Figure 15 shows the rapid increase in people in Tonga. Increasing numbers of people automatically means increased land use, especially to meet future requirements of highly nutritious food. The additional people require living space as well as food and thus garden land becomes still more critical. Use of land for roads, schools, buildings, industrial activities, disposal of wastes, construction materials, and other demands of a larger population all compete with the use of land for growing food for Tongan people.

102. These considerations, plus the impact of agricultural poisons on marine resources, make pesticide use a very serious matter.

103. Methods of farming without pesticides are known. The Principal

Agricultural Officer of Vavau, Haniteli Ofa Fa'anunu, is an expert in gardening without pesticides and his expertise could be usefully put into the school system and agricultural extension system as part of an "organic farming" curriculum.

> RECOMMENDATION 7: Develop a pesticide free gardening curriculum for the school and extension educational system.

104. The Director of the Research Division of MAFF suggested that SPREP conduct an investigation into the ecological impact of various pesticides as a service to its member countries. A list of hazardous pesticides and their deleterious effects would provide the Agricultural Plant Protection Officers with information which is otherwise not available or difficult to obtain.

> RECOMMENDATION 8: Investigate the impact of pesticides on the public health, ground water resources, soils, wildlife (including bees and birds), and marine ecosystems of Tonga.

> RECOMMENDATION 9: Shift towards non-pesticide using crops and farming techniques as soon as possible and reduce pesticide use to cases of absolute necessity.

105. The Ministry of Health uses pesticides on the public solid waste dumps (stations 108 Tongatapu & 103 Vavau). Both dumps are located on the edge of intertidal mangrove swamps and are, in fact, filling these productive ecosystems. (Problems associated with filling mangrove areas are discussed by Dahl (1978), Ludwig (1980), and Wolterding (1983)). The pesticide used for fly control is Vapona and the container has a warning printed on it that the pesticide must not be used near waterways, drainage areas, or coastlines as fish and other aquatic organisms are highly sensitive to it. The subject of solid waste disposal is covered in section 6 of this report, but the use of Vapona in a mangrove area should be discontinued and alternate pesticides considered. Diatomaceous Earth, a powdery white substance made of diatoms, has been used successfully for fly control and it is not toxic.

> RECOMMENDATION 10: Discontinue Vapona use on public solid waste sites adjacent to mangrove areas.

SILTATION OF HARBOURS AND REEFS

106. Data sheet 109 shows the Nuka'alofa waterfront. Construction activities have been underway on the Queen Salote Wharf, Boat Basins and Sea Walls for many years. During the survey the Queen Salote Wharf and main sea wall was under active construction. In periods of heavy rains, silt plumes were observed coming from the construction sites.

107. The silt plume settles into the deep water of the Nuku'alofa Lagoon and resides there for long periods of time, gradually settling to the bottom or washing out of the narrows with the tide.

108. Examination of the deep water fauna of the lagoon, specifically the black corals, indicated that this periodic siltation was creating considerable stress. 49 percent of the commercially valuable black coral colonies which were observed were dead, but still standing (Chesher 1984). Some of the colonies appeared to have been dead for some time and were encrusted with other organisms.

109. Divers for black coral also reported that 4 out of 5 colonies which they collected were already dead.

110. The reef flat along the waterfront is heavily silted but supports a sparse sea grass community.

111. Evidence of siltation stress was observed on several coral reefs surrounding the lagoon, especially in deeper water.

112. Similar problems were seen in Neiafu Harbour in Vavau. Because of the steeper land gradients in Neiafu, siltation during heavy rains is a greater danger than in Tongatapu. Construction activities associated with the wharf and siltation of Vaipuua Lagoon by run off from a quarry (Data sheet 107 Vavau) created stress on the lagoon fauna.

113. When construction work is carried out adjacent to lagoons (harbors) silt screens may be employed to reduce damage to the marine communities. These are simply heavy plastic sheeting suspended from floats. They are widely used in coastal construction in the United States.

114. Quarries should be constructed in locations and in such a way as to minimize siltation of the marine environment. If poorly constructed, a quarry can go on silting an area for many years after it is abandoned. If properly constructed, a quarry need not create siltation problems and can, in fact, become a useful area. Thus, a quarry can result in a sports arena, with tiered seats, a swimming area, a hole to put trash into, or a boat basin depending on where and how it is built.

115. Topsoil and plants should be applied to construction sites or the loose rock topped with concrete as soon as possible to reduce siltation.

> RECOMMENDATION 11: Apply soil and plants or concrete to harbour construction sites as soon as possible to reduce siltation from rain water run-off.
>
> RECOMMENDATION 12: Use silt screens and silt-preventative construction techniques when doing required construction on lagoonal coastlines.
>
> RECOMMENDATION 13: Site quarries inland, in locations where rain water run-off will not foul marine resources, or use silt-preventative precautions (ie. dikes and plugs would be a good idea for the area being dredged east of Queen Salote Wharf). Design the quarry to result in a useful area when

it is finished.

CAUSEWAY BLOCKAGE OF WATER FLOW & MIGRATION ROUTES

116. Passes between islands are important, highly productive, marine environments. They permit flushing of lagoons, circulation of water and plankton for corals and fish, and provide pathways for fish migrations and larval release.

117. The causeway between Lifuka and Foa islands (Data sheet 101 Haapai) in the Ha'apai Group has no ducts to permit water flow to continue through this pass. Reef degradation in the area to the west of the causeway was observed and fishermen from the area claim the reefs no longer are the excellent fishing grounds they were before construction.

118. The Causeways between Vavau and Koloa (Data sheet 109 Vavau) have no ducts to permit water flow. Haniteli Ofa Fa'anunu, who lives just to the seaward of one of these causeways, reports that when the causeways were rebuilt in 1980 without water ducts, there was a die-off of the clam "Kaloaa to'o". In addition, there was a seasonal mullet run through the pass. The mullet entered into the huge tidal lagoon to spawn. The causeway has eliminated the fish run and may have reduced the mullet population of the area.

119. The Causeway between Pangimotu and Vavau (Data sheet 110 Vavau) has three small water ducts but water circulation is restricted and the flushing rate of Neiafu Lagoon is thus reduced.

120. Other causeway construction has been planned for the future. It is less expensive to install water ducts during initial construction than to have to put them in later. In addition, a causeway without water ducts is a dam and construction of a dam which can withstand storm conditions is very difficult. It is cheaper and biologically sensible to install water ducts in causeways.

> RECOMMENDATION 14: Install sufficient water passages in existing causeways to permit proper water flow and fish migration. When building new causeways include numerous large water ducts.

PREVENTATIVE MEASURES

HAZARDOUS CHEMICAL IMPORT RESTRICTIONS

121. Islands are fortunate in being naturally free from most hazardous substances and in having limited port facilities through which their environment might be invaded by poisons. If hazardous substances are

not imported, they will not become a problem.

122. The difficulty is in knowing what these substances are and what products contain them. Thus, ecologically damaging substances such as lead, mercury, chlorinated hydrocarbons, and an array of other metallic and organic poisons which can pollute the Tongan Environment for many years, are being imported unknowingly.

123. All of the imported products pass through customs and statistics before being distributed onto the islands. Some hazardous substances are necessary, such as mercury for dental work, lead in batteries, PCB's in electrical transformers, copper compounds for lumber treatment, and so on. Others could be replaced with newer, not toxic substances, like lead-free paint, non-leaded gasoline, biodegradeable detergents, paper bags instead of plastic, etc.

124. An inventory of Hazardous Substances (including hazardous wastes which may derive from imported products) should be conducted and a study made of which ones could be easily eliminated or substituted with non-harmful ones.

125. A list of prohibited imports should then be drawn up along with suggested substitutes.

126. Those hazardous substances which must be imported, including pesticides, should be kept track of. Statistics should be kept on how much of what brand of poisonous material is imported and where it is sent on the island. This is fairly simply done as all imports are registered by the Statistics Department. Imports of Hazardous Chemicals or Substances thus would become a special heading in the normal list of import categories.

127. By recording what companies or governmental agencies receive how much toxic material, it becomes possible to know where the poisons are on the island and where they might get into the ecosystem or into the people.

128. In addition, it would be possible to keep track of wastes and empty containers which need proper disposal techniques (see below in Solid Waste Disposal Plan).

> RECOMMENDATION 15: Conduct an Inventory of Hazardous Substances being imported into Tonga and draw up a list of prohibited imports with suggested substitutes.
>
> RECOMMENDATION 16: Instruct Statistics to register Hazardous Substances and keep a record of imports by brand name, quantity, and who, exactly, the importer is. A Hazardous Substance Import Licence should be required which includes the necessity to account for the distribution of these substances on the island (s) and with provisions for retrieval of these substances and their containers as hazardous wastes.

SOLID WASTE DISPOSAL PLAN

129. Tonga's solid waste problems are minimal, at present, and require only slight modification to prevent future problems. One of the reasons why solid wastes are not the problem they are in more industrialized countries is that many items which would be "waste" elsewhere are useful if used with some imagination. Thus, especially in the outer islands of Tonga, glass containers are generally used for a variety of purposes and old cars are kept for spare parts. Metal products are used in a variety of ways and waste paper is excellent for fires.

130. The public dump in Lifuka and Vavau, therefore, is small and not often used. Many people bury their own trash in small holes on their property thus leveling the land. Aluminum cans and rubbish from public waste containers are thus the main items at the public dump.

131. Tongatapu has more of a problem as urban dwellers have little opportunity to dispose of wastes and also buy more prepackaged products and imported items which result in solid wastes. Figure 16 shows the increase of solid wastes in Tongatapu in the past few years. As imported goods increase, the residual solid wastes will also increase. Locally produced goods and drinks do not generate toxic or accumulative solid wastes. Non-biodegradeable or toxic wastes are all imported (at great cost).

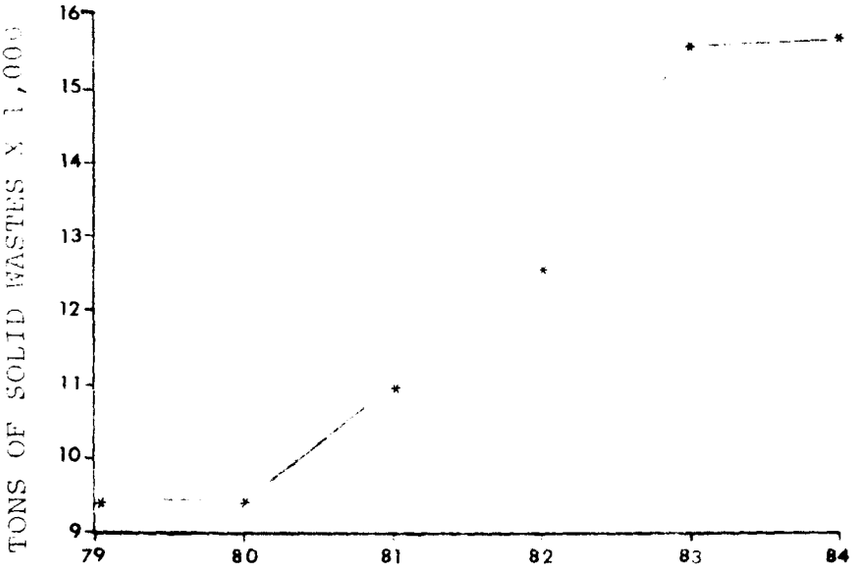

Figure 16. Increase of solid wastes in Tongatapu.

132. As is evident from practices in most of the Kingdom, most of the "wastes" are useful. Paper, old wood or old cloth can be burned, glass and stone and some metal products make good construction material, containers or land fill, all leaves, branches, and organic matter can be used as compost or mulch.

133. The public should, therefore, be asked to separate trash into different categories which can then be disposed of accordingly.

134. There are some substances which pose problems as they are not useful or biodegradable and even poisonous or dangerous. Clearly the solution to these items is to import something else whenever possible. Many of the items are, however, popular and/or required and their substitution with other products will take time.

135. Aluminum cans are, at present, the most notable solid waste problem and because they are often casually disposed of, they form the greatest litter problem on the islands today.

136. Recycling aluminum cans is a good idea but the recent introduction of steel/aluminum cans has made this impractical. If people can be encouraged to squash the cans flat before disposing of them, the volume of drink cans is very slight, and imposes little ecological threat. When cans are left intact, however, they form places for rain water to accumulate and thus places for mosquitoes to breed.

> RECOMMENDATION 17: Produce posters, newspaper adds, and radio spots encouraging people to "Flatten that Can" and thus reduce waste volume and breeding places for mosquitoes.

137. Glass containers are more useful than aluminum containers and can be utilized as building material, land stabilizers, drinking containers, and they are recyclable. Therefore, short of the ideal solution of Tonga producing its own beverages, expensive imports should be purchased in glass containers. Because a deposit is commonly obtained for the glass bottles, they can be expected to return to the stores when used thus facilitating their reuse.

138. Glass crushers are commercially available to reduce bottles to a sand which is especially good for producing a very hard and strong cement for special construction purposes.

> RECOMMENDATION 18: Prohibit imports of drinks in aluminum cans in preference to glass containers and instigate re-use or disposal plans for the glass containers.

139. Imported drinks are of better quality and taste than locally produced drinks and have a certain status symbol. The team inspected two soft drink factories and the facilities and product were found to be of very low grade. One team member remarked, upon leaving, "The only pollution from that place is inside the bottles."

140. Locally producing good tasting, nicely bottled, sanitary and nourishing drinks and raising taxes on imported bottled drinks would be a worthwhile activity. Tongan Coconut Drink, Passionfruit Drink, Watermelon Drink, Mango Drink, Coconut Toddy, Lime Drink, Orange Bitters, and so on could be a useful local industry and perhaps a viable export item if quality controls are assured.

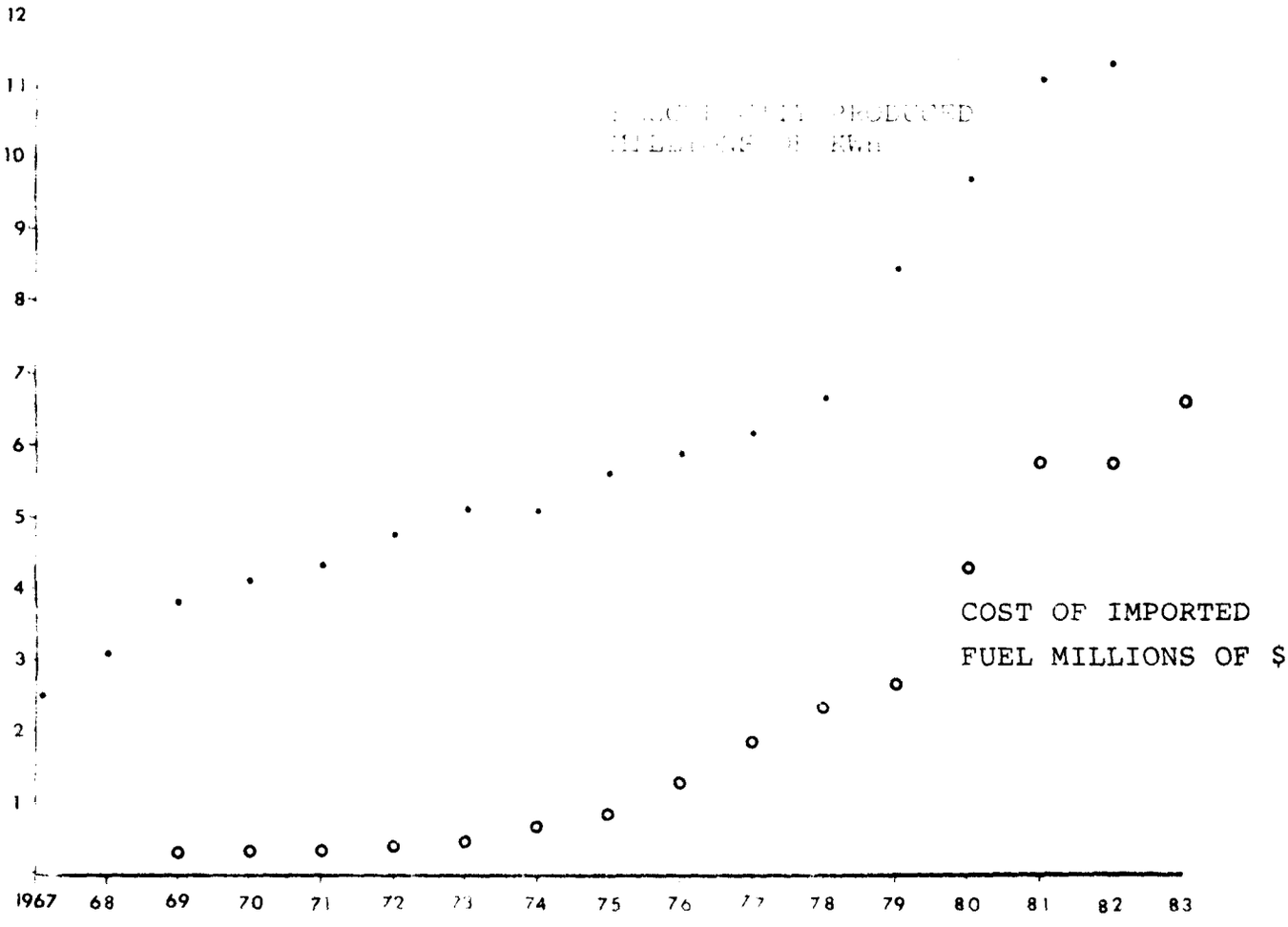

Figure 17. Increase in electricity produced and fuel used in Tonga.

154. The effluent from the power plant empties into a very shallow sea grass bed. The effluent is lagoon water heated through heat exchangers (Data sheet 801 Tongatapu) and carried through an open cement flume back into the lagoon.

155. Electricity produced from the power plant (and thus thermal effluent generated) has increased rapidly in the past 6 years (Figure 17). Problems attendent with this increase may include:

1. Excessive temperatures during hot summer months may kill both fish and invertebrates.

2. Copper ions from the heat exchangers might, especially when the heat exchangers are cleaned, kill fish and jellyfish in the lagoon.

3. Juvenile fish and invertebrates which pass through the heat exchangers will probably be killed. Depending on rates of water circulation in the lagoon this could represent a significant mortality.

RECOMMENDATION 23: Monitor the effluent from the Popua Power Plant for copper ion discharge, plankton mortality and temperature. If possible, clean heat exchangers when off-line and discharge cleaning fluid into the oil sump discussed in recommendation 22.

156. Several old transformers were observed at the power plant site. These may be filled with dangerous PCB chemicals and should be properly disposed of. Chemically, PCBs are almost identical to DDT and should be treated accordingly (see recommendation 20, above).

157. Boats change oil on a regular basis and a used oil drum should be installed under a sign so marked at the small boat basin and the military basin in Nuku'alofa, and on (or near) the main wharf in Neiafu. One of the major oil companies should be asked to maintain this service in exchange for obtaining the used oil for reprocessing.

RECOMMENDATION 24: Install used oil containers under a sign in English and Tongan saying "Put Used Oil Here" at the small boat harbors of Nuku'alofa and Neiafu. Impose stiff fines for dumping used oil into the water.

ENVIRONMENTAL IMPACT STATEMENTS

158. The least expensive kind of mistake is one you don't make. This is especially true when dealing with biological systems where mistakes in judgement can lead to the death of the system. It is always more expensive to take corrective action than to do it right the first time. This is the economic and practical justification for doing an Environmental Impact Statement.

159. In brief, this means that before ANY major project is begun someone (with biological expertise) examines the what that project is going to do to the environment. In this case, the environment includes, the biological, social and economic environment.

160. Thus, if a causeway is to be built, consideration of the environment would identify the need for water passages through the causeway. If a construction project is begun or an industrial activity, someone would be wondering, in advance, about the wastes from the project and how these might be disposed of safely or even used constructively.

161. Not all aid or development projects are environmentally safe as initially proposed. All projects should have, as a component of their proposal, an environmental impact statement.

162. Such reviews can be expensive and take time to do correctly. Some government agencies resist environmental impact statements on the grounds that they will discourage "development". This assumes that environmental (social, economic, and biological) consequences of development are of less importance than money; a short-time view that almost always turns out to be wrong. Environmental Impact Statements are not always expensive when compared to the projects they investigate and possible environmental damage. In addition there are ways to get them done at minimal cost to the Government.

163. Information about how to get Environmental Impact Statements done will be prepared by SPREP in its Guidelines for Coastal Zone Management for South Pacific Island Countries.

> RECOMMENDATION 25: Legally require an Environmental Impact Study before beginning any major project in the Kingdom, and as part of any development proposal scheme.

POSITIVE FINDINGS

164. The most positive finding of the Pollution Sources Survey was an increasing public and governmental awareness and concern over the condition of the Tongan environment. The activities during the National Environment Awareness Week were of really great value. Environmental "problems" vanish quickly if the people are aware of the biological consequences of what they do or don't do to the islands.

165. Public awareness programmes are the least expensive and most effective means of environmental improvement and should be expanded as much as possible.

> RECOMMENDATION 26: Continue support and development of the National Environment Awareness Week programme as a priority item.

166. The WHO development of improved septic tanks for sewage disposal is a good project. Proposals to develop large sewage treatment plants to replace septic tanks can create several environmental hazards including:

1. Loss of fresh water from the island water budget.
2. Point discharge of large amounts of fresh water and organics.
3. Loss of organics from the island's soil system.
4. Economic pressures met by selling natural resources.

167. Thought should be given to the use of dry digesters, especially in low-lying areas or out-islands where contamination of the ground water may be a danger. Howorth (1983), Ludwig (1980) and Dahl (1978) have all discussed dangers of septic tanks in areas subjected to storm flooding.

168. The Small Industries Centre is a sound idea as it concentrates industrial (and waste producing) activities in a limited area where discharges may be handled as one package.

169. The vanilla project is an excellent economic use of Tonga's limited land area for economic development and it uses no pesticides.

170. Waste products from agricultural by-products such as chicken wastes from chicken farming, slaughter-house refuse, and husks and shells from coconuts are all used for fertilizer, animal feed, or fuel. The proposed new coconut oil processing plant which will produce its power from coconut husks is an excellent example of efficient, ecologically sound resource utilization.

171. The proposed Environmental Protection Act is an excellent step forward and its passage and support will be of long lasting benefit to the Kingdom.

172. The support and cooperation shown by the Tongan Government and the people of Tonga towards this study was greatly appreciated. Immediate action to remedy the pollution problem from the Dateline Hotel and Lead content of paint and the interest and concern of the Agricultural officers about pesticide problems all point towards an optimistic future.

CONCLUSIONS AND RECOMMENDATIONS

173. A survey of the pollution sources of the Kingdom of Tonga revealed a sincere commitment on the part of the Tongan Government and the people of Tonga to maintain and improve their environment.

174. The most serious pollution problems discovered by the survey were the harm to coral reefs by destructive fishing techniques and contamination of shallow water reef areas by sewage from hotels. Long term dangers to the Tongan environment come from accumulation of hazardous wastes and pesticide contamination of water, soils, and marine ecosystems.

175. Environmental Impact Statements should be done for all proposed development or aid projects to avoid future hazards, and a programme of regulation of harzardous substances begun to limit imports and account for wastes.

176. Specific recommendations are:

RECOMMENDATION 1:(Page 13) A central library be established containing all reports, studies, documents relative to pollution and environment conducted within the Kingdom of Tonga. This reference library should be indexed according to subject and author and kept in the Department of Lands, Survey, and Natural Resources.

RECOMMENDATION 2:(Page 14) Put signs surrounding the reef area between Yellow Pier and the Vuna Wharf written in Tongan indicating the water is polluted and forbidding swimming or fishing or washing of food in the water. Repair and activate the chlorinator on the septic tank storage tank. Build appropriate drainage fields for the septic tanks.

RECOMMENDATION 3:(Page 14) Test the effluent from the drainage field at the Paradise Hotel and insist on adequate sewage facilities before allowing further expansion of the hotel capacity.

RECOMMENDATION 4:(Page 15) Sample seepage from the base of the Neiafu waterfront seawall to see if it is from the public toilets and take corrective action if necessary.

RECOMMENDATION 5:(Page 22) Prepare:

1. Educational materials on the importance of and dangers to the coral reefs and what needs to be done.

2. Posters on "Don't Break the Coral" and "Turn the Rocks Back Over".

3. Educational Radio programme on Coral Reefs.

4. Newspaper Articles on Coral Reefs and the danger of their death.

5. Environmental Radio and Talk-Back Radio on Coral Reefs and Fishing techniques to save them.

6. A fact-sheet covering all aspects of the problem.

7. A video for public and educational use showing Tongans working to improve their coral reef environments.

RECOMMENDATION 6:(Page 23) Label all paint containers containing leaded paint with clear health hazard warnings in both English and Tongan. As soon as possible ban the import of lead chemicals into Tonga except for critical needs. Shift to the use of non-leaded paints, especially in public buildings, schools, interior use around children, and on water catchment systems.

RECOMMENDATION 7:(Page 32) Develop a pesticide free gardening curriculum for the school and extension educational system.

RECOMMENDATION 8:(Page 32) Investigate the impact of pesticides on the public health, ground water resources, soils, wildlife (including bees and birds), and marine ecosystems of Tonga.

RECOMMENDATION 9:(Page 32) Shift towards non-pesticide using crops and farming techniques as soon as possible and reduce pesticide use to cases of absolute necessity.

RECOMMENDATION 10:(Page 32) Discontinue Vapona use on public solid waste sites adjacent to mangrove areas.

RECOMMENDATION 11:(Page 33) Apply soil and plants or concrete to harbour construction sites as soon as possible to reduce siltation from rain water run-off.

RECOMMENDATION 12:(Page 33) Use silt screens and silt-preventative construction techniques when doing required construction on lagoonal coastlines.

RECOMMENDATION 13:(Page 33) Site quarries inland, in locations where rain water run-off will not foul marine resources, or use silt-preventative precautions (ie. dikes and plugs would be a good idea for the area being dredged east of Queen Salote Wharf). Design the quarry to result in a useful area when it is finished.

RECOMMENDATION 14:(Page 34) Install sufficient water passages in existing causeways to permit proper water flow and fish migration. When building new causeways include numerous large water ducts.

RECOMMENDATION 15:(Page 35) Conduct an Inventory of Hazardous Substances being imported into Tonga and draw up a list of prohibited imports with suggested substitutes.

RECOMMENDATION 16:(Page 35) Instruct Statistics to register Hazardous Substances and keep a record of imports by brand name, quantity, and who, exactly, the importer is. A Hazardous Substance Import Licence should be required which includes the necessity to account for the distribution of these substances on the island (s) and with provisions for retrieval of these substances and their containers as hazardous wastes.

RECOMMENDATION 17:(Page 37) Produce posters, newspaper adds, and radio spots encouraging people to "Flatten that Can" and thus reduce waste volume and breeding places for mosquitoes.

RECOMMENDATION 18:(Page 37) Prohibit imports of drinks in aluminum cans in preference to glass containers and instigate re-use or disposal plans for the glass containers.

RECOMMENDATION 19:(Page 38) Encourage the development and use of locally produced, nourishing beverages and reduce drink imports.

RECOMMENDATION 20:(Page 39) Separate wastes into categories with disposal systems for Organics, Burnables, Metals, Glass, Hazardous and Dangerous. Separation is to be done by the public and collected on different days to be disposed of as appropriate.

RECOMMENDATION 21:(Page 39) Build fuel retaining walls around the fuel tanks at all power stations and refueling depots.

RECOMMENDATION 22:(Page 39) Stop discharging oil and detergent from the Popua Power Plant into the lagoon.

RECOMMENDATION 23:(Page 41) Monitor the effluent from the Popua Power Plant for copper ion discharge, plankton mortality and temperature. If possible, clean heat exchangers when off-line and discharge cleaning fluid into the oil sump discussed in recommendation 22.

RECOMMENDATION 24:(Page 41) Install used oil containers under a sign in English and Tongan saying "Put Used Oil Here" at the small boat harbors of Nuku'alofa and Neiafu. Impose stiff fines for dumping used oil into the water.

RECOMMENDATION 25:(Page 42) Legally require an Environmental Impact Study before beginning any major project in the Kingdom, and as part of any development proposal scheme.

RECOMMENDATION 26:(Page 42) Continue support and development of the National Environment Awareness Week programme as a priority item.

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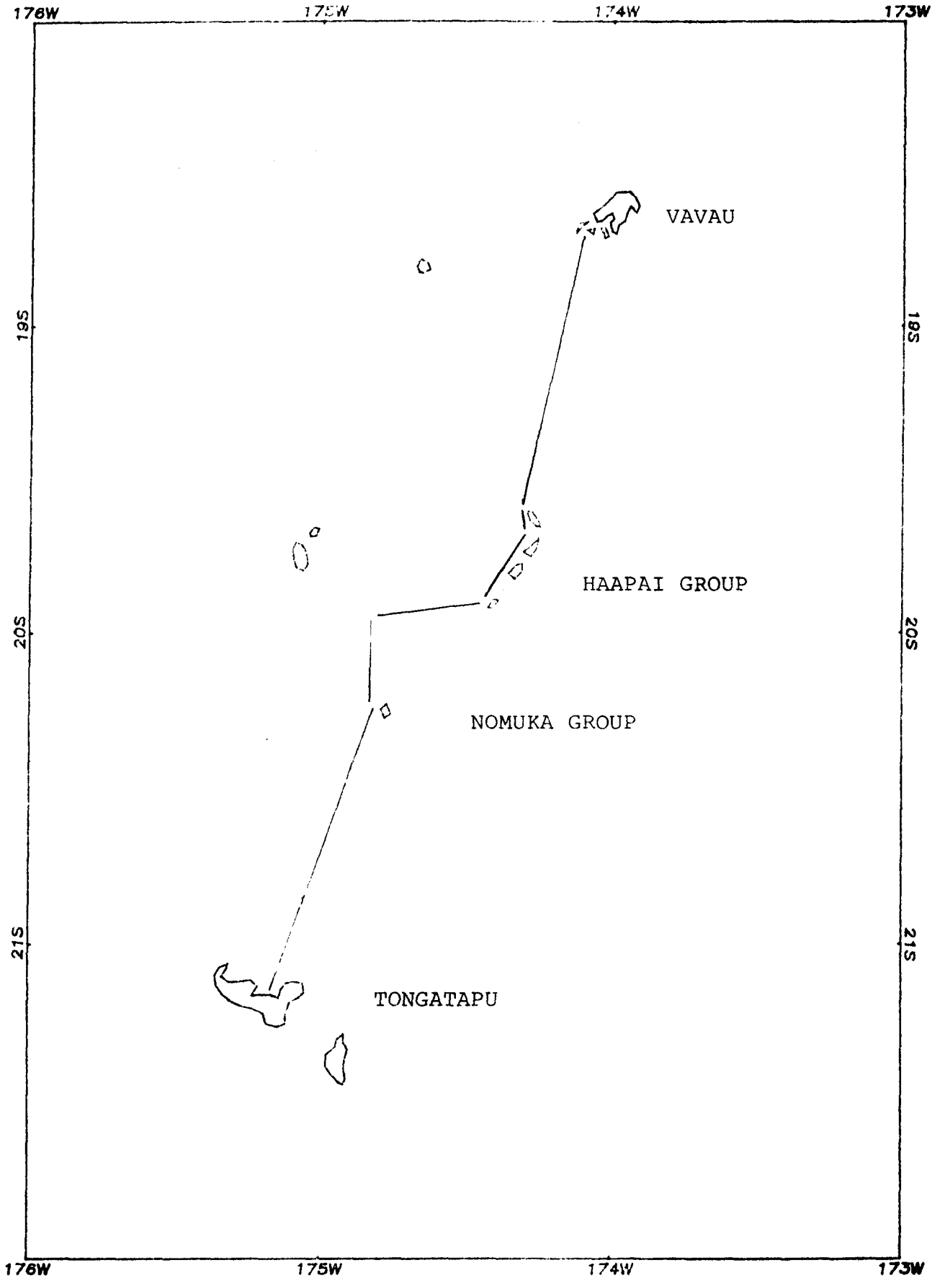


Figure 2: The Kingdom of Tonga showing the cruise plan of the Research Vessel MOIRA 1984

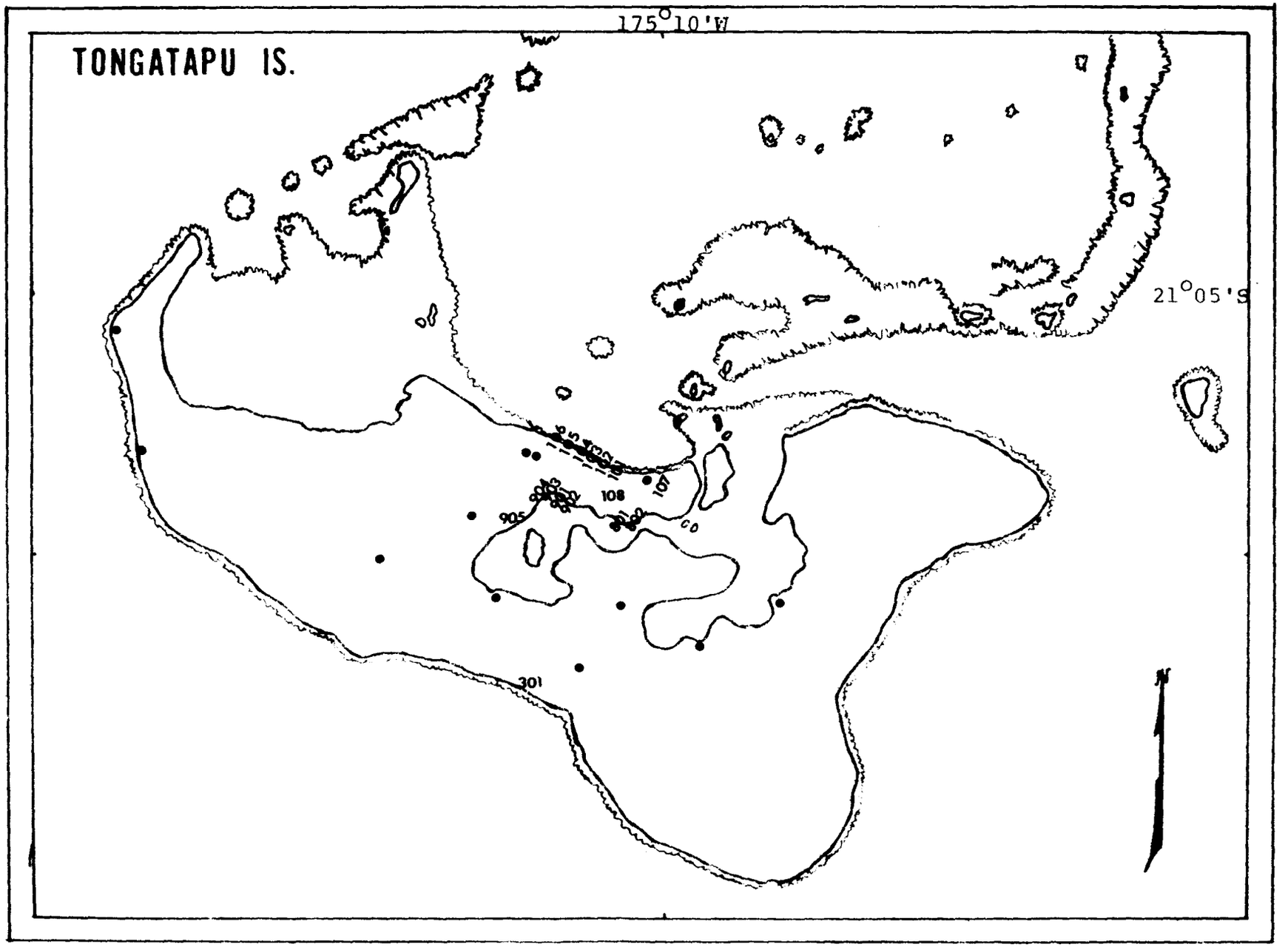


Figure 3A. Pollution Sources Stations in Tongatapu, Tonga.

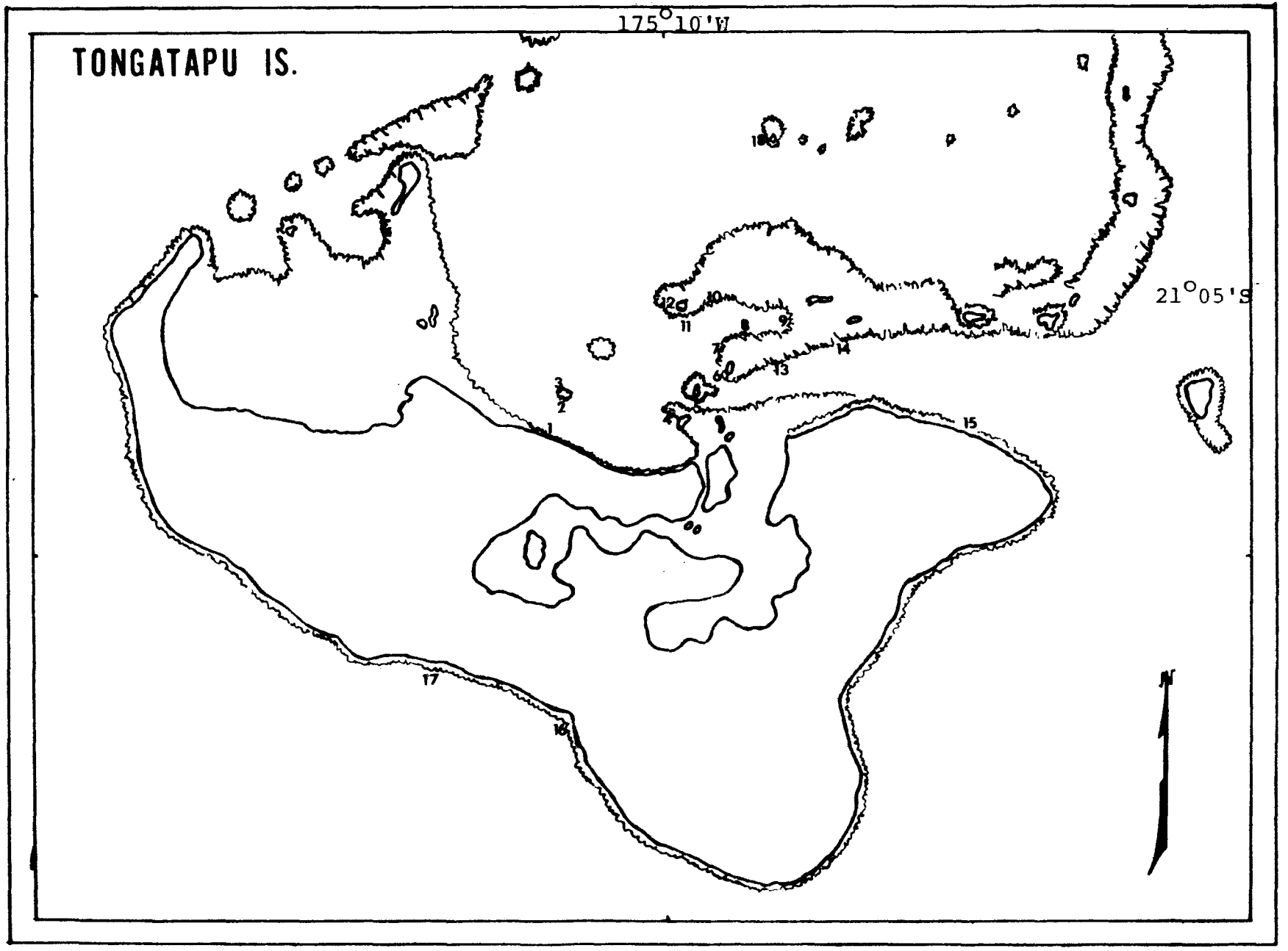
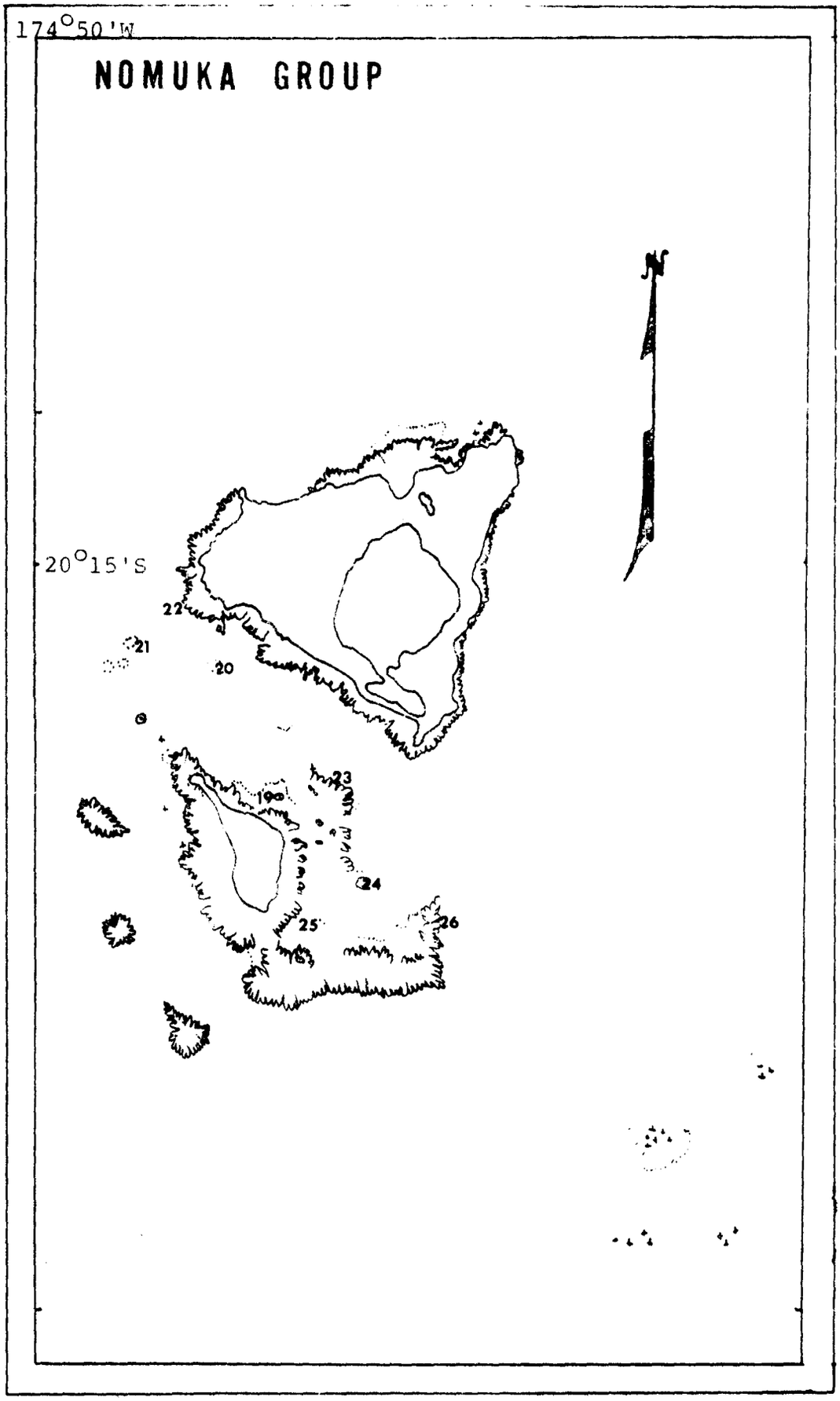


Figure 3B. Coral Reefs Examined in Tongatapu

Figure 4. Coral Reef examined in Nomuka



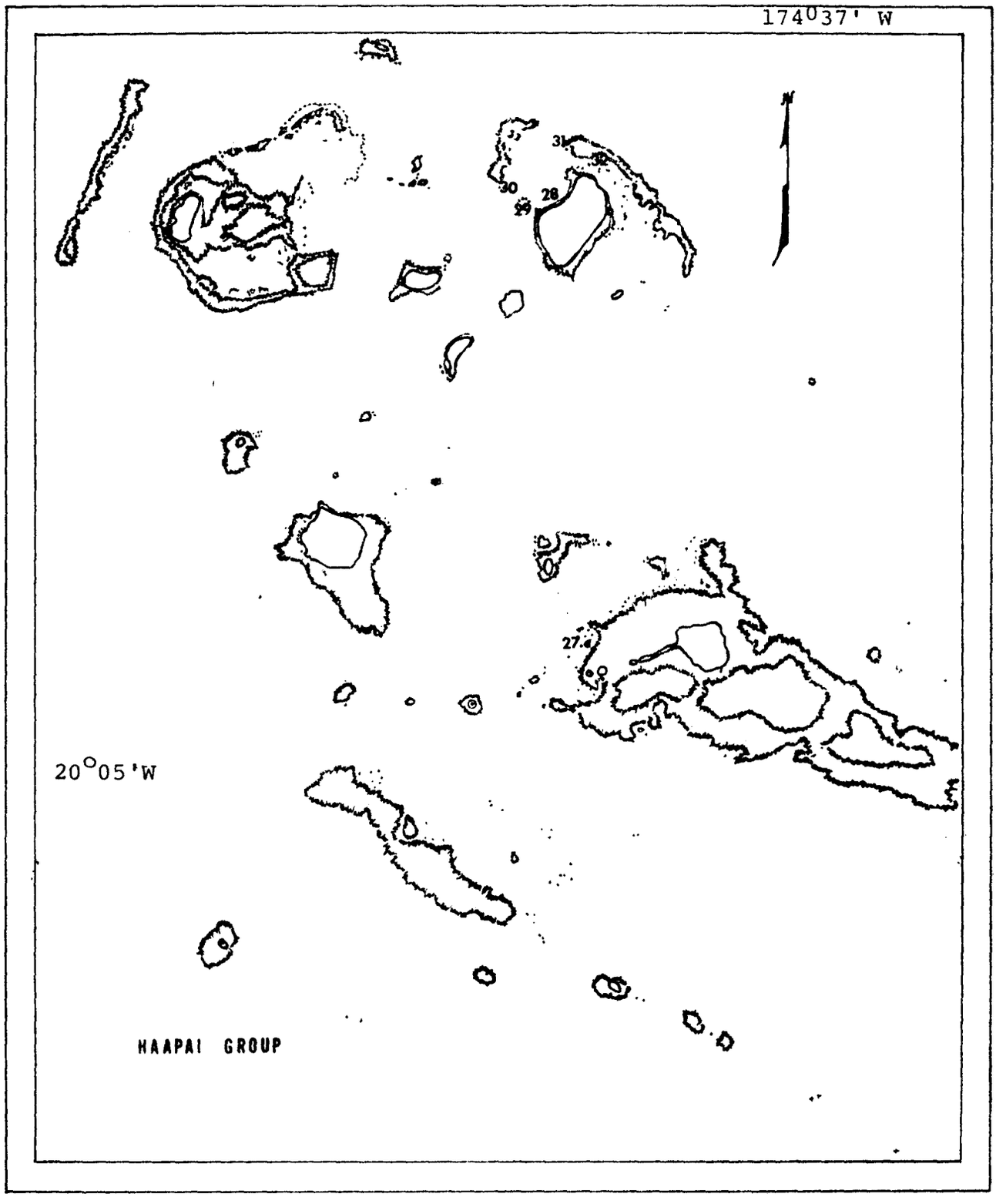


Figure 5. Coral Reefs examined in the Southern Haapai Group.

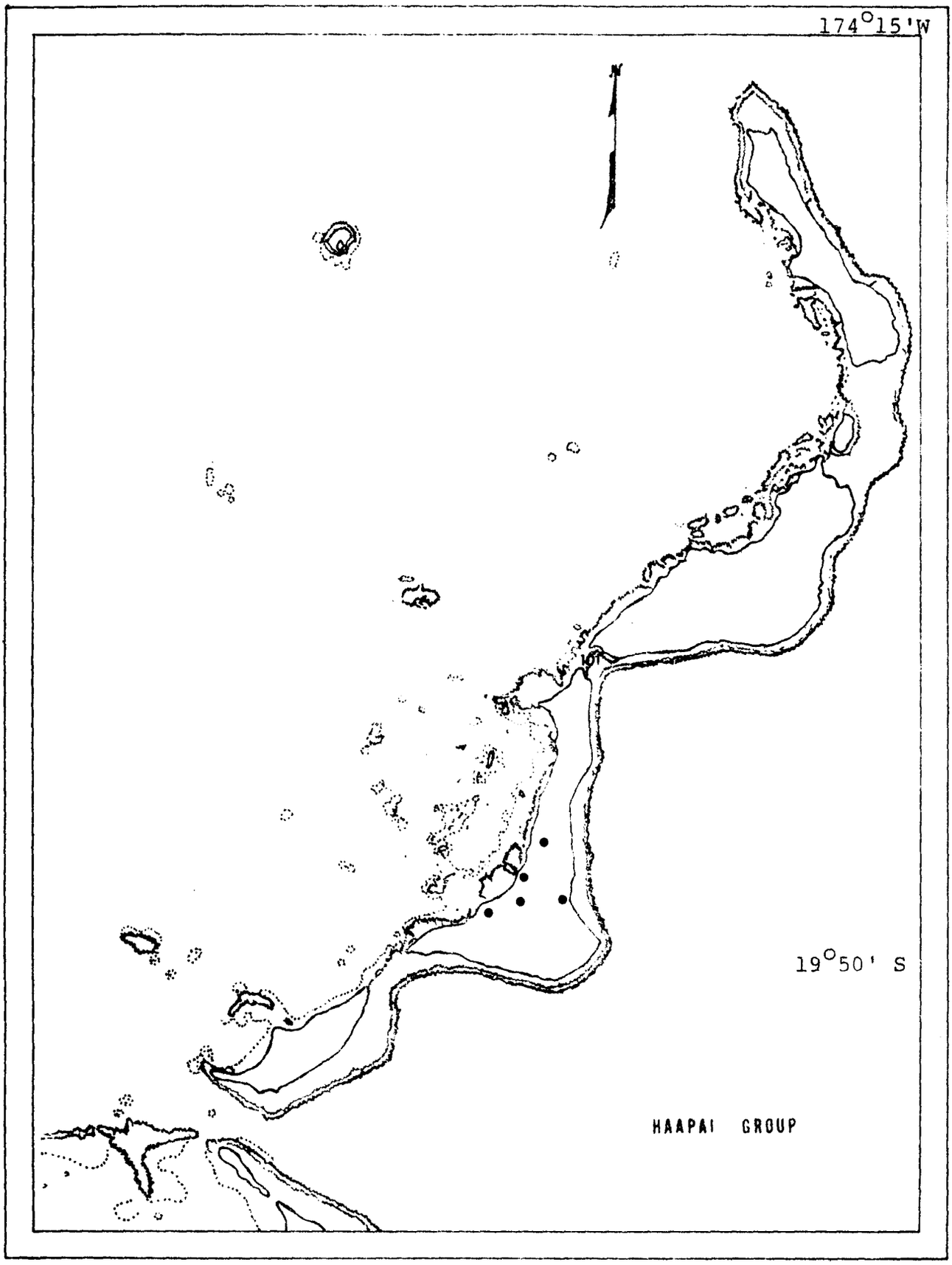


Figure 6: The Northern Haapai Islands: Pollution Sources Stations

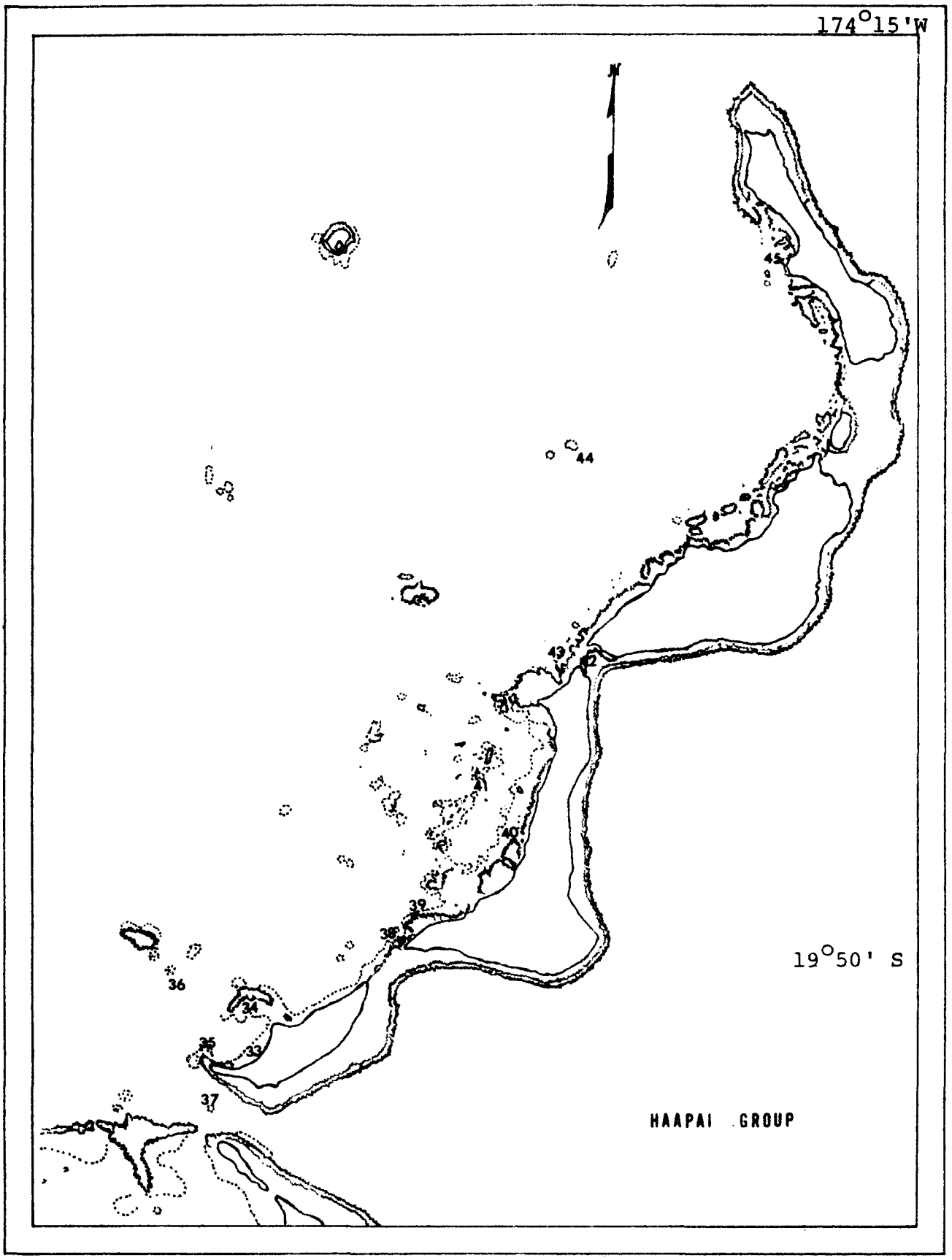


Figure 6: The Northern Haapai Islands: Coral Reefs examined.

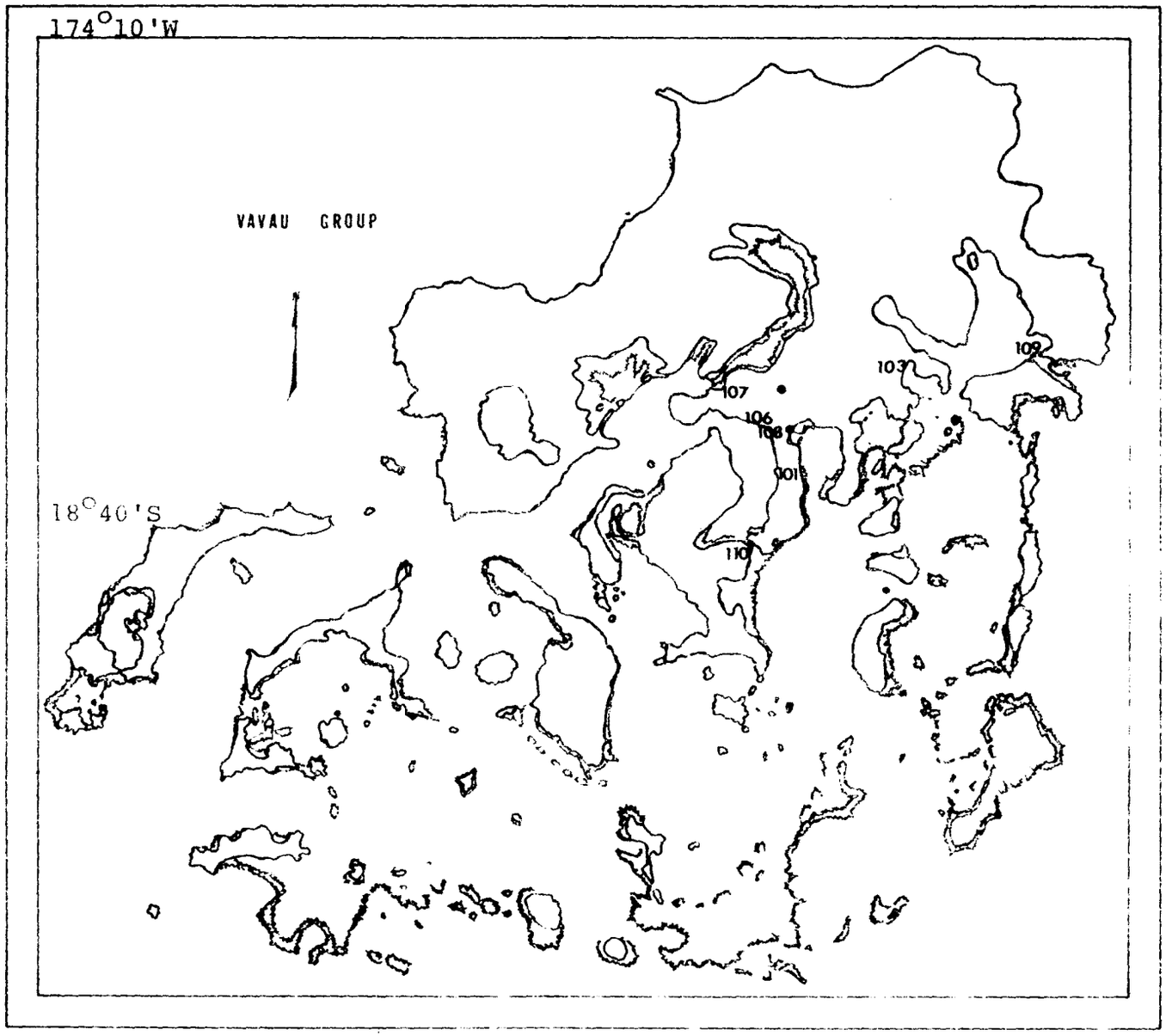


Figure 7A. Pollution Sources Stations in the Vavau Group.

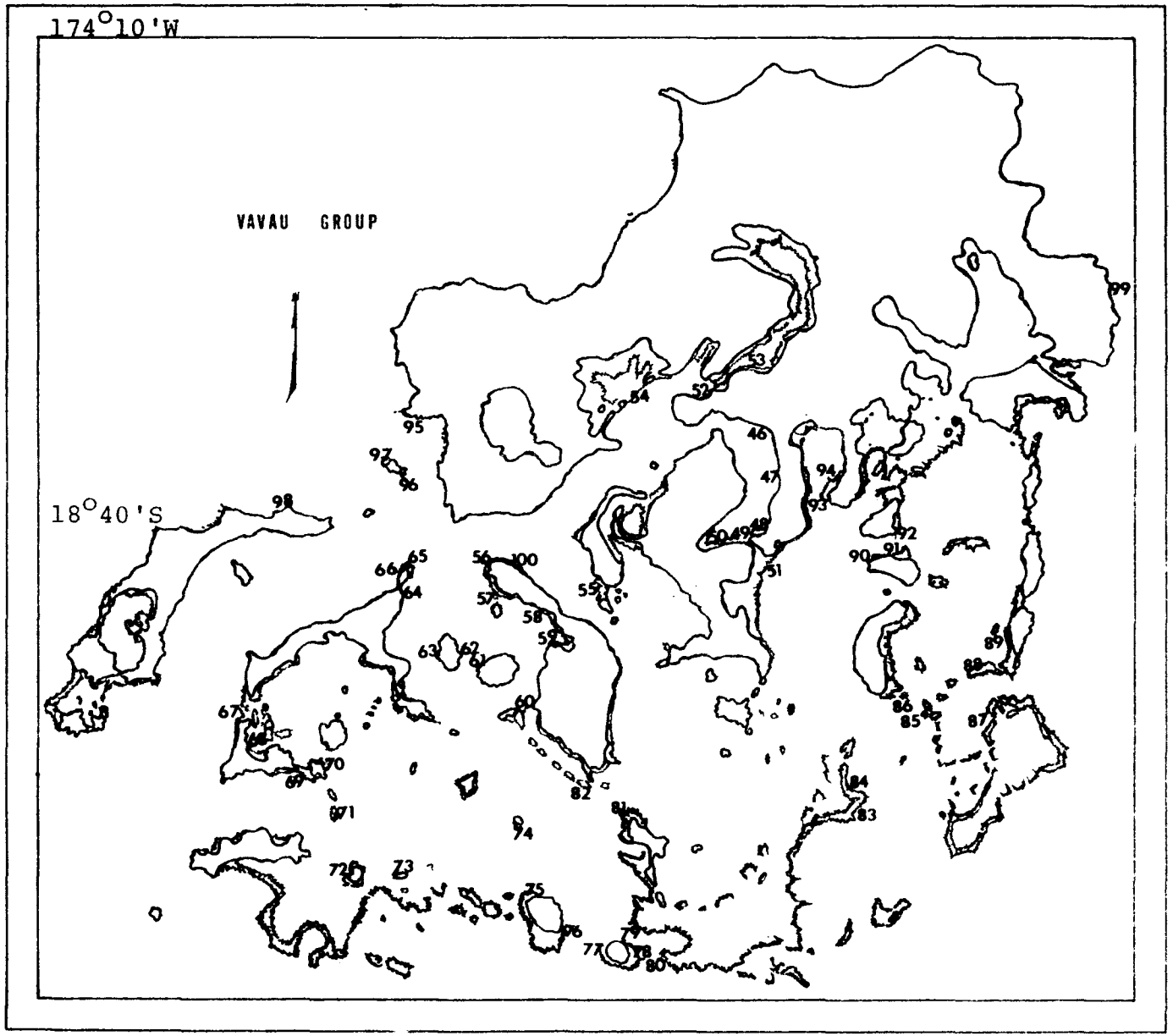


Figure 7B. Coral Reefs Examined in the Vavau Group.

TABLE 3

CORAL REEFS EXAMINED MAY TO SEPTEMBER 1984

These data represent a subjective overview of the reefs examined during the progress of the Pollution Sources Survey and the Black Coral Survey. The extent and cause of coral mortality was not suspected during the Tongatapu and Nomuka surveys. Coral breakage and blue-green algae infection was first observed at station 4, off Pangimotu Island, but its importance was not fully understood until the survey reached Vavau. Acropora mortality and a shift in community structure towards Milleporids indicated long-term stress of the reef community, especially in Tongatapu.

STATION NUMBER	CONDITION OF REEF
TONGATAPU	
1	Stressed from siltation, breakage.
2	Stressed from siltation, breakage.
3.	No recent changes evident, coral in fair condition.
4.	Good coral cover in very shallow water but breakage and infection common.
5.	Fair coral cover long-term shift to Millepora Community
6.	No recent changes evident.
7.	Long-term shift to Millepora Community
8.	Breakage & infection, fair coral in shallow water only.
9.	Sea Grass, patch reefs poor condition
10.	Coral cover fair on patch reefs, some breakage evident.
11.	Breakage, shift towards milleporids.
12.	No recent changes evident.
13.	Excellent condition
14.	Good condition
15.	Reef top mostly rubble.
16.	Normal
17.	Normal
18.	Excellent coral reef area, coral mortality seems high but cause unknown.
NOMUKA	
19.	Good coral but evidence of breakage and infection
20.	Poor coral
21.	Coral on shoal appears normal for area.
22.	Normal
23.	Extensive coral death, cause not determined, appears old.
24.	Normal
25.	Coral breakage on some patches.
26.	Normal

SOUTHERN HAAPAI GROUP

27 Coral normal but some breakage and infection
28 Lagoon corals show extensive mortality, Acanthaster common.
29. Coral poor, but appears normal for area.
30. Normal.
31. Extensive coral mortality, appears 10 to 12 years old.
32. Extensive coral mortality, cause unknown.

NORTHERN HAAPAI GROUP

33. Good Patch Reef area
34. Back Reef coral normal
35. Normal
36. Excellent Coral Development
37. Normal
38. Normal, good coral area
39. Coral broken & infection present
40. Nearshore reefs in poor condition, extensive mortality
41. Some coral breakage & infection.
42,43. Reef adjacent to causeway in poor condition.
44. Excellent condition, good coral
45. Extensive coral mortality, regrowth appears slight, infections common.

VAVAU GROUP

46. Extensive coral mortality in lagoon. Evidence of siltation, breakage, infection.
47. Extensive coral mortality, evidence of breakage, infection.
48. Extensive coral mortality, evidence of breakage, infection.
49. Coral in shallow and deep waters show extensive mortality from siltatation and breakage.
50. Slope corals in good condition, shoal and deep corals show mortality and infections.
51. Reef-top and edge dead. Slope corals in poor condition.
52. Corals in poor condition, evidence of siltation from quarry and coral breakage.
53. Laggon corals in poor condition, evidence of siltation from quarry and coral breakage.
54. Reef reduced to rubble by fishermen from 1975 to present. See McLean report
55. Corals in some areas in good condition. Breakage and infection present.
56. Vertical slope. Corals normal
57. Reef top and upper slope corals show extensive mortality breakage and infection, deeper corals with some infection but good in local areas. People observed breaking coral with bush knives and iron pole.
58. Extensive breakage and infection.
59. Shallow corals with extensive breakage and infection, deeper corals in good condition. Acanthaster and Culcita abundant.
60. Corals generally OK but some breakage in shallower patches.
61. Vertical slope corals normal.

62. Coral poor, evidence of breakage and infection.
63. Coral poor, evidence of breakage and infection.
64. Vertical slope. Corals normal.
65. Shelf slope corals normal.
66. Corals in fair condition, fisherman observed breaking coral while takeing Vasua.
67. Excellent corals, unharmed, in good condition.
68. Good coral, some patches reduced to rubble: reported to be done by fishermen (Wolfgramm, personal communication).
69. Corals recently broken and turned over along reef flat, extensive coral breakage in reef lagoons and behind reef. Fishermen observed breaking coral.
70. Corals in poor condition, broken in shallow water.
71. Shallow corals broken, deeper corals in good condition.
72. Shallow corals broken, deeper corals in poor condition.
73. Evidence of coral mortality, some breakage.
74. Extensive coral mortality from Acanthaster (B. Davis, personal communication).
75. Poor coral condition, cause undetermined.
76. Poor coral condition, cause undetermined.
77. Vertical slope, coral seems normal.
78. Coral normal.
79. Breakage and infection in local areas.
80. Coral poor, cause unknown.
81. Coral poor, cause unknown.
82. Extensive coral mortality, breakage and Acanthasters observed.
83. Coral Normal, in fair condition.
84. Extensive coral mortality, evidence of breakage.
85. Extensive coral mortality, evidence of breakage & infection.
86. Extensive coral mortality, breakage & infection present.
87. Extensive coral mortality, breakage & infection present. Coral in deeper water outside reef in good condition.
88. Extensive coral mortality, breakage and infection.
89. Extensive coral mortality, breakage and infection.
90. Extensive coral mortality.
91. Poor coral, siltation, breakage.
92. Poor coral.
93. Coral normal.
94. Coral normal.
95. Coral poorly developed.
96. Coral in good condition
97. Coral in Excellent condition
98. Coral in Excellent condition
99. Reef top and lagoon reduced to rubble, people observed breaking coral while fishing using bush knives, hammers, and iron poles. Lagoon corals broken by tourists and fishermen within past 4 years (B. Davis, personal communication).
100. Coral mostly dead, evidence of breakage and infection.

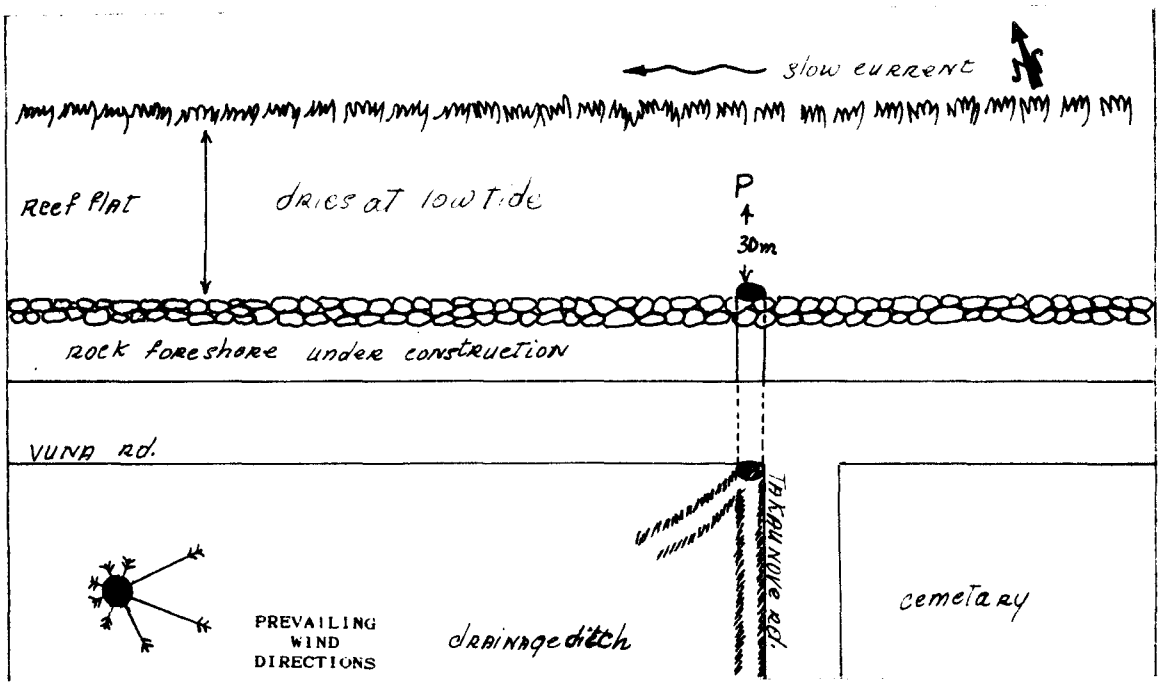
STATION NUMBER 1.01 MAP REF Tongatapu IV

NAME AND LOCATION Street drain
TAKAUNOVE Rd.

MEANS OF DISCHARGE pipe 45cm

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE Storm water runoff from tar sealed road and lawn
AMOUNT OF WASTE slight seasonal with rainfall
PERIODIC DANGERS NONE

DILUTION AT DISCHARGE POINT- Good: Fair: Poor:
Comments: poor at low tide

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
Open lagoon coastline, Reef flat covered with silty sand along whole waterfront. Halimeda, Sparse sea grass, Foraminifera.

HEALTH HAZARD

ECOLOGICAL HAZARD possible use of weed killers or pesticides on lawn.

USES OF STATION AREA Fishing X Swimming Tourism X
Food Gathering (List kind of food taken) Subsistance fishing for shellfish and octapus, leaf soaking for mats and baskets
OTHER USES tourism

ALTERNATIVE DISPOSAL As aland gradient is towards the South it would be possible to dig a drainage pond to the South west, thus saving the water to recharge the aquifer it could be stocked with fish and frogs to keep mosquitoes down.
RECOMMENDED ACTION NONE

INSPECTOR Chesher DATE 13-6-84

PHOTOGRAPH Taken at location marked "P" on the chart

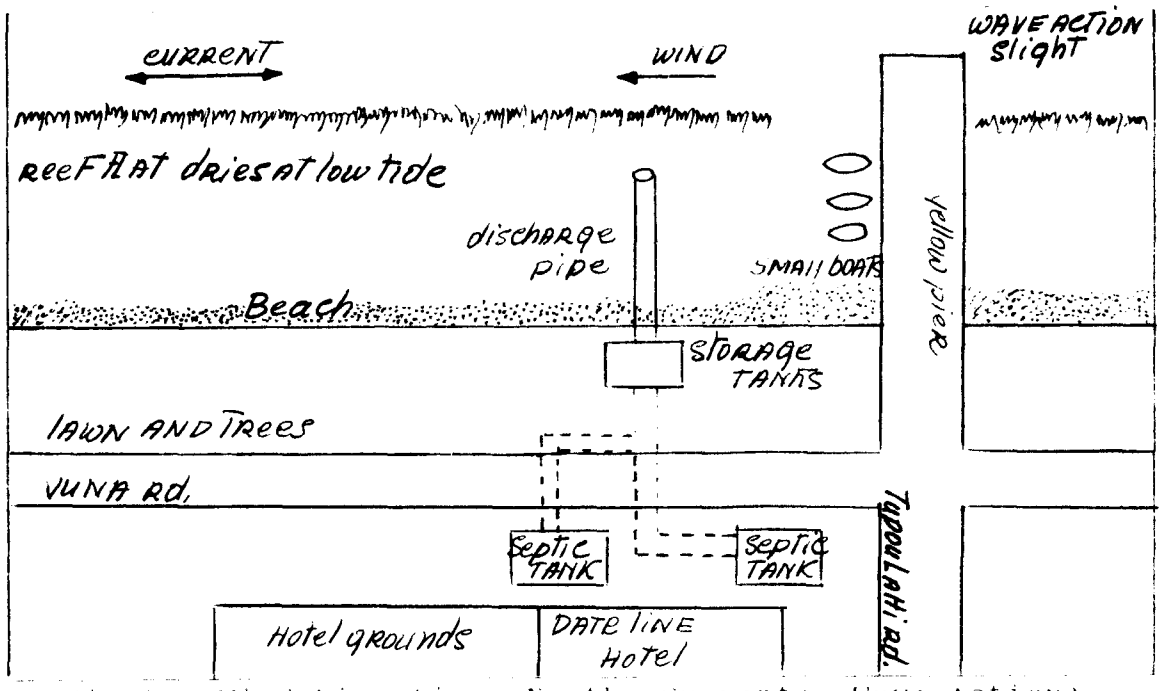
STATION NUMBER 102 A MAP REF TONGATAPU N.

NAME AND LOCATION Date line Hotel /

MEANS OF DISCHARGE pipe ON Reef Top

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, currents, wave action)
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE UNTreated overflow FROM septic TANKS
AMOUNT OF WASTE 380,000 TO 1,180,534 GALLONS per MONTHS
PERIODIC DANGERS Tourists with Typhoid, Cholera, Hepatitus or other water borne communicable diseases.
DILUTION AT DISCHARGE POINT= Good: Fair: Poor: X
Comments: undiluted effluent covers coral reef at low tide.

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
open lagoon coastline, Reef Flat covered with silty SAND, SPARSE sea grass

HEALTH HAZARD People eating CONTAMINATED shellfishs, OR WALKING IN CONTAMINATED WATER, MAY START epidemic.
ECOLOGICAL HAZARD EUTROPHICATION of reef community, AND subsequent CORAL death.

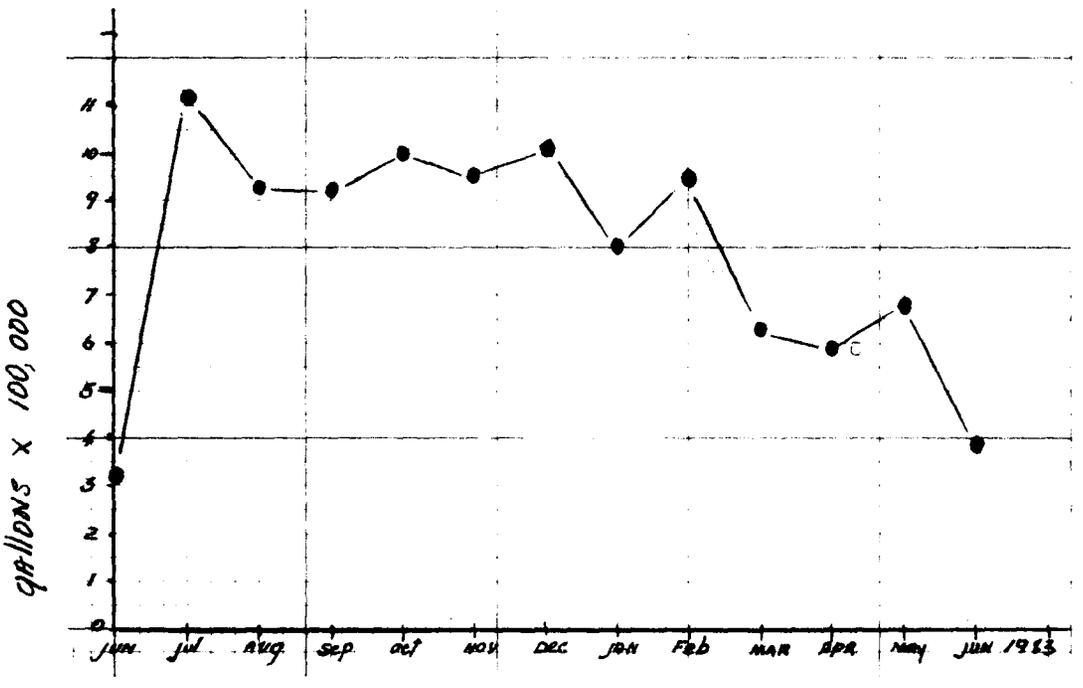
USES OF STATION AREA: Fishing X Swimming X Tourism X
Food Gathering (List kind of food taken) subsistance fishing for shellfish octopus, sea hares, and fish.

OTHER USES small boat harbor, Tourist scenic view.

ALTERNATIVE DISPOSAL drainage fields.

RECOMMENDED ACTION construct adequate septic tanks and drainage fields.

INSPECTOR Chesher DATE 13-6-84



MONTHLY WATER USE OF THE DATELINE HOTEL 1983-84

SAMPLE OF EFFLUENT SHOWS NO CHLORINE
COLIFORM BACTERIA TOO NUMEROUS TO COUNT.

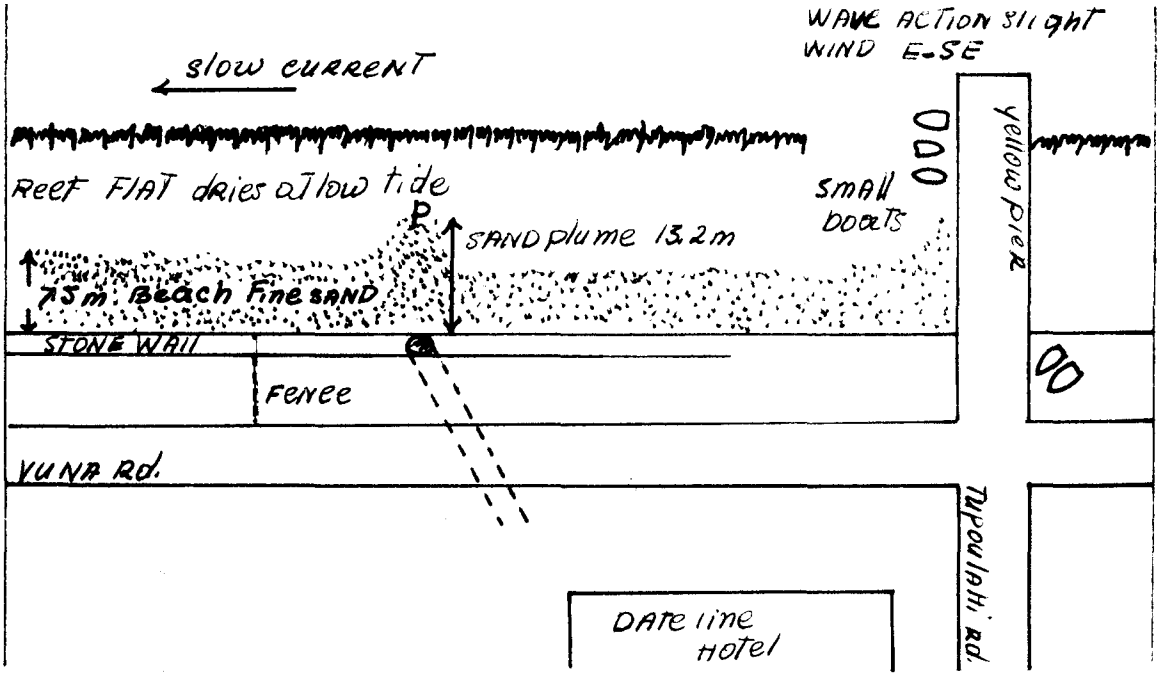
STATION NUMBER 102 B MAP REF TONGATAPU N.

NAME AND LOCATION DATELINE Hotel 2

MEANS OF DISCHARGE pipe 70 cm

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
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TYPE OF WASTE Drainage from Hotel road and grounds
AMOUNT OF WASTE periodic with RAIN Fall and activities.
PERIODIC DANGERS cleaning solutions FOR drains

DILUTION AT DISCHARGE POINT Good: Fair: Poor: X
Comments: undiluted effluent covers reef at low tide

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
open lagoon coastline, SAND Beach Above SILTY SAND Reef flat SPARSE SEAGRASS, Halemeda, HoloThroids Sponges Tubeworms, small corals, Foraminifera, STARFish GASTROPODS.

HEALTH HAZARD possible lead paint accumulation in Reef organisms used as food.
ECOLOGICAL HAZARD possible use of weed killers or pesticides on lawn and Toxic cleaning solutions.

USES OF STATION AREA Fishing X Swimming X Tourism X
Food Gathering (List kind of food taken) Shell Fish, octopus seahares, and Fish

OTHER USES Small boat harbor, Tourist DARK.

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION NONE.

INSPECTOR Chesher DATE 13/6/84

PHOTOGRAPH taken at location marked on the chart

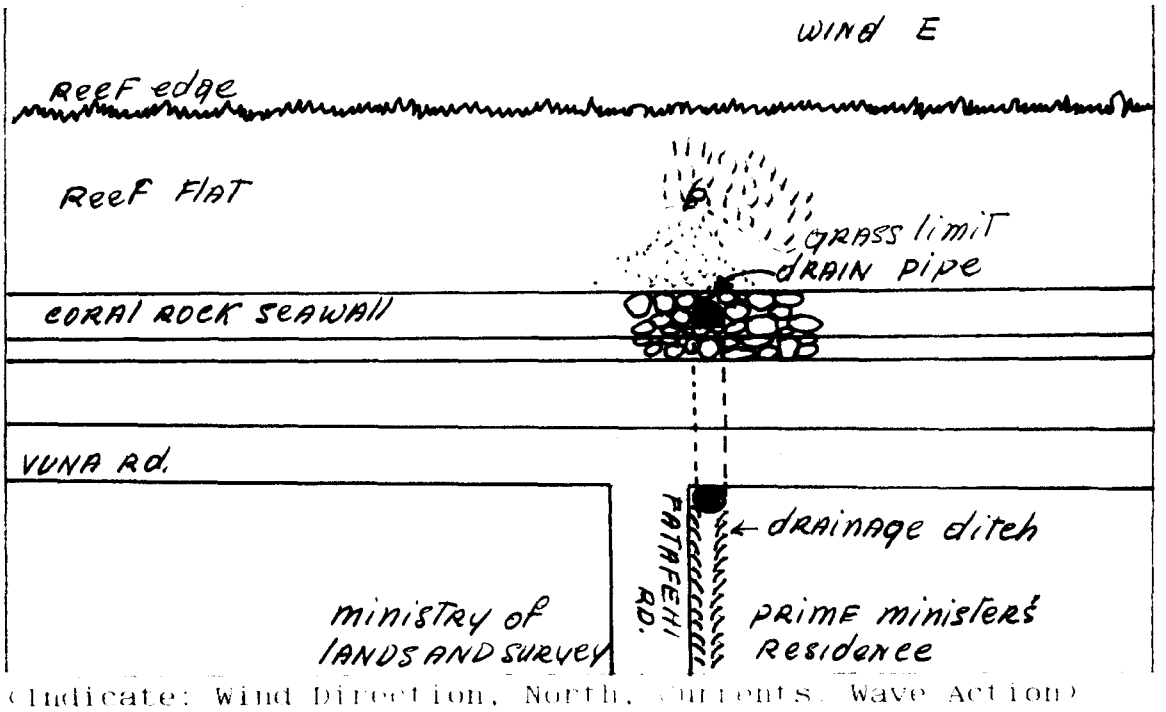
STATION NUMBER 103 MAP REF TONGATAPU N

NAME AND LOCATION FATAFEHI STREET DRAIN AND VUNA ROAD.

MEANS OF DISCHARGE pipe 45cm

POLLUTION INDEX
STOP NOW
MONITOR
WATCH
OK

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P-Photograph taken from here, arrow shows angle of view

TYPE OF WASTE STREET RUN-OFF FROM CITY
AMOUNT OF WASTE MODERATE during HEAVY RAIN
PERIODIC DANGERS

DILUTION AT DISCHARGE POINT- Good: Fair: Poor: X
Comments: POOR AT low Tide

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
REEF FLAT With silty SAND, ROCKS, pipe empties behind ROCK WALL. sea GRASSES holoTROIDS halameda FORAMINIFERA.

HEALTH HAZARD lead PCB's hydrocarbons FROM city STREETS MAY accumulate IN reef organisms, and produce low level
ECOLOGICAL HAZARD poisoning.
BIOACCUMULATION of TOXINS FROM STREETS DURING HEAVY RAINS

USES OF STATION AREA Fishing X Swimming Tourism X
Food Gathering (List kind of food taken) shell Fish, octopus sea hares AND Fish. leaf soaking AREA FOR MATS AND BASKETS.
OTHER USES

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION use unleaded gasoline, paints non Toxic Roads surface compounds.

INSPECTOR Chesher DATE 13-6-8

PHOTOGRAPH: Taken at location marked "P" on the chart

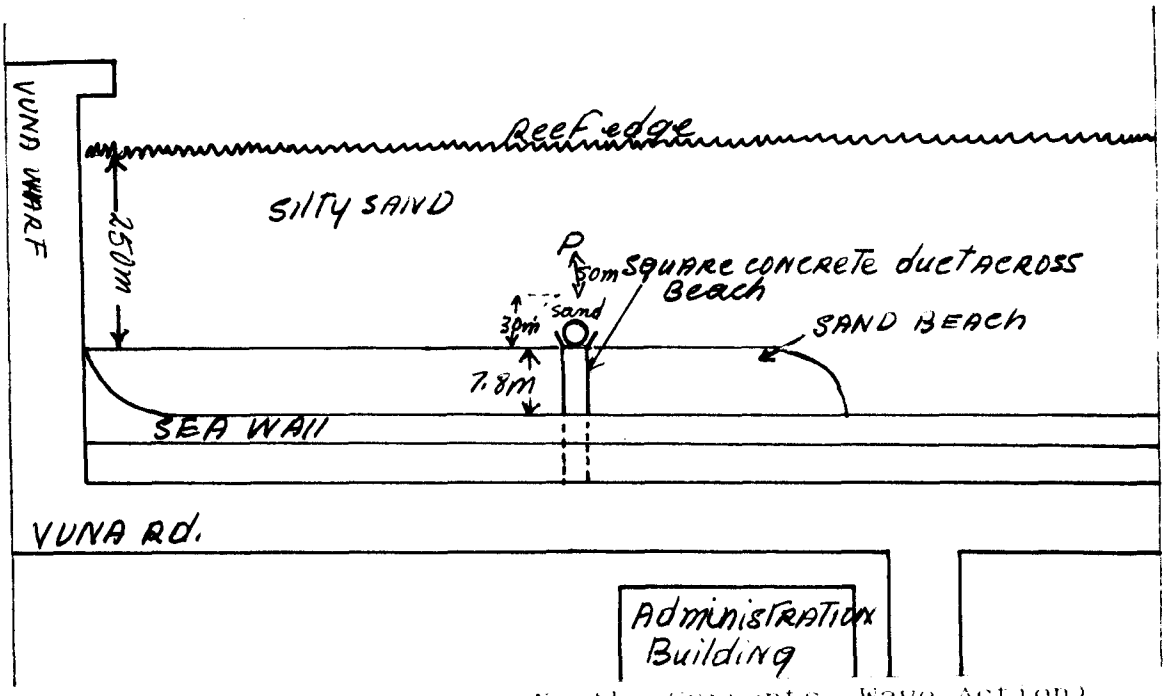
STATION NUMBER 104 MAP REF Tongatapu N

NAME AND LOCATION MARKET AND BUS-STATION DRAIN

MEANS OF DISCHARGE 40 empipe 1.8m FROM Foreshore

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE MARKET WASTES AND city streets run-off.
AMOUNT OF WASTE Slight
PERIODIC DANGERS Night-Time wash discharge

DILUTION AT DISCHARGE POINT Good: _ Fair: _ Poor: X
Comments: poor at lowtide

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
Silty sand Reef Flat, sparce sea grass with Holothroids, crabs.

HEALTH HAZARD lead, PCB's, hydrocarbons, may accumulate in reef organisms, and produce lowlevel poisoning.
ECOLOGICAL HAZARD Bioaccumulation of toxins from streets during heavy rains.

USES OF STATION AREA Fishing X Swimming Tourism X
Food Gathering (List type of food taken) Shell Fish, octopus
Seahares and Fish.

OTHER USES

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION: use unleaded gasdines and paints
non-toxic Roadsurface compounds.

INSPECTOR Chesher DATE 13-6-84

PHOTOGRAPH: Taken at [illegible] Chart

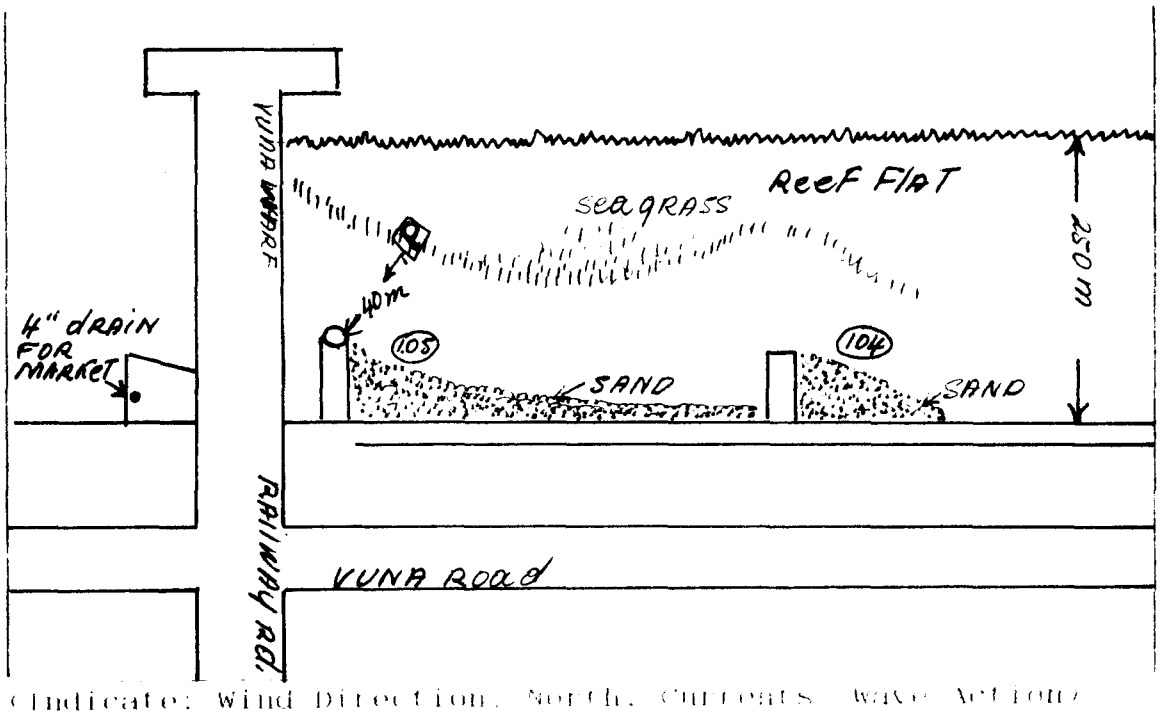
STATION NUMBER 105 MAP REF TongaTapu IV

NAME AND LOCATION Street drain
Railway Road

MEANS OF DISCHARGE 40cm pipe with inoperative Flapper valve

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Current, Wave Action)
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE Street runoff
AMOUNT OF WASTE VARIES with RAINFALL
PERIODIC DANGERS

DILUTION AT DISCHARGE POINT Good ___ Fair ___ Poor X
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
POOR silty SAND Rubbish at 50 paces seaward sea grass with Holothroids and sponges, mollusks.

HEALTH HAZARD lead PCB's hydrocarbons may accumulate in reef organisms and produce low level poisoning
ECOLOGICAL HAZARD Bioaccumulation of toxins From streets during heavy rains

USES OF STATION AREA Fishing Swimming Tourism X
Food Gathering Type of Food Taken

OTHER USES *small boat anchorage*

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION *use nonleaded gasolines and paints*
non Toxic road surface compounds

INSPECTOR *Chesher* DATE *13/6/84*

PHOTOGRAPH taken at location marked "P" on the chart.

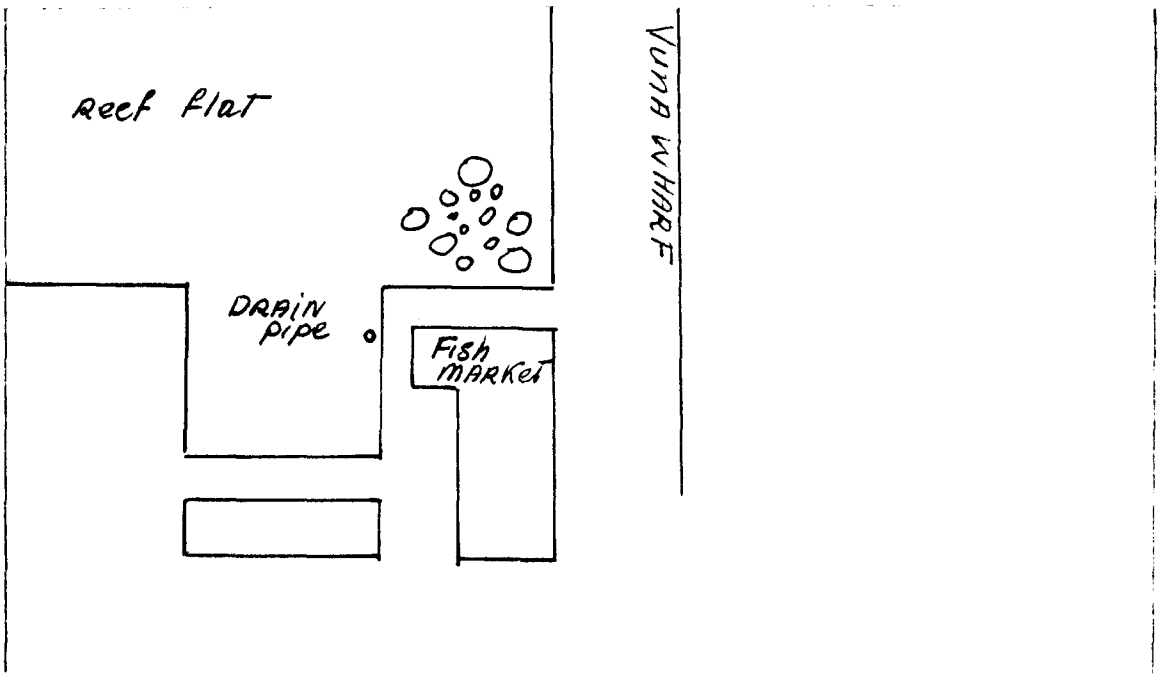
STATION NUMBER 106 MAP REF TONGATAPU N

NAME AND LOCATION Fish MARKET

MEANS OF DISCHARGE 10 cm pipe FROM sea wall

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE cleaning WATER FROM Fish MARKET Floor
AMOUNT OF WASTE slight
PERIODIC DANGERS with washdown STRONG detergent RAT poisons insecticides organics.
DILUTION AT DISCHARGE POINT Good: Fair: Poor: X
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
muddy sand, stones

HEALTH HAZARD Fish OR shellfish being washed in sea WATER might become contaminated.
ECOLOGICAL HAZARD AREA dead

USES OF STATION AREA: Fishing Swimming Tourism
Food Gathering (List kind of food taken) buying fish when boats come in.

OTHER USES landing area for small boats and fishing boats.

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION pipe to end of wharf

INSPECTOR Chesher DATE 13/6/84

PHOTOGRAPH: Taken at location marked "P" on the chart.

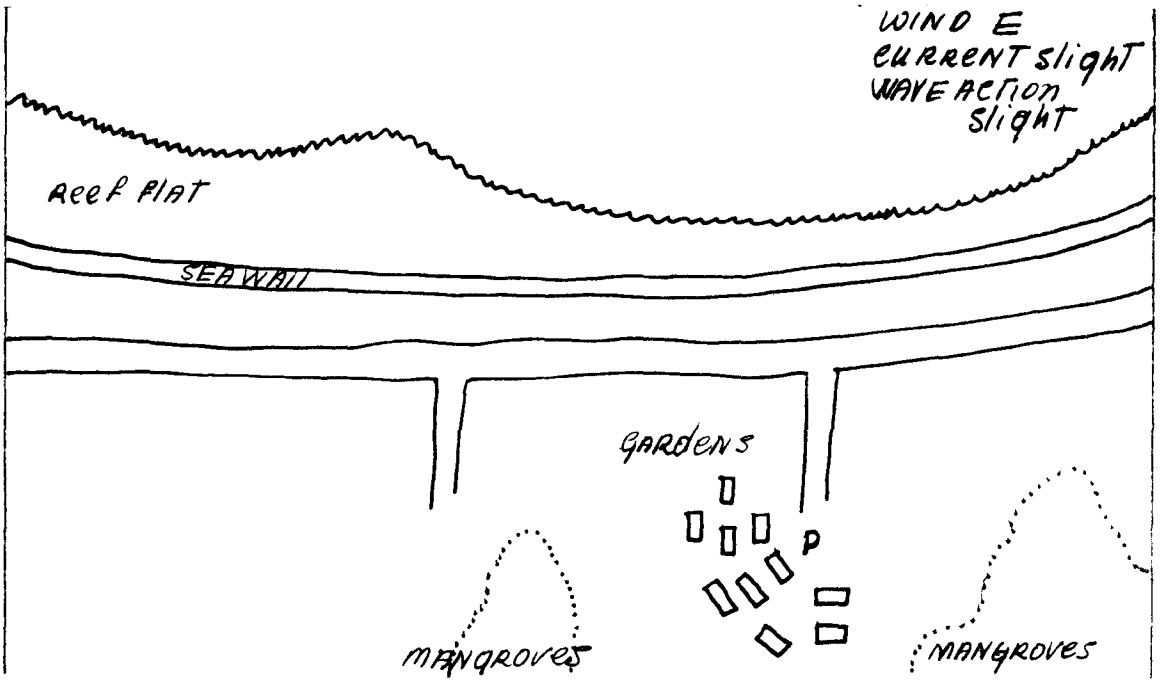
STATION NUMBER 107 MAP REF TONGATAPU NE

NAME AND LOCATION sludge drying beds

MEANS OF DISCHARGE Trucks From septic TANKS

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P-Photograph taken from here, arrow shows angle of view

TYPE OF WASTE Sludge from septic TANK
AMOUNT OF WASTE About 1 Truck load per week
PERIODIC DANGERS PARASITE eggs in sludge heavy metals

DILUTION AT DISCHARGE POINT Good: Fair: Poor: N/A
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
Terrestrial area reclaimed land lush gardens papaya TARO near mangrove swamp

HEALTH HAZARD Spread of parasites by use of uncurred sludge for fertilizers.
ECOLOGICAL HAZARD NONE

USES OF STATION: Boating Fishing Swimming Tourism
Food Gathering Hunting Kind of Food Taken: garden

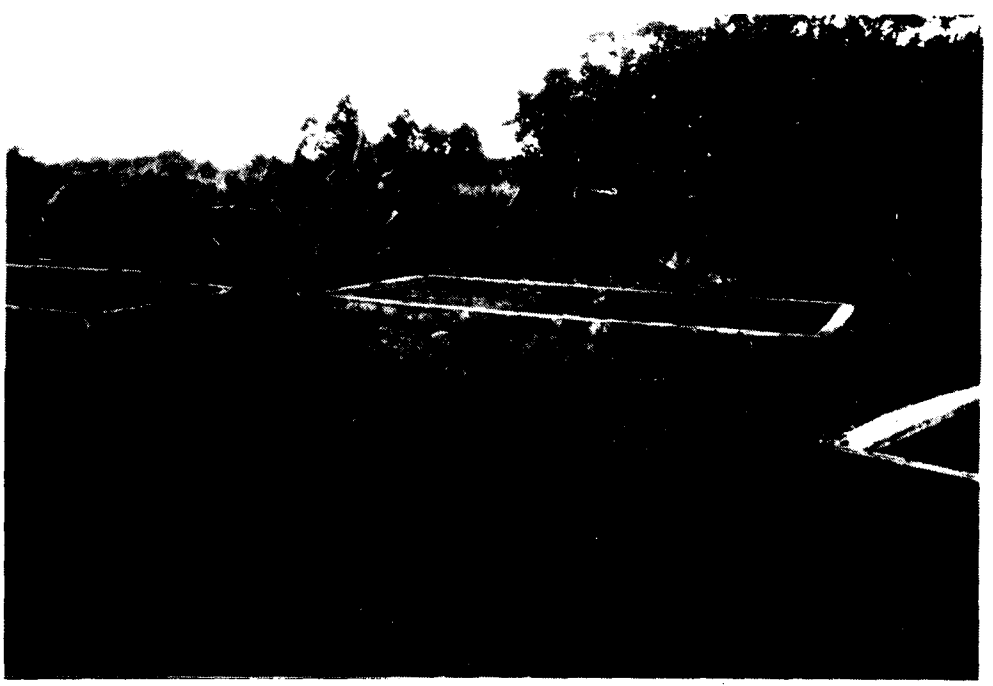
OTHER USES

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION: existing health department regulations satisfactory.

INSPECTOR Chesher DATE 14/6/84

PHOTOGRAPH: Taken at location marked "P" on the chart



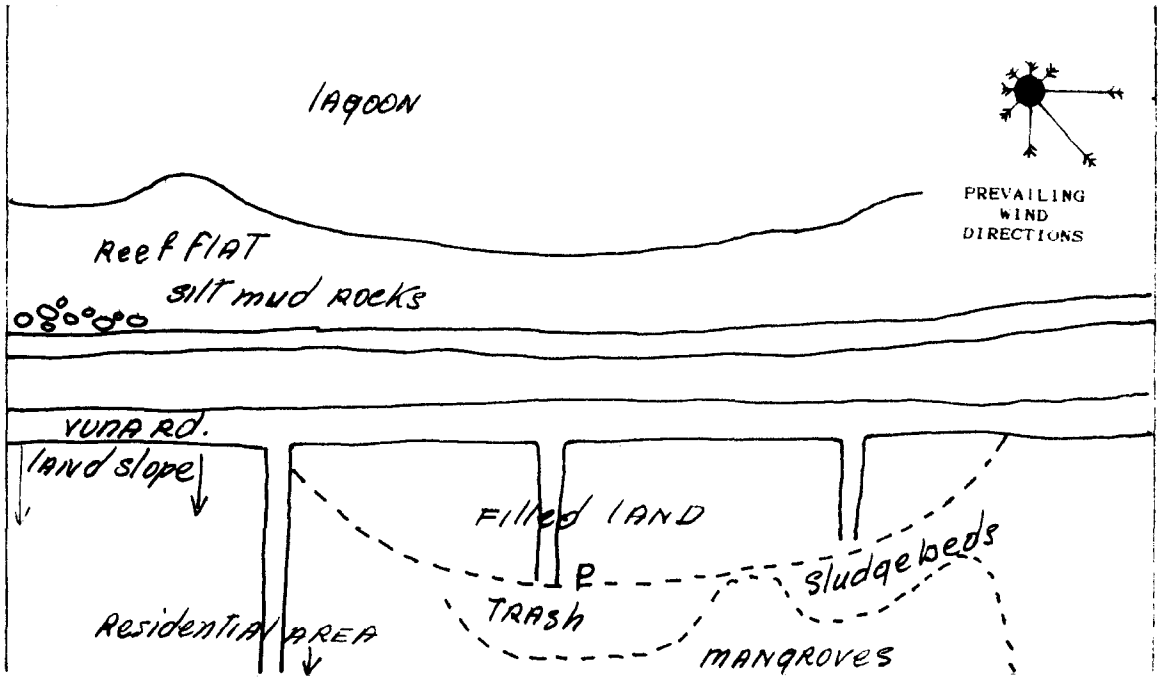
STATION NUMBER 108 MAP REF TONGATAPU NE

NAME AND LOCATION Popua Rubbish dump

MEANS OF DISCHARGE Trucks

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



Indicate: Wind Direction, North, Currents, Wave Action
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE Solid wastes
AMOUNT OF WASTE 10 TRUCK LOADS PER DAY (About 50 TONS)
PERIODIC DANGERS HAZARDOUS WASTE : medicine, MERCURY lead pesticides oil PCB's ect...
DILUTION AT DISCHARGE POINT Good: Fair: Poor: NONE
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
MANGROVE SWAMPS being filled

HEALTH HAZARD contamination of shellfish with pesticides and heavy metals - RATS and wild dogs.
ECOLOGICAL HAZARD destruction of MANGROVES AND poisoning of mangrove community with pesticides and leachates

USES OF STATION AREA: Fishing X Swimming ___ Tourism ___
Food Gathering (List kind of food taken): new residential area south of dump Also filling in mangroves

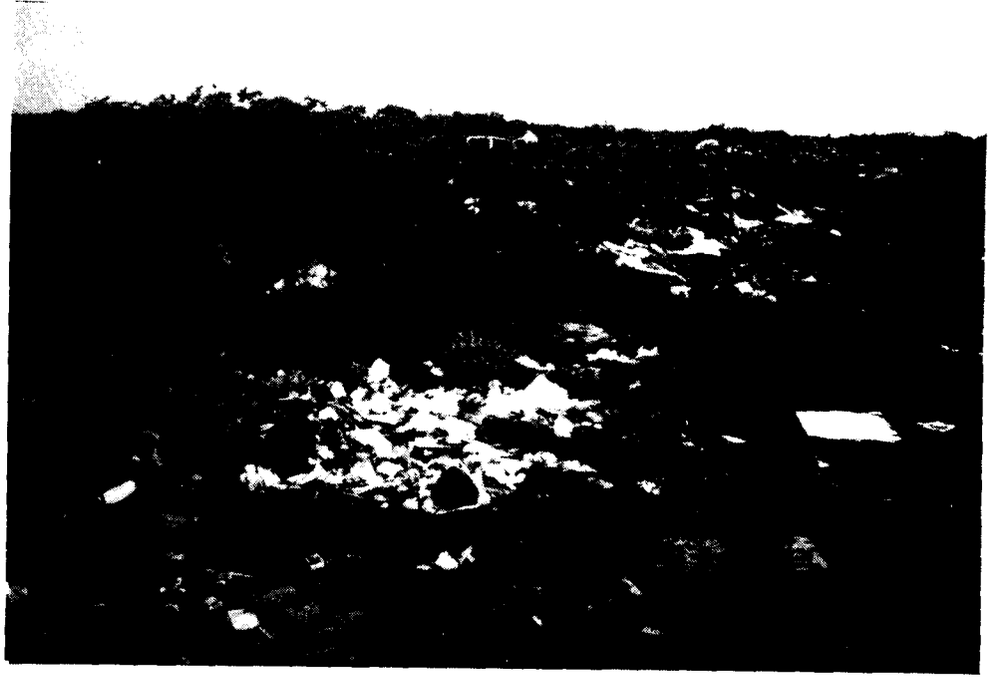
OTHER USES: possible subsistence fishing and farming crabs, shellfish

ALTERNATIVE DISPOSAL: separation of waste into: biodegradable, burnable, metalic, glass. and hazardous with proper disposable site for each.

RECOMMENDED ACTION: new solid waste disposal plan.

INSPECTOR: Chesher DATE: 14/6/84

PHOTOGRAPH: Taken at location marked "1" on the chart



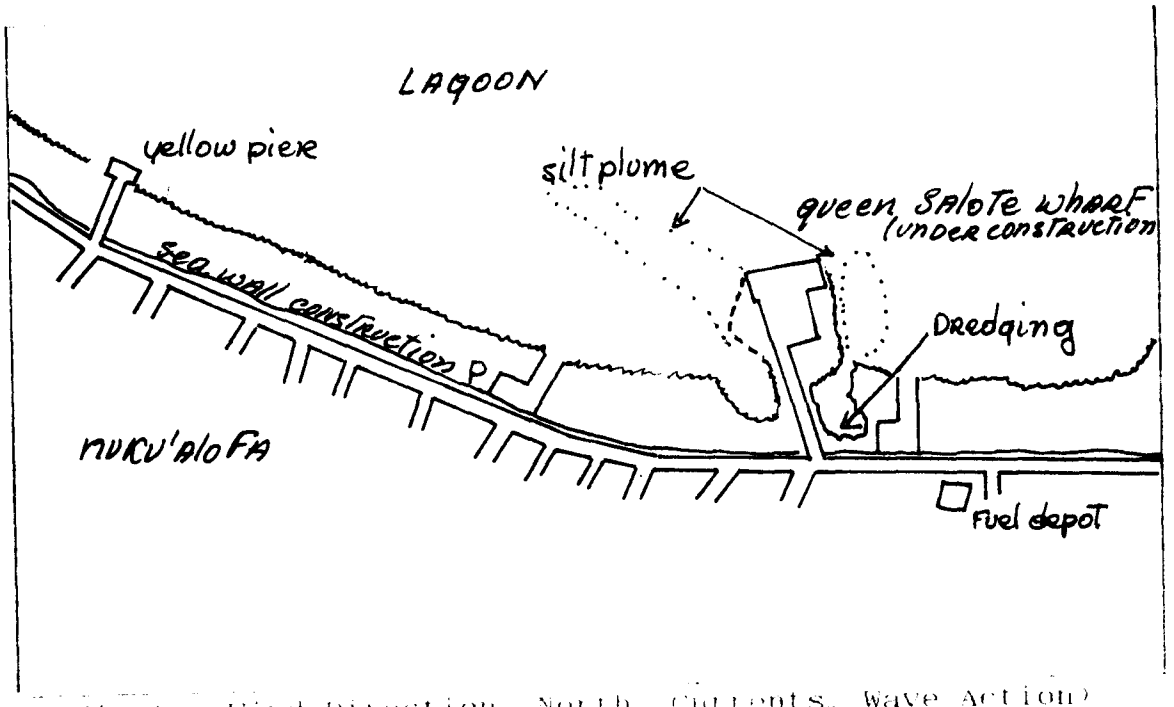
STATION NUMBER 109 MAP REF NUKUALOFA

NAME AND LOCATION WATER FRONT CONSTRUCTION and Fuel TRANSFER

MEANS OF DISCHARGE run off and oil spills

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind direction, North, Currents, Wave Action)
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE silt oil
AMOUNT OF WASTE considerable with heavy RAIN OR N WIND
PERIODIC DANGERS oil spills

DILUTION AT DISCHARGE POINT Good: Fair: X Poor:
Comments: NUKU'ALOFA HARBOR basin collects Fine silt in deep water

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
coral lined lagoon Average depth 30M black coral population in deep water

HEALTH HAZARD

ECOLOGICAL HAZARD Death of silt sensitive reef and Black corals

USES OF STATION AREA: Fishing X Swimming X Tourism X
Food Gathering (if so, kind of food taken): Fish, shellfish
octopus black coral

OTHER USES: boat harbor

ALTERNATIVE DISPOSAL: use silt screens and plant grass as soon as possible

RECOMMENDED ACTION: Apply top soil and plants or cement to cut down siltation

INSPECTOR: Chesher DATE: 16/6/84

PHOTOGRAPH: Taken at location marked "P" on the chart.

POLLUTION SOURCES

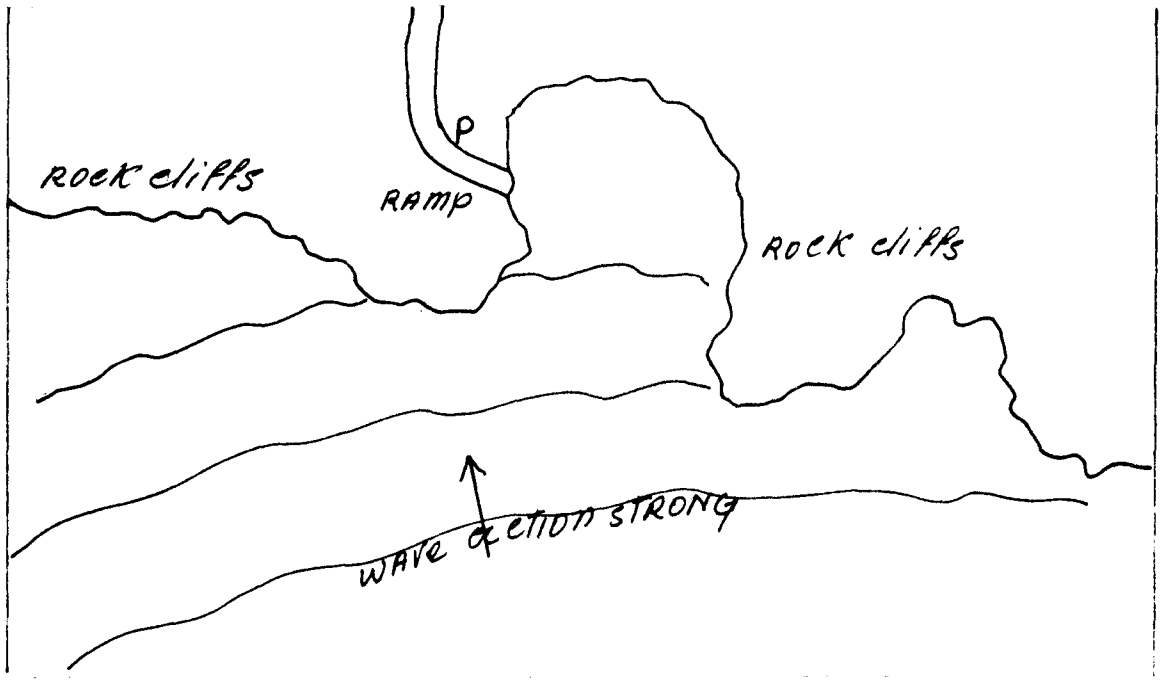
STATION NUMBER 301 MAP REF Tongatapu S.W

NAME AND LOCATION Makeke Rubbish dump

MEANS OF DISCHARGE Trucks dump into SEA

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE solid waste
AMOUNT OF WASTE slight (Liahona college)
PERIODIC DANGERS possible dumping of laboratory chemicals
DILUTION AT DISCHARGE POINT Good: X Fair: Poor:
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
rock cliffs on seaward coast strong surge

HEALTH HAZARD

ECOLOGICAL HAZARD

USES OF STATE [illegible]
Food Gathering [illegible]

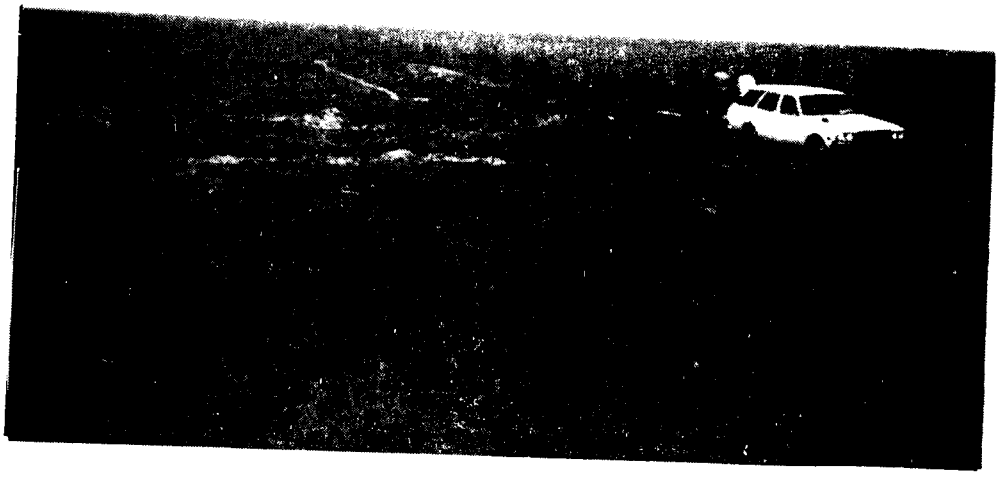
OTHER USES scenic area

ALTERNATIVE [illegible] sold to produce solid waste disposal system

RECOMMENDED [illegible] make into scenic stop

INSPECTOR Chesher DATE 12/6/84

PHOTOGRAPHS [illegible]



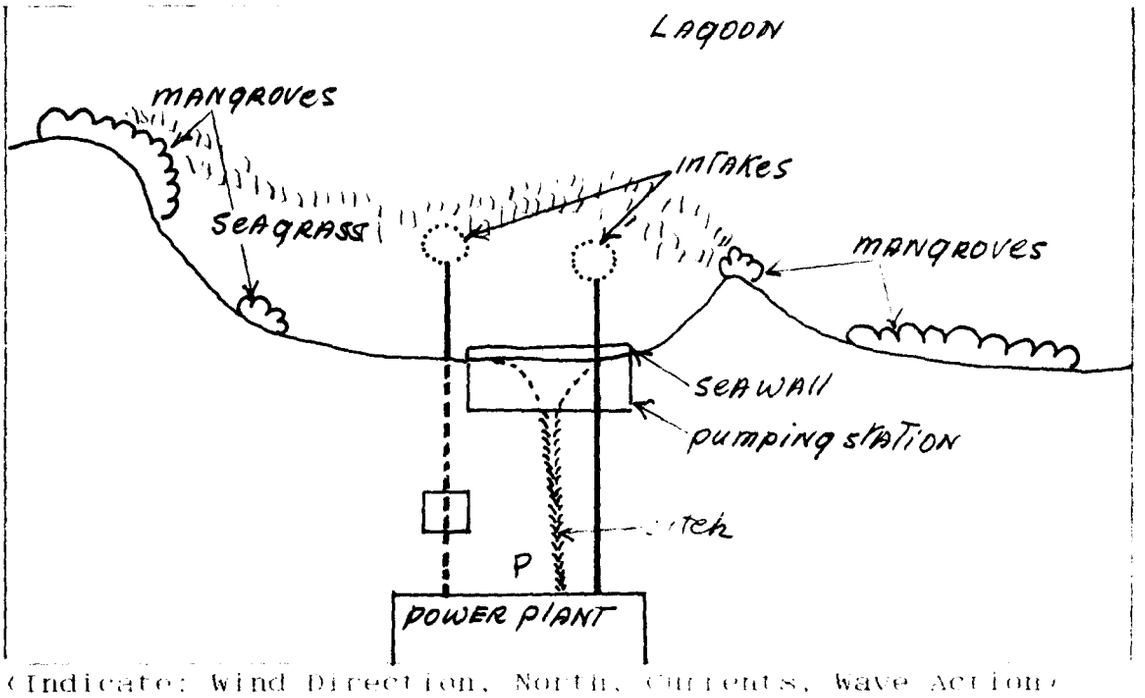
STATION NUMBER 802 MAP REF Tongatapu lagoon

NAME AND LOCATION Sopua power plant
discharge of oil and detergent ditch

MEANS OF DISCHARGE ditch

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P=Photograph taken from here, arrow shows angle of view

TYPE OF WASTE oil and soap from power plant floor
AMOUNT OF WASTE unknown
PERIODIC DANGERS large spill of oil and cleaning solution

DILUTION AT DISCHARGE POINT Good: Fair: Poor: X
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
sea grass and mangroves shallow water lagoon

HEALTH HAZARD

ECOLOGICAL HAZARD oil and solvents can be toxic to wide variety of lagoon invertebrates and fish.

USES OF STATION AREA Fishing X Swimming Tourism
Food Gathering (List kind of food taken) Fish, jelly fish
shrimps, shellfish

OTHER USES

ALTERNATIVE DISPOSAL Drainage pit

RECOMMENDED ACTION use biodegradable detergent and crushed coral drain field.

INSPECTOR Chesher DATE 14/6/84

PHOTOGRAPH: Taken at location marked "P" on the chart.

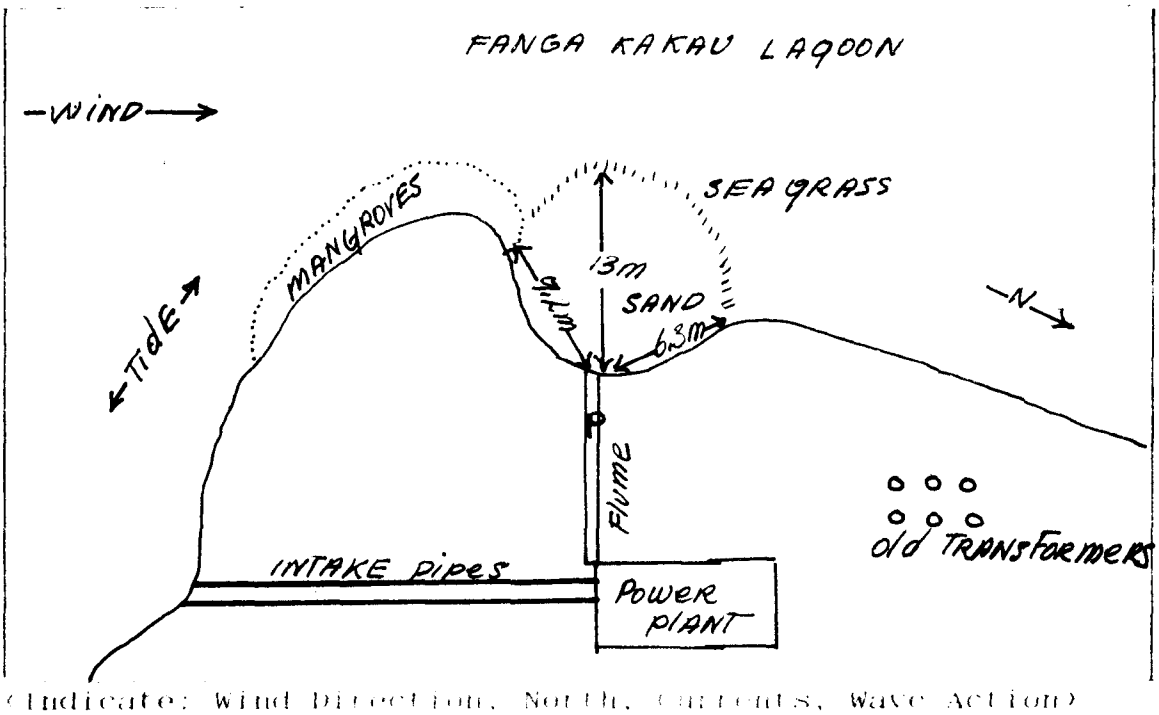
STATION NUMBER 801 MAP REF Tongatapu

NAME AND LOCATION popua power plant
discharge of cooling water
old TRANSformers

MEANS OF DISCHARGE flume 34cm x 22cm
deep water depth 12cm x 24.5 cm

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE SEA-WATER heated effluent from power plant
AMOUNT OF WASTE 380 – 570 litres/sec. continuous
PERIODIC DANGERS descaleing chemicals when heat exchangers are cleaned.
DILUTION AT DISCHARGE POINT Good: Fair: X Poor:
Comments: old transformers may contain PCBs

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
cleared mangrove area - sea grass beds numerous sardines in effluent-discharge onto shallow silty sand - water depth 20cm

HEALTH HAZARD

ECOLOGICAL HAZARD possible thermal and descaling pollution of lagoon: if copper is discharged jellyfish and other copper sensitive invertebrates could be killed.

USES OF STATION AREA: Fishing X Swimming Tourism
Food Gathering (list kind of food taken) Fish, jellyfish shrimps, clams, shellfish.

OTHER USES

ALTERNATIVE DISPOSAL cooling towers

RECOMMENDED ACTION check effluent For copper discharge monitor during cleaning of heat exchangers For chloride copper, nickel lead, temperature other contaminents.

INSPECTOR Chesher DATE 14/6/84

PHOTOGRAPH: Taken at location marked "P" on the chart.

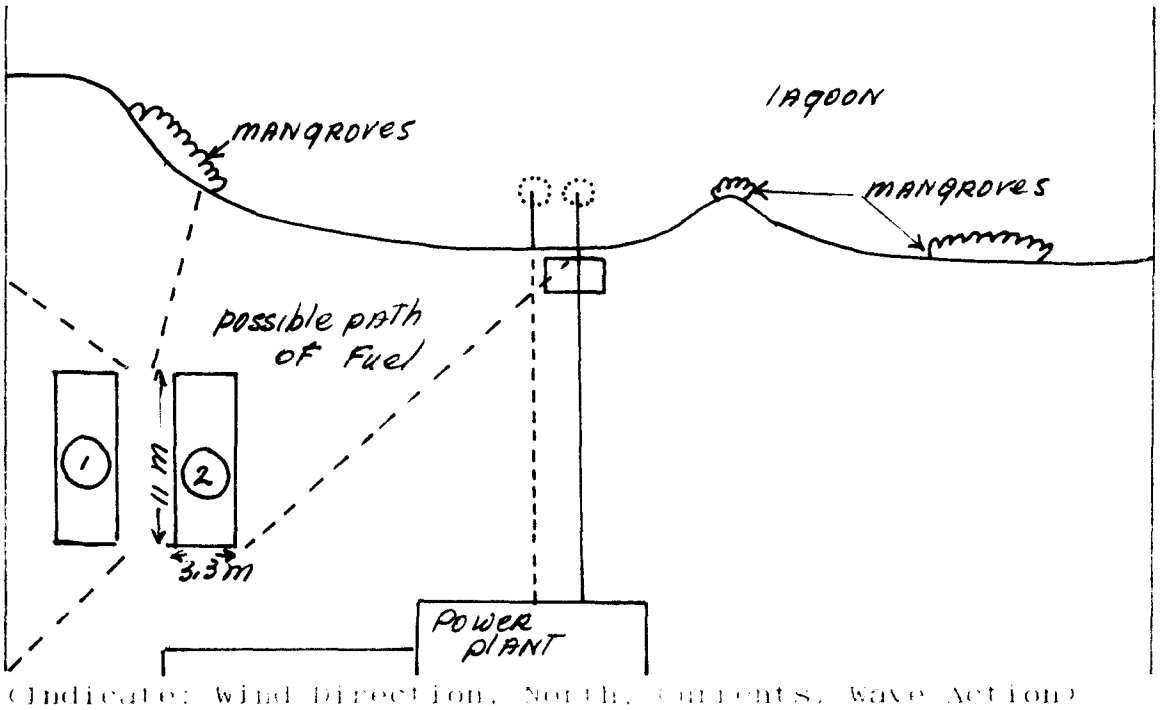
STATION NUMBER 8.03 MAP REF Tongatapu Lagoon

NAME AND LOCATION Fuel oil tanks popua power plant

MEANS OF DISCHARGE accidental Breakage of tanks

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P-Photograph taken from here, arrow shows angle of view

TYPE OF WASTE Diesel Fuel
AMOUNT OF WASTE 94,000 litres per TANK
PERIODIC DANGERS accidental breakage (Fire or collision)
DILUTION AT DISCHARGE POINT Good: Fair: Poor:
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
TANK 1: pasture land
TANK 2: mangroves and sea grass beds of Fanga Kakau lagoon

HEALTH HAZARD Fire

ECOLOGICAL HAZARD destruction of area by Fire or spillage

USES OF STATION AREA: Fishing X Swimming Tourism
Food Gathering (list kind of food taken) FARMING cattle.

OTHER USES

ALTERNATIVE DISPOSAL Build retaining walls around TANKS.

RECOMMENDED ACTION Build Fuel retaining walls around TANKS

INSPECTOR Chesher DATE 14/6/84

PHOTOGRAPH: Taken at location marked "P" on the chart.

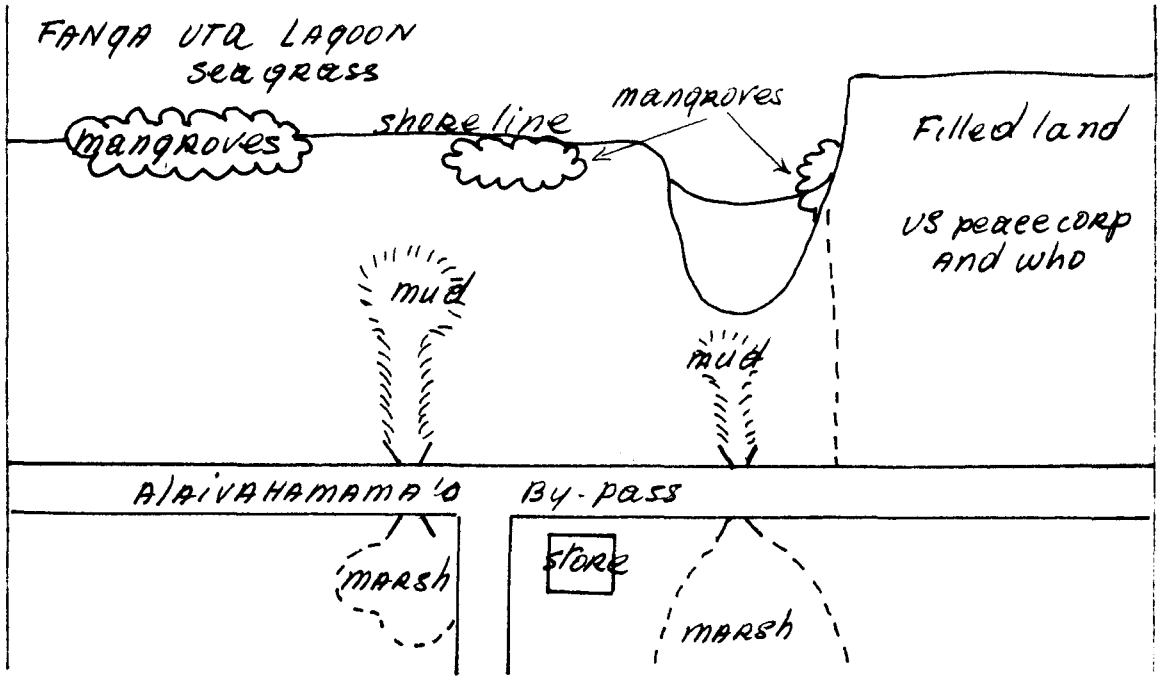
STATION NUMBER 9.0290/ MAP REF Tongatapu Lagoon

NAME AND LOCATION street drains

MEANS OF DISCHARGE culvert under road

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P-Photograph taken from here, arrow shows angle of view

TYPE OF WASTE marsh run off
AMOUNT OF WASTE slight
PERIODIC DANGERS pesticide use

DILUTION AT DISCHARGE POINT Good: Fair: X Poor:
Comments: seasonal with rain fall

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER
mangrove swamp, mud, pigs, and horse

HEALTH HAZARD

ECOLOGICAL HAZARD

USES OF STATION AREA: Fishing ___ Swimming ___ Tourism ___
Food Gathering (List kind of food taken) ___

OTHER USES ___

ALTERNATIVE DISPOSAL ___

RECOMMENDED ACTION ___

INSPECTOR Chesher DATE 8/6/84

PHOTOGRAPH: Taken at location marked "P" on the chart.

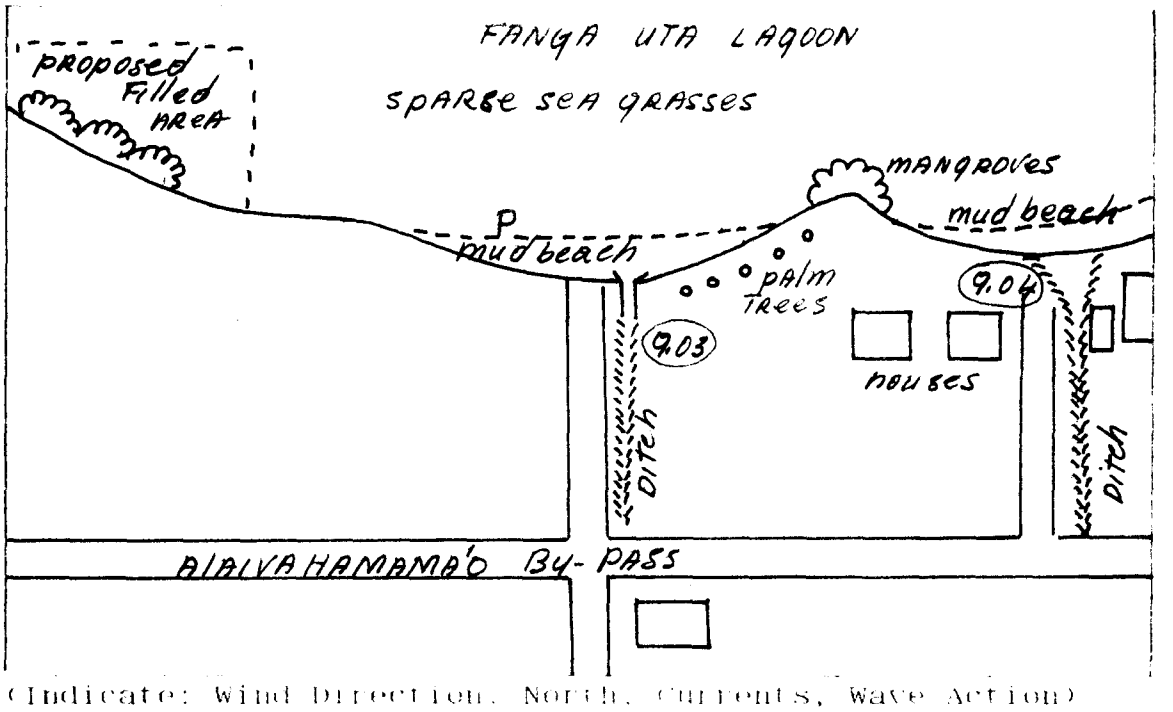
STATION NUMBER 9.03 9.04 MAP REF Tongatapu lagoon

NAME AND LOCATION street drains

MEANS OF DISCHARGE drainage ditches

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE street run-off
AMOUNT OF WASTE slight, varies with rainfall
PERIODIC DANGERS

DILUTION AT DISCHARGE POINT Good: Fair: Poor: X
Comments: accumulation of trash

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
shallow muddy sparse grass beds

HEALTH HAZARD depends on substances used on land

ECOLOGICAL HAZARD contamination of lagoon by pesticides PCB's oil TRASH From Nukualofa

USES OF STATION AREA [illegible]

Food Gathering [illegible]

OTHER USES Residential

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION: Avoid hazardous chemicals and wastes in upland area

INSPECTOR Chesher DATE 18/6/84

PHOTOGRAPH: Taken at location marked "P" on the chart

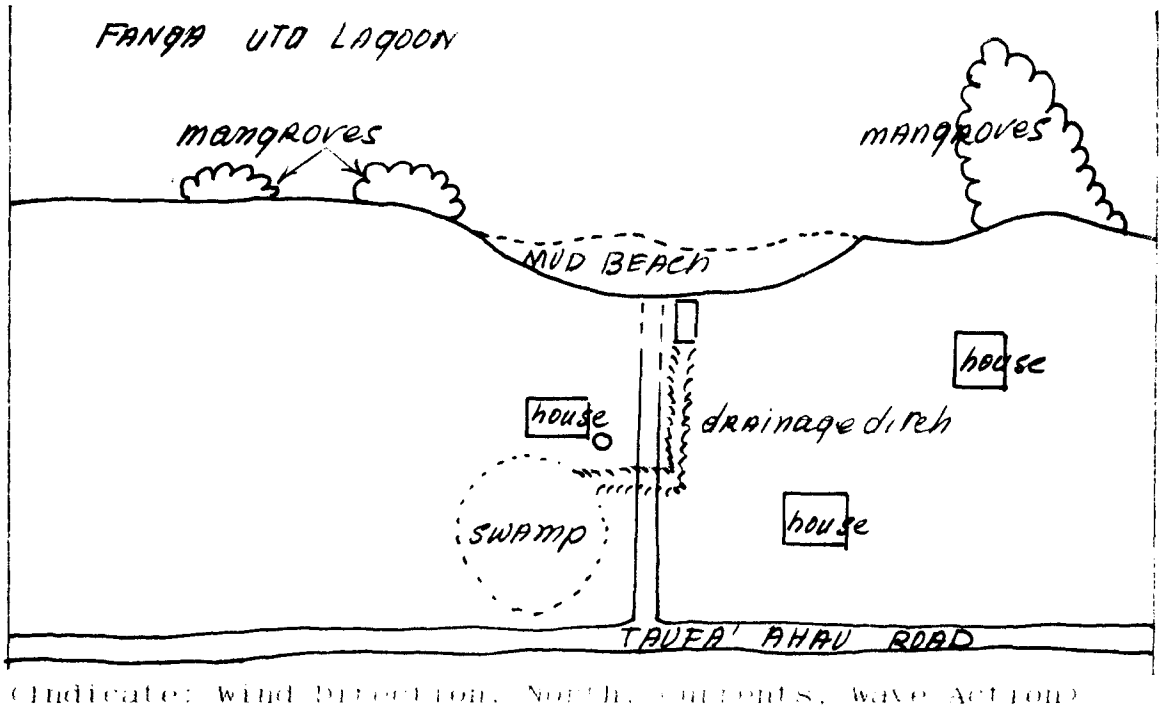
STATION NUMBER 9.05 MAP REF Tongatapu lagoon

NAME AND LOCATION street drain
TAUFA' AHAU ROAD

MEANS OF DISCHARGE 45cm culvert
under construction

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P Photograph Taken From here, arrow shows angle of view

TYPE OF WASTE runoff from grassy swamp
AMOUNT OF WASTE varies with rainfall
PERIODIC DANGERS

DILUTION AT DISCHARGE POINT Good ☐ Fair ☐ Poor ☒
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER.
shallow lagoon grass flats sparse mangrove fringe

HEALTH HAZARD

ECOLOGICAL HAZARD

USES OF STATION AREA. Fishing__ Swimming_ ___Tourism_____
Food Gathering (List kind of food taken)_____

OTHER USES Residential

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION

INSPECTOR_____ DATE 18/6/84

PHOTOGRAPH: Taken at location marked "P" on the chart.

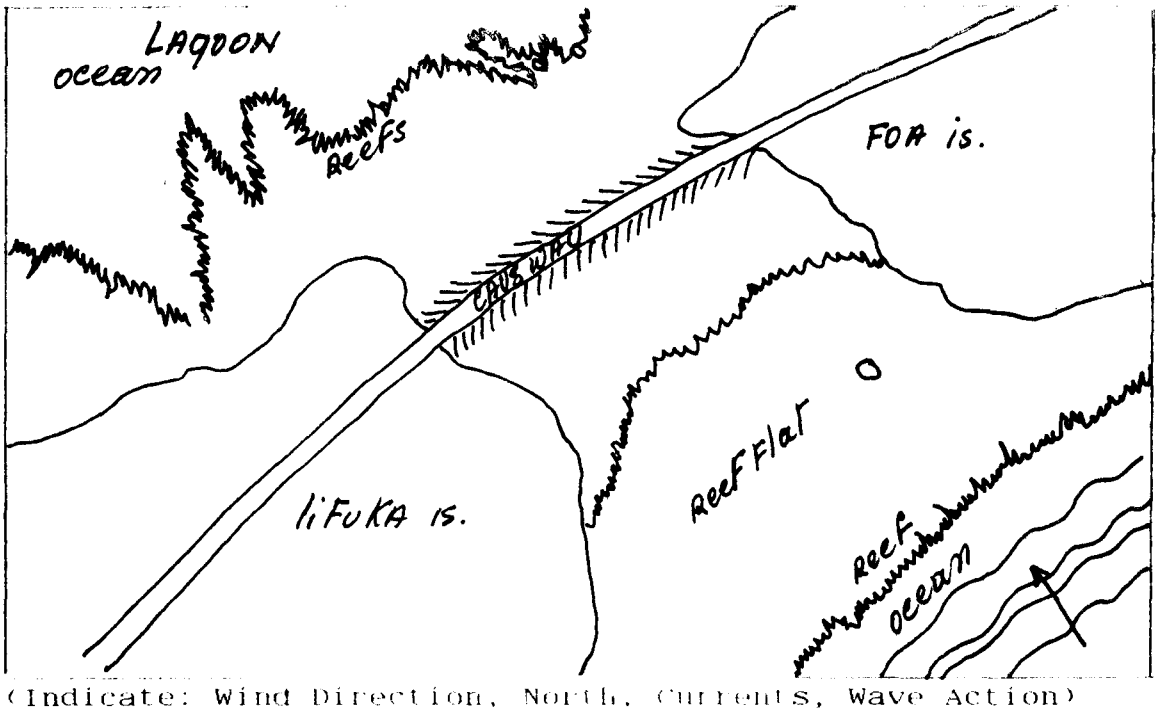
STATION NUMBER 101 MAP REF HAAPAI

NAME AND LOCATION LIFUKA-FOA CAUSWAY

MEANS OF DISCHARGE TRUCKS

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P=Photograph taken from here, arrow shows angle of view

TYPE OF WASTE solid Fill CAUSWAY
AMOUNT OF WASTE
PERIODIC DANGERS

DILUTION AT DISCHARGE POINT: Good: Fair: Poor:
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
CORAL REEF FLAT between islands

HEALTH HAZARD

ECOLOGICAL HAZARD water circulation stopped depriving corals of necessary water flow

USES OF STATION AREA: Fishing X Swimming X Tourism
Food Gathering (List kind of food taken) Fish lobster octopus clams

OTHER USES

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION construct culverts every 10 m to restore water flow

INSPECTOR Chesher DATE Jul 19 / 84

PHOTOGRAPH: Taken at location marked "P" on the chart.

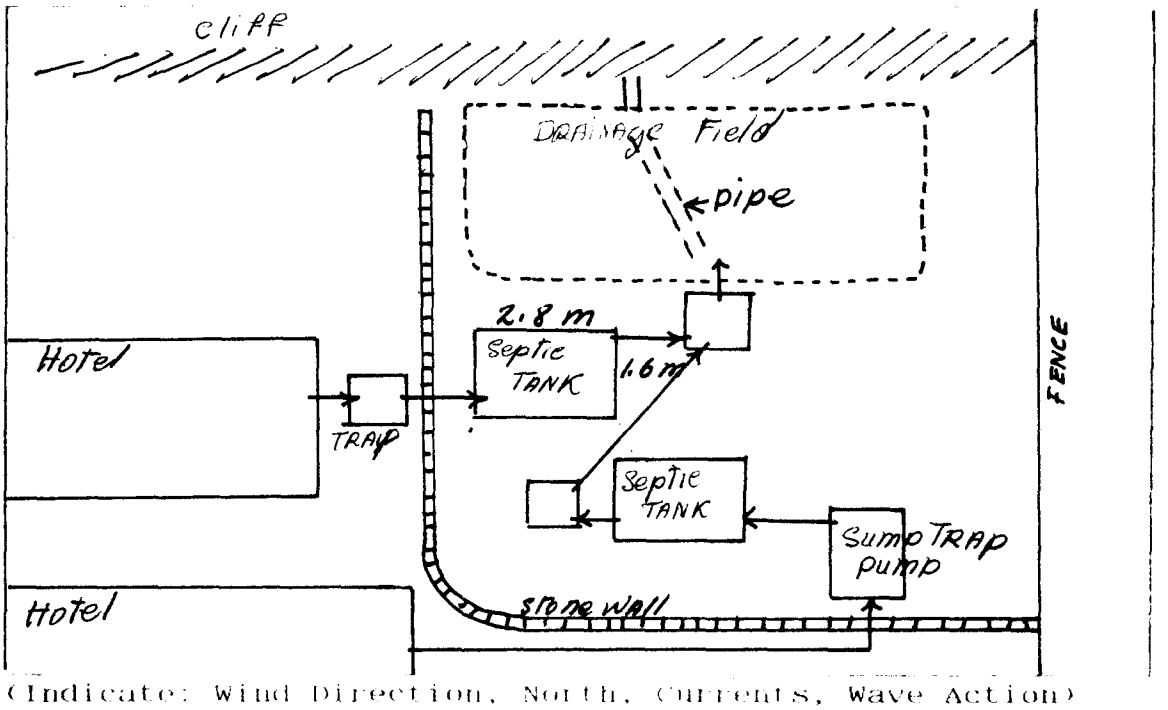
STATION NUMBER 101 MAP REF VAVAU

NAME AND LOCATION sewage disposal PARADISE Hotel

MEANS OF DISCHARGE Septic TANK and drainfield

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P=Photograph taken from here, arrow shows angle of view

TYPE OF WASTE Effluent from drainage Field
AMOUNT OF WASTE slight (Hotel Full)
PERIODIC DANGERS drainage of septic TANK effluent into lagoon
DILUTION AT DISCHARGE POINT Good: Fair: X Poor:
Comments: drainage field ineffective because of drainpipe installed by hotel

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
20m high cliff covered with vegetation Then on to reef flat and lagoon

HEALTH HAZARD septic TANK effluent may contaminate reef

ECOLOGICAL HAZARD

USES OF STATION AREA Fishing X Swimming X Tourism X
Food Gathering (if so, kind of food taken) Fish

OTHER USES boat harbor

ALTERNATIVE DISPOSAL improved drainage Field and additional septic TANKS. o

RECOMMENDED ACTION monitor effluent remove drainage Field overflow pipe -

INSPECTOR Chesher DATE 27/7/84
31/7/84 Effluent still Flowing

PHOTOGRAPH: Taken at location marked "P" on the chart

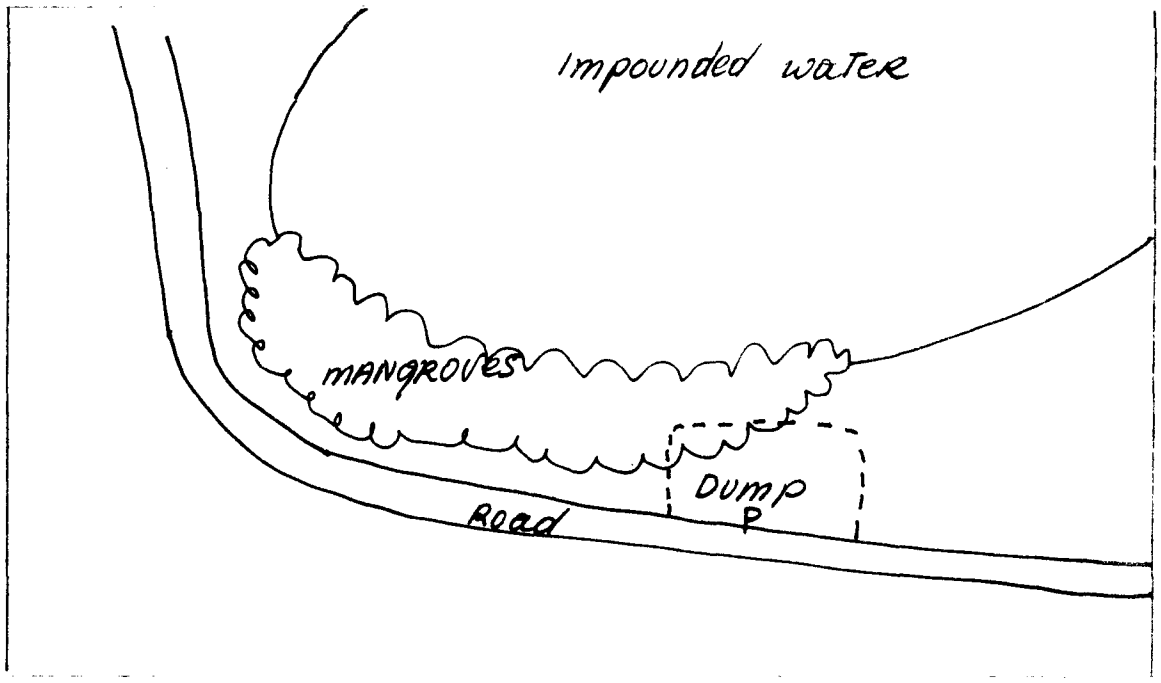
STATION NUMBER 1.03 MAP REF VAVAU

NAME AND LOCATION FANGAEUA Rubbish dump

MEANS OF DISCHARGE TRUCKS

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P=Photograph taken from here, arrow shows angle of view

TYPE OF WASTE Solid wastes VAPONA and malation used
AMOUNT OF WASTE 4 oz. VAPONA / week sprayed FOR fly control
PERIODIC DANGERS FIRE

DILUTION AT DISCHARGE POINT Good: Fair: Poor: X
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
intertidal mangrove being filled and poisoned

HEALTH HAZARD pesticides in shellfish and crabs leachates from HAZARDOUS WASTES
ECOLOGICAL HAZARD destruction of productive mangrove environment,

USES OF [illegible] X [illegible]
Food Gathering [illegible]

OTHER USES

ALTERNATIVE [illegible] quarry site or inland location proper separation of wastes.

RECOMMENDED ACTION new solid wastes disposal plan. Stop use of VAPONA. Dichlorvos is toxic to fish should not contaminate ponds water ways swamps or drains

INSPECTOR Chesher DATE 27/7/84

PHOTOGRAPH [illegible]

POLLUTION SOURCES

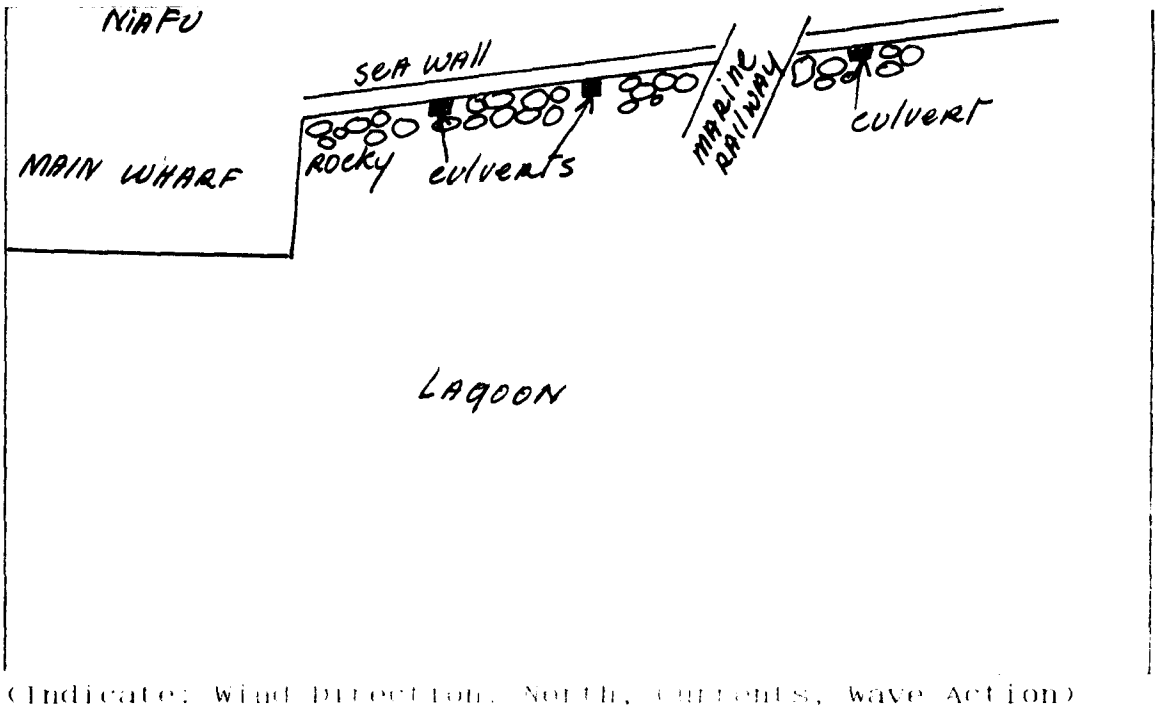
STATION NUMBER 106 MAP REF VAVAU

NAME AND LOCATION STREET DRAINS NIAFU WATER FRONT

MEANS OF DISCHARGE SQUARE CULVERTS

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P Photograph taken from here, arrow shows angle of view

TYPE OF WASTE STREET RUN OFF FROM NIAFU
AMOUNT OF WASTE CONSIDERABLE DURING HEAVY RAINS
PERIODIC DANGERS SILTATION OF LAGOON AND URBAN CONTAMINENTS
DILUTION AT DISCHARGE POINT Good: Fair: X Poor:
Comments: POOR IN DEEPER WATER

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
WATER FRONT DEVELOPED SHORELINE SILTY SAND ROCKS DROPS OFF RAPIDLY INTO 20-30 METERS

HEALTH HAZARD SLIGHT UNLESS TOXIC COMPOUNDS ON USED ON STREETS
ECOLOGICAL HAZARD CONTAMINATION OF HARBOR AREA WITH SILT AND URBAN CONTAMINENTS

USES OF STATION AREA: Fishing X Swimming Tourism X
Food Gathering (List kind of food taken)

OTHER USES boat harbor

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION

INSPECTOR DATE 30/7/84

PHOTOGRAPH: Taken at location marked "P" on the chart.

POLLUTION SOURCES

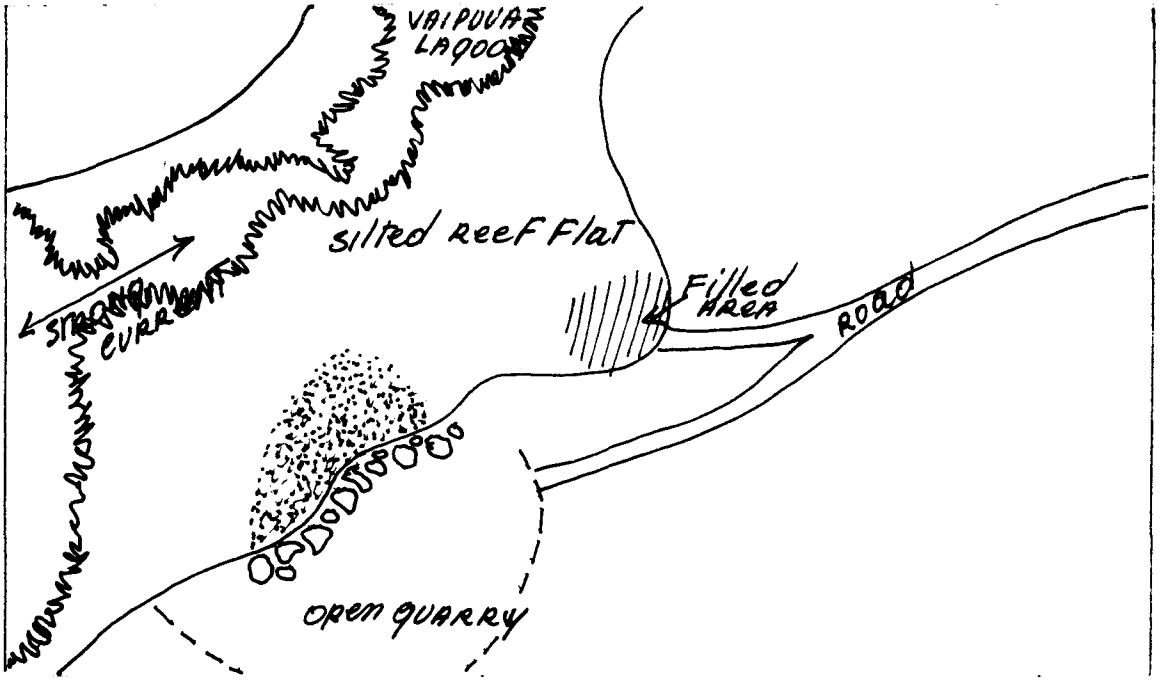
STATION NUMBER 1.07 MAP REF VAVAU

NAME AND LOCATION QUARRY LAVAKI

MEANS OF DISCHARGE Runoff of silt

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P=Photograph taken from here, arrow shows angle of view

TYPE OF WASTE silt
AMOUNT OF WASTE considerable during rainfall
PERIODIC DANGERS

DILUTION AT DISCHARGE POINT Good: Fair: X Poor:
Comments: Tidal current strong but deeper part of Vaipuva lagoon poorly circulated

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
entrance to lagoon coral reefs deepwater invertebrates including ~~the~~ black coral

HEALTH HAZARD

ECOLOGICAL HAZARD ~~loss~~ siltation of lagoon result in coral death and loss of black coral populations

USES OF STATION AREA: Fishing X Swimming X Tourism X
Food Gathering (list kind of food taken) Fish shell
black coral

OTHER USES

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION

INSPECTOR Chesher DATE 30/7/84

PHOTOGRAPH: Taken at location marked "P" on the chart.

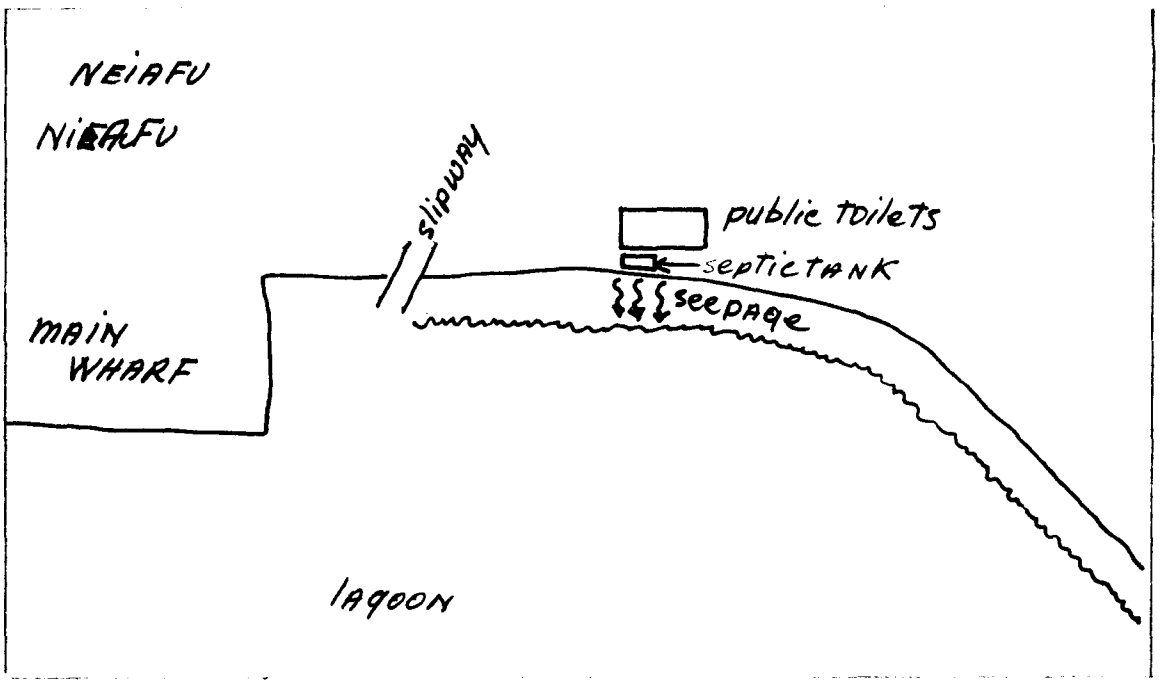
STATION NUMBER 1.08 MAP REF VAVAU

NAME AND LOCATION Public Toilets WATERFRONT NEIAFU

MEANS OF DISCHARGE seepage

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave action)
P-Photograph taken from here, arrow shows angle of view

TYPE OF WASTE Sewage from public toilets
AMOUNT OF WASTE 2
PERIODIC DANGERS could vary with tourism Tour ship usage.
DILUTION AT DISCHARGE POINT Good: Fair: X Poor:
Comments: seepage along reef FLAT visible from bottom of seawall AT low tide

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
developed waterfront intertidal flats dead fill And Rubble

HEALTH HAZARD contamination of lagoon

ECOLOGICAL HAZARD

USES OF STATION AREA: Fishing Swimming Tourism X
Food Gathering (List kind of food taken)
boat harbor

OTHER USES

ALTERNATIVE DISPOSAL proper drainage fields

RECOMMENDED ACTION sample seepage

INSPECTOR Chesher DATE 31/7/84

PHOTOGRAPH: Taken at location marked "P" on the chart.

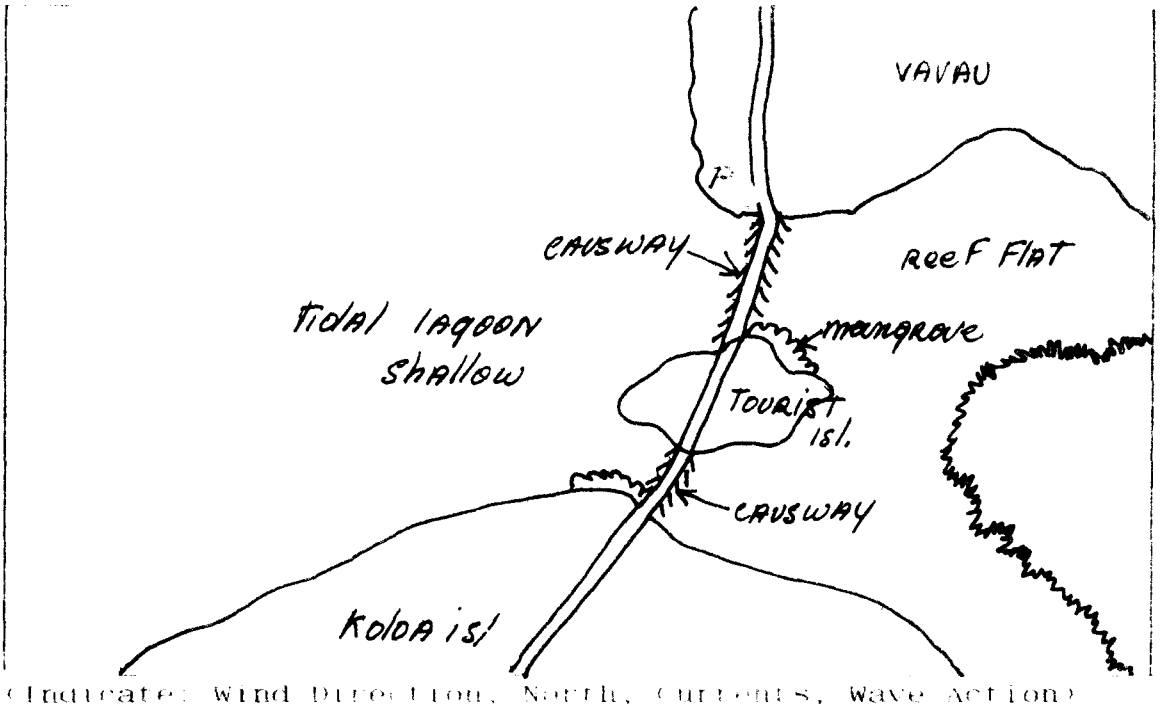
STATION NUMBER 1.08 MAP REF VAVAU

NAME AND LOCATION KOLOA CAUSWAY

MEANS OF DISCHARGE TRUCKS

STOP NOW
MONITOR
WATCH
OK
POLLUTION INDEX

MAP OF DISCHARGE SITE



(Indicate: Wind Direction, North, Currents, Wave Action)
P: Photograph taken from here, arrow shows angle of view

TYPE OF WASTE solid Fill
AMOUNT OF WASTE
PERIODIC DANGERS

DILUTION AT DISCHARGE POINT Good: Fair: Poor:
Comments:

BIOLOGICAL AND PHYSICAL CONDITIONS OF RECEIVING WATER:
pass between islands to large tidal lagoon and mangrove area

HEALTH HAZARD

ECOLOGICAL HAZARD Reported to have eliminated seasonal mullet migration killed clam and crustacean populations.

USES OF STATION AREA: Fishing X Swimming X Tourism X
Food Gathering (List kind of food taken)

OTHER USES road

ALTERNATIVE DISPOSAL

RECOMMENDED ACTION increase number of culverts

INSPECTOR Checher DATE 31/7/84

PHOTOGRAPH: Taken at location marked "P" on the chart