9.0 REGIONAL SUMMARY AND CONCLUSIONS

The study clearly showed the need for continued improvement in waste monitoring activities and improved record keeping on the types and sources of pollutants. Appropriate waste management practices need to be based on accurate and up-to-date information. The WHO method provides a rapid assessment method that could be very appropriate for this region pending monitoring and data collection. At present, however, there is insufficient production data to get a complete and detailed quantification of industrial pollutant loading to the environment. As a first pass it has provided a reasonably complete overview and quantifies what many professionals have concluded from water and environmental quality studies.

The continued dominance of the domestic contribution indicates it is necessary to apply increased effort in resolving issues of sanitation and waste disposal. The discharge of untreated sewage to near shore areas is still too common in the region. Partially treated wastes are also discharged in near shore waters. While some treatment with discharge to near shore water is better than none, the location of the outfall can also play a major role in minimizing the public health and ecological dangers.

While domestic waste remains a serious problem, industrial waste loadings to the marine environment are increasing not only in quantity but toxicity. Previously conducted water quality and marine environmental studies have clearly demonstrated the presence of metal, organic chemicals, and other toxics in the marine environment. Though this study was unable to quantify industrial wastes in some cases, it does identify a number of industries that generate wastes that are harmful or potentially harmful to the marine environment. The effects of industrial discharges need to be more urgently addressed in the more industrialized countries of the region: Fiji, New Caledonia, and Papua New Guinea. Countries with growing industrial activity such as Vanuatu, American Samoa, and others are in a position to take proactive action toward preventing environmental degradation from industrial waste discharges.

Agricultural sources of pollutants other than sediments are minor compared to the other sources. Except for the potential of accidental spills and accidents, the environmental impact of agrochemicals is negligible. Erosion as a result of improper or inappropriate cultivation practices contributes substantial quantities of sediment to the marine environment.

The most critical finding of this study is the need for increased monitoring and data collection on the various contributing sources, particularly industrial sources, in order to concurrently develop improved waste management plans. Of critical importance is the need to train local officials in the use of rapid assessment methods and simple control strategies. The gap that will continue to exist without established and ongoing monitoring programs can be bridged through the use of rapid assessment methods. The WHO method, if improved to include more of the industries found in the region, can be

valuable if data is made available in a usable form. The collection of such data needs to be made a part of the ongoing statistical data collection process.

Data on the waste loadings to the marine environment is of little value unless steps are then taken to utilize this data to prevent or minimize such wastes. Long-term environmental, communal, health, and economic well being require close attention to land-based sources of pollution in the region.

PART II

AMERICAN SAMOA

American Samoa is the only territory of the United States located south of the equator. It consists of five principle islands and two atolls in the Samoa Group. Its main island is Tutuila, which is the government centre and the centre of most commercial activity. Most of the population of 32,760 lives on Tutuila, and most of these live in the Utelei town area.

The total land area of American Samoa is 197 square kilometres (km^2). Tutuila is 147 (km^2). Pago Pago Harbour nearly bisects the island and provides a large and very safe anchorage. This harbour was of great interest to the early European traders and whalers and eventually the American military.

Public service and tuna canneries are the largest employers. Commercial and industrial activity is mainly of a retail and service nature. There are a number of automotive, electrical, and machinery shops, as well as a soft drink bottler and sandal factory.

Domestic Wastewater

The majority of the population is served by a piped sewer system which provides secondary treatment. The sewer system, including the treatment plant are regulated by the U.S. Clean Water Act that requires permitting and setting of effluent standards for any facility discharging to navigable waters. As such the wastewater treatment plants in American Samoa generally provide reasonable treatment of domestic waste waters. Annual pollutant loadings from these plants is estimated from permit monitoring reports as follows: BOD 145 tonnes and suspended solids 276 tonnes. Nitrogen and phosphorous loading are estimated using flow data from the permit reports and World Health Organization (WHO) loading factors (translated to concentrations). Nitrogen loading from the plants is estimated to be 44 tonnes per year and phosphorous is estimated to be 2.4 tonnes per year. The rest of the population uses septic tanks and latrines. Total loading from domestic sources in American Samoa is therefore estimated to be 217 tonnes of BOD; 259 tonnes of suspended solids; 90 tonnes of nitrogen, and eight tonnes of phosphorous.

Industrial Wastewater

The only significant industry is the tuna cannery operations. These facilities have in the past been identified as the sources of significant pollution in Pago Pago Harbor. The American Samoa and U.S. Environmental Protection Agencies (EPA) have pressured the two facilities to upgrade their treatment facilities and comply with the effluent standards required by their permits.

As a result the marine pollution problems due to the tuna canning operation have subsided somewhat. The two facilities have been granted an ocean dumping permit for sludges resulting from the tuna canning operations. The selected ocean dumping site presumably is in an area of adequate circulation and poses minimal ecological and public health risks.

Production data for the two facilities is confidential; however, permits are based on production of 291 tonnes (320 U.S. tons) and 454 tonnes (500 tons) per day. Since wastewater flow, including contaminant concentration data, was available from the permit monitoring reports, annual pollutant loadings were calculated directly. These calculations yielded annual pollutant loadings from the two canneries to be 4.53 tonnes of BOD (for one plant only); 179 tonnes of suspended solids; 254 tonnes of nitrogen; and, 1,810 tonnes of phosphorous. These loadings are much less, approximately two and three times less, than that predicted by the WHO method. Without accurate production data, it is uncertain whether production is the source of the difference or if the loading factors are totally applicable to these plants.

There are also two bulk fuel storage facilities with permits allowing for the discharge of stormwater wastes. Actual pollutant loadings are difficult to predict because of the intermittent nature of the discharges.

High concentrations of lead were found in some fish harvested from Pago Pago Harbour (Weigman, 1992). Other toxics have also been identified in the bottom sediments of the harbor. The sources of these contaminants have not yet been identified.

Solid Waste

No information was available at the time of the report on solid waste disposal issues.

Litter floating on Pago Pago Harbor is routinely collected by a contractor to the ASEPA. The collected trash is estimated to be about 0.9 tonnes per month (Weigman, 1992). This is indicative of the significance of urban runoff problems as well as solid waste disposal problems.

Agricultural Runoff

Agriculture in American Samoa is limited to subsistence agriculture. No data was available on pesticide and fertilizer imports.

Summary

The American Samoa EPA has an established monitoring system for the regulation and management of domestic and industrial wastes. This system generally functions well and provides

an adequate means of monitoring marine pollution sources.

The tuna canneries and urban runoff are significant contributors to marine pollution. Domestic wastewater is managed well in most areas and marine pollution minimized through the use of secondary treatment facilities.

COMMONWEALTH OF NORTHERN MARIANA ISLANDS

The Commonwealth of Northern Mariana Islands (CMNI) consists of three main islands; Saipan, Rota and Tinian, located 5,635 km west-southwest of Honolulu in the North Pacific Ocean, about three-quarters of the way between Hawaii and the Philippines. The combined total land area of the CNMI is approximately 477 km2 with 1,482 km of coastline. The population was estimated to be around 39,000 in 1990 with 80 percent of the Commonwealths population located on Saipan (Hazardous Waste Storage and Disposal in the South Pacific). The population growth rate is estimated to be 10.2 percent in this decade (Duenas & Associates, Inc., April, 1992).

The CNMI has a tropical marine climate with little seasonal temperature variation. The dry season is from December to July and the rainy season is from July to October. The southern islands are of carbonate origins with level terraces and fringing coral reefs. The northern islands are volcanic in origin with Mt. Tagpochu on Saipan having the highest elevation of 471 meters. Mt. Pagan, CNMI's one active volcano, last erupted in October 1988. Natural resources are arable land and fish.

CNMI's economy is based upon five broad industries and the resulting secondary supporting industries. Of the five broad industries (the Federal Government, garment factories, transhipment, construction, and the visitor industry) the visitor industry is the most dynamic (Duenas & Associates, Inc., April 1992).

Land-based pollution sources center around domestic waste. Pollution of marine areas around the Sadog Tase and Agingan Wastewater Treatment Plants is likely to increase if the Section 301(h) NPDES Waivers are approved. It is likely that there is localized pollution from the discharge and waste handling activities of individual factories and manufacturers.

There is one U.S. EPA Priority Superfund Site located in Saipan. This site consists of a temporary shelter for approximately 1,400 gallons of PCB transformer fluid with PCB concentrations of up to 25,000 parts per million (Hazardous Waste Storage and Disposal in the South Pacific).

The results of two hazardous waste surveys, conducted in 1977-78 and 1980, indicated that limited amounts of hazardous wastes were generated in the CNMI and these wastes posed a significant threat to the small island environments. Large quantities of hazardous wastes which included asphaltic oil, calcium hypochlorite, pesticides, and chlorextol were being stored in Saipan. The Division of Environmental Quality of the Commonwealth reported that approximately one tonne of agricultural pesticides had been disposed and stored in the region (Hazardous Waste Storage and Disposal in the South Pacific).

No comments on the draft report were received thus the following information has not been confirmed by representatives of the CMNI.

Domestic Wastewater

A large majority of the CNMI population is connected to the public sewer systems. The CNMI has two wastewater treatment plants (WWTP); the Agingan WWTP, located on the southwest section of the island of Saipan and the Sadog Tase WWTP, located approximately 150 feet north of the Agingan WWTP. The Agingan plant services an estimated population of 25,872; the Sadog Tase plant services approximately 12,896 (Duenas & Associates, Inc., April, 1992).

Currently the Commonwealth Utilities Corporation (CUC) is in violation of it's extended NPDES permit for the Agingan effluent. The CUC has contracted to build a new WWTP which will improve the Agingan discharge to secondary effluent quality by February 1993. The CUC has applied for 301(h) waivers for both Agingan and Sadog Tase which will allow the discharge of primary treated effluent at each outfall while the plants are upgraded (Duenas & Associates, Inc., April 1992).

Commercial and Industrial Wastewater

There are less than ten manufacturing businesses in the CNMI. The garment industries account for approximately half of these businesses; the other half consists of wood, fiberglass, beef jerky, and miscellaneous manufacturers. Other small industries include garment assemblers, printers, photo processors, dry cleaners, and auto repair shops. There are three bulk fuel storage facilities in the CNMI; one located on each of the three islands.

Solid Waste

A new sanitary solid waste landfill is under construction in CMNI that should result in adequate solid waste disposal for the majority of the population.

Agricultural Runoff (Pesticides And Fertilizers)

No information on pesticide and fertilizer imports was available at the time of this study. It is not expected that pollutant contributions from this sector are significant.

Summary

The CMNI Department of Environmental Quality has an established monitoring system for the regulation and management of domestic and industrial wastes. This system generally functions

well and provides for an adequate means of monitoring marine pollution sources. Domestic wastewater is managed well in most areas and marine pollution minimized through the use of secondary treatment facilities. Continued enforcement of discharge permits will serve to limit most adverse effects from point sources of pollution.

Non-point sources of pollution likely contribute significant pollutant loadings to marine waters. Continued efforts including public educational programs, implementation of stormwater controls, and enforcement of anti-littering provisions is recommended.

COOK ISLANDS

The Cook Islands are located between 156° and 167° west longitude and between 8° and 23° south latitude and consist of 15 islands spread throughout an area of two million square kilometres. The total land area of the Cook Islands is 236 km^2; Raratonga (65 km^2) and Mangaia (51 km^2) are the two largest islands with the individual areas of the remaining 13 islands no greater than 30 km^2. Six of the islands, the Southern Group, Mangaia, Atiu, Mitiaro, Mauke, and Aitutaki comprise 88 percent of the 18,000 people living in the Cook Islands. Fifty-three percent of the population is centered on the main island of Raratonga which also contains the capital, Avarau. The population density is 76.9 people per square kilometre. The population growth rate is declining due to out-migration to New Zealand.

The Cook Islands lie within the hurricane zone with the wet season extending from December to March. The mean annual temperature and rainfall on Raratonga are 23.6° C, and 2,134 mm, respectively. The islands are comprised of both low lying coral atolls and cays and majestic volcanic islands rising to more than 650 metres on Raratonga.

The economy of the Cook Islands is agriculture-based with some light manufacturing in Raratonga. The government employs about 80 percent of the wage earners with the remainder employed in service and retail activities, and the light manufacturing sector.

No response was received on the draft summary table, thus information is that obtained from the literature.

Domestic Wastewater

Limited information on sewage disposal was available for the Cook Islands. Data was obtained from the International Water Supply and Sanitation Decade Directory, 3rd Edition (1983). This indicated good coverage of adequate sanitation, but did not provide specific data on facility types and/or populations using them. Thus, for the purposes of this study it was assumed that Raratonga was served by septic tanks and all other areas served by latrines. No over-the-water latrines were included though it is likely that some percentage of the population still uses this type of facility.

The Cook Islands have not been specifically cited as having marine pollution problems resulting from domestic waste disposal (Brodie et al. 1990). Since marine and fresh water quality are especially critical to an insular environment, however, domestic waste disposal should always be properly managed and monitored.

Commercial and Industrial Wastewater

Manufacturing is limited to fruit processing, clothing assembly, assembly of electronic parts and a small distillery. Although the Cook Islands are reported to have no major industrial facilities and no industries generating hazardous wastes, the presence of industries such as agriculture, fruit canning, health care, printing and publishing, and transportation, makes it likely that small quantities of hazardous wastes may be present in the islands (PBHWRC, 1989). The Secretary of Health reported that there have been no environmental impacts or health effects from any hazardous wastes stored or disposed in the region (UNEP, 1984).

Solid Waste

The present solid waste disposal site for the Cook Islands is located inland and thus is not a threat to marine water quality (Morrison, 1992).

Agricultural Runoff (Pesticides and Fertilizers)

Data from Mowbray (1988) indicates that pesticides are used in The Cook Islands at the rate of approximately 8.5 tonnes per year. Although this level of pesticide usage is high in the region for countries of this size it is still low on a world scale. No pollution problems have been described as a result of pesticide usage. If the assumption that five percent of all applied chemicals reach the marine water is used then 0.43 tonnes of pesticides, in terms of formulation quantities not actual chemical contamination, may reach marine waters. Given the application rates normally used in the region this is probably an overestimate of pesticide loadings.

Erosion problems are also associated with agricultural practices in the Cook Islands as in other areas of the region. Poorly planned plantation-scale pineapple cultivation has resulted in considerable soil loss to coastal swamps and the sea producing some coastal water pollution.

Summary

The lack of production data for the light manufacturing, particularly the distillery and food processing facilities, does not allow for a accurate assessment of the contribution of this sector to marine pollution. However, it is expected that marine pollution loading from the manufacturing sector is low. This is for two reasons, the processes are probably dry, and the production number are probably low.

Information on the sanitary facilities in the Cooks Islands is somewhat speculative. Though marine pollution may not be significant at this time domestic waste water is still probably

the larger contributor of pollutants to the marine environment.

THE FEDERATED STATES OF MICRONESIA

The Federated States of Micronesia (FSM) is located approximately 5,150 kilometers west-southwest of Honolulu in the North Pacific Ocean. The FSM is composed of four major island groups totaling 607 islands with a total land area of 702 square kilometers and 6,112 kilometers of coastline. There are four states, Pohnpei, Yap, Kosrae, and Chuuk. There are approximately 102,000 people residing in the FSM with a population growth rate of 2.8 percent.

The natural resources in the FSM consist of forests, marine products, and deep-seabased minerals. The geology of the island varies from high mountain island of volcanic nature to low, coral atolls.

The environmental issues the FSM faces include provision of a safe drinking water supply, solid waste disposal, and the disposal of domestic and commercial waste water. Currently safe drinking water is often not available to much of the population. There is coastal degradation and resource depletion, particularly in the reef and the nearshore area.

The use of the explosive/chlorine fishing, the loss of reef area from filling and dredging, and the degradation of water quality and reef habitats from pollution sources has led to the significant depletion of reef fish stocks and shellfish in certain coastal areas. Specific pollution sources impacting the coastal water quality in the FSM are runoff and associated sedimentation, discharge of sewage, siltation from dredging activities, sunken vessels, fish canneries, domestic waste management, increased fishing pressures from rising populations and new technologies, and increasing non-traditional land use and conservation practices associated with coastal fishing.

Fresh water quality is threatened by accelerated rates of erosion caused by poor agricultural and development practices which degrade the forests of all the states. There is also potential for soil and water contamination to occur from the improper use of pesticides.

Domestic Wastewater

Domestic wastewater facilities in both rural and urban areas of the FSM are poor in all states. The situation is particularly poor in urban areas of Pohnpei and Chuuk. The urban areas were provided with wastewater treatment facilities during the time these newly independent countries were territories of the United States. Lack of trained personnel and funding of operations and maintenance has resulted in the failure of the plants. The wastewater treatment plants, though designed as secondary treatment plants, in Chuuk and Pohnpei do little to treat the sewage flows. The effluent is essentially raw sewage. Wastewater treatment

plants in Kosrae and Yap serve small populations, but are believed to still provide reasonable treatment. The pollutant loading calculations assumed secondary treatment, however it is not certain that they attain this level of pollutant removal.

The prevalence of water-related diseases and water quality monitoring data indicate that the sewage pollutant loading to the environment is very high. A recent waste quality monitoring study (as part of a workshop) was unable to find a clean, uncontaminated site in the Kolonia, Pohnpei area.

In urban areas not served by sewers, and rural areas most persons are served by latrines. There are some septic tanks, but most are of poor design and construction. Over-the-water latrines are found in many low-lying areas.

Sewage disposal facilities, the estimated population using each type, the resultant pollutant loadings are presented in Table B.4. Former U.S.EPA discharge permits were used to obtain flow data and estimate populations served (using 150 US gallons per capita per day). Fairly recent (1988) U.S. EPA permits indicated plants in Yap and Kosrae operating reasonably; therefore BOD and suspended solids data was used and nitrogen and phosphorous were calculated using the WHO method.

Total pollutant loadings for the FSM from domestic waste disposal is estimated to be 1,010 tonnes of BOD; 1,314 tonnes of suspended solids; 434 tonnes of nitrogen; and 50 tonnes of phosphorous.

Solid Waste

Solid waste disposal is poorly managed throughout the FSM. Most disposal sites are located in mangrove areas and litter is common. The Pohnpei dump is located adjacent to the fish processing plant, airport, and a hotel.

Industrial Wastewater

Industry in the FSM is very limited. Fish processing, cleaning and dressing only, occurs in a small facility in Pohnpei. Other states have sold storage facilities, but no significant processing facilities. Canneries are planned for all states.

Other commercial activities that may contribute to marine pollution, but for which no data is available include, laundries, auto shops, ship repair, and printers.

Agriculture Runoff

No data on agrochemical use was available. Erosion as the result of poor agricultural practices, especially on the steep slopes of Pohnpei, is likely to result in loss of valuable topsoil and downstream sedimentation.

Summary

Domestic waste disposal is indisputably the major contributor to marine pollution in the FSM. The pollution is visibly evident in the urban areas and is validated by sporadic water quality data. Improved waste management in this area is essential to the improvement o marine environmental quality in the FSM.

Regulations exist for the control of land-based sources but have not been enforced due to a lack of an adequate number of trained personnel and the will of the government. This lack of trained personnel also hinders efforts of the public works department. There is little funding for operation and maintenance of sewage disposal (and water) infrastructure.

The improvement of this sector will require a large financial investment, however, if improvements are to be made it must receive priority for the limited financial resources of the government.

FIJI

Fiji is located 2,500 kilometres north of New Zealand in the South Pacific, and is composed of 332 islands (approximately 110 are inhabited) with a total land area of 18,274 km^2 and 1,129 kilometres of coastline. There are four major islands which include Viti Levu, Vanua Levu, Taveuni, and Levuka; the two largest islands, Viti Levu and Vanua Levu, have areas of 6,418 and 3,419 $miles^2$ respectively. In 1989 the Fijian population was estimated to be approximately 756,559 of which 61 percent lived in rural areas. The population density is 39.7 persons km^2. Suva, the capital city of Fiji, has an estimated population of 157,980 and the urban growth rate is 3.4 percent. The overall population growth rate for Fiji is 2.1 percent. The majority of the Fijian population is found in the lowlands which consist of flatter land in the coastal areas and near large deltas.

Approximately 19 percent of the land in Fiji is very good and 10.5 percent is still arable (Fiji's State of Environment Report in Nair, personal communication, 1992). The majority (43 -45 percent) of land in Fiji is forest and three percent is pasture. Natural resources consist of timber, fish, copra, gold, and copper (Fiji's State of Environment Report in Nair, personal communication, 1992).

Except for a few islands underlain by limestone, the islands of Fiji consist of volcanic mountains, the highest of which are found on the two largest islands. Viti Levu has a central plateau but most of the land is composed of steep slopes with elevations ranging between 150 and 1,300 metres. Most of Vanua Levu consists of generally flat-topped mountains cut by deep, narrow valleys.

The height of the land on both the larger islands has a profound effect upon the tropical marine climate. Slight seasonal temperature variation occurs with yearly maximum and minimum temperatures of about 32 and 16 degrees Centigrade (°C) respectively. The cool season extends from May to October. The southeast trades are the dominant winds which control the pattern of rainfall. Fiji is subject to hurricanes from November to April (Fiji's State of Environment Report in Nair, personal communication, 1992).

Surface water is the major source of water and is used to supply all the large communities and most of the villages, a majority of which are situated on the tributaries of main rivers. Surface water can be, and is readily, polluted by village and cattle effluent. Groundwater, particularly deep groundwater, is less easily contaminated from surface pollution sources. Shallow groundwaters, however, are easily contaminated by surface pollution sources such as latrines, septic systems, and sullage.

The Fijian economy is primarily agriculturally based and has a large subsistence sector. Sugar is a major export product; its processing accounting for a third of the industrial output. The

industrial sector is among the largest in the region. Only New Caledonia and Papua New Guinea have similarly large industrial sectors. Large by regional standards these are of only small to medium scale on a worldwide scale.

Industrial, agricultural, and domestic activities are the major sources of marine pollution in Fiji. These activities include mining, shipyards, slipways, moorages, sugar mills, timber mills, cement factory, litter refuse disposal sites, sewage, pesticides and herbicides, tourist developments, and changing land-use practices. Environmental problems in Fiji also arise from highly erosive rainfall in areas impacted by deforestation and agriculture. Suva Harbour is described as highly contaminated (Cripps, 1992; Morrison, 1992).

Marine pollution may have major impacts on the local fishery in Fiji by destroying or modifying coastal habitats making them less suitable for commercial species by killing or reducing survivorship of individuals. Not only does marine pollution impact the coastal ecosystems; local studies show that it is also affecting the health and welfare of the people inhabiting the coastal regions.

Domestic Wastewater

According to the WHO, urban areas of Fiji are reasonably well-served by adequate sanitation facilities. As discussed in Section 3.1, there is no standard definition of adequate sanitation and the WHO relies on the interpretation and the reports of the individual countries. Ninety one percent of the urban population in 1990 was considered to have adequate coverage. The rural coverage was determined to be even better, 99 percent coverage (Guo, 1991). Cripps (1992) reports much lower levels of coverage. That study reported urban coverage of 61 percent and just 12 percent coverage for the rural populations. Clearly, the definition of adequate sanitation must be clearly defined to explain the different determinations and its affect on assessing the pollution potential of sanitary facilities. Regardless of the level of coverage accepted, sanitation problems exist and numerous marine pollution problems are associated with domestic sewage.

Urban areas are served by both sewered and individual wastewater disposal/treatment systems. Sewered areas, with the exception of the Raiwaqa plant in Suva, treatment of waste from sewered areas is adequate for the protection of public health. High levels of treatment, ie., tertiary treatment, is necessary to remove nutrients. Thus, minimization of risks to marine ecosystems is dependent on the proper location of the outfall.

Urban areas not served by sewers are often the older areas of the towns and thus also have inadequate septic tanks, cesspools, and latrines. These individual facilities are known to be undersized and often discharge overflows and or leachate directly to marine areas or streams and

storm drains. Septic systems in the Suva region are also hampered by the local geology, which includes a soapstone called Suva Marl (Nair, personal communication, 1992). The soapstone does not allow for adequate perocolation and absorbtion of the septic tank effluent.

Sanitary facilities and the resultant pollutant loads calculated by the WHO methods are included in Table B.5.

Solid Waste

Bronders (1991b) conducted an extensive survey of solid waste disposal sites in Fiji. He concluded that all dumps, except the one located at Tavua, were badly maintained and most are located in environmentally sensitive areas. Eleven of the 21 sites surveyed were located in mangrove or other coastal areas. Smoke, smell, insects, water pollution, and loss of natural beauty were the environmental problems noted by Bronders. The need for improved solid waste management was highlighted. Table 1 summarizes his results.

The Bronders study is comprehensive and points out the need for additional studies to determine the quantities of waste generated and disposed at different facilities, and the potential for leachate discharge to marine waters. The direct discharge of wastes to coastal areas inevitably results in pollution of the marine environments. The pollutants of concern will vary from facility to facility, but nutrients, BOD, and toxics such as heavy metals and pesticides can be expected in some quantity at most facilities. It is likely that insecticides and rodenticides, where used to control pests (which occurs at several Fiji dumps), will leach into surrounding waters.

Industrial Wastewater

The industrial contribution to marine pollutant loadings in Fiji is comprehensively described by Cripps (1992). Cripps study focused on Suva Harbour, but also included general information applicable to the whole of Fiji with additional specific data on Lautoka. Section 5.0 in Part I of this report utilized Fiji as an example for the other medium-sized industrial economies in the region. That discussion will not be repeated here, rather a brief summary is provided. The reader is referred to Part I of this report for additional discussion of the issues and to the Cripps report for details of that industrial survey.

Cripps identified a number of industries contributing to the pollutant loading of Fiji's marine waters. The industries survey by Cripps are listed in Table 6.4 of Part I of the report, and includes, battery manufacture, food production, cleaning products manufacturing, electroplating, auto repair shops, beer production, sugar milling, and others.

Analyses of samples collected from nine out of 39 industry effluents in Fiji significantly

exceeded levels permissible for effluent discharge into port waters. Constituents analysed for included, BOD, solids, lead, zinc, nutrients, pH, and oil and grease. Effluents from the Carlton Brewery, Fiji Foods, CASCO Steel, manufacturers of cleaning agents, petroleum product storage terminals, a photoprocessing company, paint factories, food processors, printing shops, electroplating industries, service stations, and Lami dump all contribute to Suva Harbour pollution (Cripps, 1992).

An additional industrial survey showed that the major generators of hazardous waste in Fiji were the battery and paint factories (Maata, 1992).

Vatuwaqa River Mouth is considered to be the most polluted site in Fiji for contamination of shellfish populations and the Nabukaulou Creek is also considered to be one of the most polluted sites in Fiji (Cripps, 1992). This is the result of the numerous small industries discharging wastes into the area as well as the numerous malfunctioning septic tanks, which also discharge into the rivers/creeks.

The effects of tributyl tin (TBT) in marine paints are evident in Suva Harbour. TBT levels in Suva Harbour are higher than any reported for other harbours (Cripps, 1992). TBT is a toxin that has been shown to cause imposex (a development of male sexulal organs on genetically female animals) in neogastropods (young mollusks, including oysters). This effect has been observed in Suva Harbour in recent studies in several neogastropod species including, Morula sp., Thais mancinella sp., Murex sp.(Morrison and Seeto, 1992).

The industrial activities and the resultant pollutant loadings that could be calculated for Fiji are found in Table C.5. The calculations indicate, as expected, that the sugar industry, tuna cannery, edible oil production, and the brewery are significant contributors, from the industrial sector of BOD, suspended solids, and, depending on the industry, nitrogen, phosphorous and oils. The loading of metals seems insignificant; however, the actual pollutant loading to the marine environment of these contaminants is probably much higher. The actual pollutant loaading is beleived to be higher because it is known that several industries and other non-point sources were not included in the survey.

Table 1 below summarises only those industries for which data was available and pollutant loadings could be calculated, using information from Cripps survey.

At present few regulations exist for the control and monitoring of pollutants entering the marine environments. In 1990, the Ports Authority of Fiji established strict regulations for port waters that included standards for types and quantities of wastes that may be discharged. The regulations apply only to port waters. Fiji has five major ports; Labasa, Lautoka, Levuka, Savusavu, and Suva. These ports, excluding Labasa, are under the Authority's jurisdiction. The regulations have yet to be enforced, and as is seen by the above description of analysis results, there is little voluntary compliance.

Agricultural Runoff

Morrison (1990) discussed the environmental impacts of agriculture in Fiji. The paper discusses issues of soil erosion, land degradation, deforestation, sedimentation, pesticides, and water resources. Soil erosion and land degradation are noted as significant problems. The topic has been reviewed at length by several researchers and estimates for erosion from different agricultural activities have been made. The Sugar Cane Farming News, (Sugar Cane Farming News, 1988) reviewed these and provided the following from a previous study. Soil erosion from sugar cane plots ranges from 69 to 77 tonnes/hectare/year; erosion from pineapple plots is approximately 71 tonnes/hectare/year; and erosion from pine seedlings is up to 4877 tonnes/hectare/year.

Summary

Fiji provides an example of the marine pollution problems associated with a medium-scale industrial economy that still maintains a strong agricultural component and large urban and rural populations. The dangers of ignoring industrial wastes while the toxic chemicals accumulate in the marine environment and then the flora and fauna consumed by the community is clear. It demonstrates that huge industrial complexes are not necessary to have serious toxic pollution problems. While domestic waste disposal remains a problem, the industrial contribution to marine pollution also grows.

Waste management needs to be provided for each sector of the economy and the population. Pollution control can be expensive and the more complex the industry, often the more complex the treatment system required. For this reason, the emerging waste management strategies should incorporate pollution prevention, or waste reduction strategies, in order to reduce the costs of treatment.

The recently enacted legislation that provided for improved monitoring of wastewater discharges to the harbors of the country should be expanded to cover all surface waters. The implementing regulations should include a permit system with enforcement provisions. As is discussed with the recommendations in the main body of this report, the permitting processes need not be confrontational. It should provide a means for the responsible government agency to interact with the industry to establish a database of information of wastewater generation and associated impacts. It provides valuable information for improving production processes in a manner that results in pollution prevention rather than simply utilizing end-of-the-pipe solutions, or even worse, significant water quality degradation. Wastewater generating facilities should be provided with information regarding the new regulations and their responsibilities under them.

Informational seminars and conferences including both government and industry representatives may be appropriate to improve industries understanding of the impact their activities have on the environment. It also provides and opportunity for joint solving of waste management problems.

An improved database of waste generation can also be established by utilizing information currently provided annually to the industrial statistics office. The information that is collected on production volumes is only recorded in monetary terms rather than quantities, though the industrial survey raw data includes this information. This information, if included on the computerized database would allow for improved rapid assessment of industrial waste generation using the WHO method employed by this study.

Industrial waste management can also be partially addressed through the use of recycling opportunities. For example, the large quantities of waste oil that is generated can be mixed with new oil for burning in a number of types of boilers. Waste oil can also be burned by the cement manufacturing plant since high temperatures similar to waste incinerators are reached by cement kilns. Some air pollution problems have been noted at the existing plant in Fiji (Morrison, personal communication, 1992), so additional air pollution controls may be necessary to allow the use of waste oil. Nevertheless, the costs of these controls may be offset by the low costs of this alternative fuel. Other recycling opportunities exist with batteries, solvents, aluminum, and other metal wastes.

Government operated wastewater treatment plants in Fiji function efficiently with the exception of the Raiwaqa Plant. Pollution problems associated with the effluents from these plants are likely the result of depths and circulation patterns of the receiving water. The outfalls should be located in areas of good circulation and preferably below the thermocline. Siting and permitting of individual wastewater treatment should require percolation tests. These tests should demonstrate adequate percolation rates for the area prior to allowing new construction of any type.

Fiji is now in a position to develop comprehensive waste management programs. Some solid efforts in this regard have been initiated. Qualified individuals are found in the government and private sector that can work toward an improved database and improved monitoring as well as address pollution prevention and waste treatment issues. Use of expertise at the University of the South Pacific should also be considered. Proactive attention to new industries through environmental impacts and development of effluent standards will aid in the prevention of future environmental problems while progress is made in remediating existing problems.

TABLE 1 SOLID WASTE MANAGEMENT IN FIJI

PLACE	POPULATION (Estimated)	DUMP PRESENT (1)	AREA		LAND SURFACE		REMARKS (Treatment, Pollution, Technical Problems and Maintenance)
			TYPE	LOCATION	TOTAL	IN USE	
CITIES							
Lautoka	30,000	Yes	Mangrove	next to river and urban area	15	3	Burning, levelling, compaction,insecticide, no pollution recorded, maintenance access difficult
Suva	75,000	Yes	Mangrove	next to river and urban area	5	all	Burning, levelling, compaction, insecticide, dump is full, pollution of sea, river and air
TOWNS							
Ba	8,000	Yes	Forest	1km urban area, .5 km village	5	1	Burning, levelling, no pollution reported
Labasa	16,000	Yes	Mangrove	close to river	5	1	Levelling, waste covering, road upgrading, insecticide, no pollution report except fly nuisance
Lami	not given	No (4)	n.a.	n.a.	n.a.	n.a.	Use of Suva City dump (located in Lami) complaints concerning bad maintenance of the site
Levuka (2)	8,200	Yes	Mangrove	next to sea	0.6	0.2	Levelling, compaction, villages have private pits, smell and air pollution, lack of cover soil
Nadi	16,000	Yes	Mangrove/Shore	next to sea	1	all	Compaction,levelling,no pollution reported,sea pollution suspected,shallow watertable,dump full
Nausori	5,000	Yes	Forest/Swamp	next to river	1	1	Levelling, insecticide, river pollution and smell, lack of cover material, cover problem river side
Savusavu	4,000	Yes	Mangrove	close to sea	2.5	0.5	Levelling, insecticide, no pollution reported
Sigatoka	2,700	Yes	Sand Dunes	close to sea	1	0.2	Levelling, back filling, burning,insecticide, no pollution reported(smoke);asked to abandon site
RURAL AREAS							
Ba	60,000	No (4)	n.a.	n.a.	n.a.	n.a.	Individual households are burning and burying waste, some villages have communal pits
Labasa	10,000	No (4)	n.a.	n.a.	n.a.	n.a.	Use of Ba town dump
Lautoka	not given	No (4)	n.a.	n.a.	n.a.	n.a.	Use of Lautoka city dump
Nadi	60,000	No (4)	n.a.	n.a.	n.a.	n.a	Use of Nadi town dump
Nausori	60,000	No	n.a.	n.a.	n.a.	n.a.	Private individual pits encouraged, some villages have communal system
Navua	25,000	Yes	Mangrove	100 meters from the sea	1	0.2	Levelling when funds and machinery are available, smell and fly nuisance are reported
Rakiraki	5,000	Yes	Mangrove	near sea	2	0.2	Levelling, compaction and use of insecticide
Sigatoka	44,250	No (4)	n.a.	n.a.	n.a.	n.a.	Use of Sigatoka Town dump, rural area: burning and burying
Taveuni	7,000	No	n.a.	n.a.	n.a.	n.a.	Dumping happens in communal and individual pits
Tavua	33,000	Yes	depression		2	1	Levelling, no treatment of waste, no pollution reported
Suva	70,000	No (4)	n.a.	n.a.	n.a.	n.a.	Use of Suva City dump

source: Bronders, 1991

notes:
n.a. = not applicable; (1) = is a dump present; owned or leased by authority; (2) = data obtained from the Rural Local Authority
(3) = population of the total island of Ovalau; (4) = dump of the ne town or city is used; (5) = Native Land T ;
(6) = owned by Vatukoula Gold Mine; (7) = approximated surface in hectares; (8) = charge included in the city or town rate

FRENCH POLYNESIA

French Polynesia, an overseas territory of France, consists of five main island groups that include over 130 islands. The total land area encompasses approximately 4,000 square kilometers in a marine area of four million square kilometers. They are located at between approximately seven to 29 degrees south latitude and 131 to 156 degrees west longitude. The capital is Papeete, which is located on Tahiti. The population of the territory as of the 1985 census is 172,080.

The economy of French Polynesia includes a tourism and limited light manufacturing as well as large agricultural and subsistence sector. There are two breweries in the territory and several plants producing soft drinks (Douglas, 1989). No production information was available for these plants. Also, no additional information was provided on other industries or manufacturing activities in the region.

Though no quantitative information is available on industrial waste, domestic waste is probably the largest land-based contributor to marine pollution. The pollutant loadings were calculated based on populations obtained from Douglas (1989) using the standard loading assumptions and it was assumed that the populations used septic tanks and latrines. These calculations are presented in Table B.6.

GUAM

Guam is located in the western North Pacific Ocean, and is the largest, southernmost island in the Mariana Islands archipelago. The land area of Guam totals 541 square kilometers with 125.5 kilometers of coastline. Eleven percent of the land is cultivated, 15 percent is pasture, and 18 percent is forest. As of July 1989, the population of Guam was 138,093 with a population growth rate of 2.8 percent. Sixty percent of the population lives in the rural areas and the population density is 661 persons per square mile. Fishing and tourism are Guam's major resources.

The island of Guam is volcanic in origin and is surrounded by coral reefs. The relatively flat northern limestone plateau is the source of most of the fresh water in Guam. The northern part of the island has steep coastal cliffs and narrow coastal plains, t here are mountains in the south, and low-rising hills in the center of the island.

Environmental issues in Guam include the marine water quality, sold waste disposal, rapid development, erosion, and pesticide use. Industrial pollution is limited in the tourist-based economy, however, there are a number of small manufacturing facilities. Approximately one-third of Guam (212 square miles) is occupied by military installations.

No response was received in a request for information to quantify land-based pollution sources in Guam. Recent hurricanes may have contributed to this.

Domestic Wastewater

Domestic wastewater disposal is well managed in Guam. Wastewater disposal in Guam is subject to U.S. Environmental Protection Agency and Guam EPA (GEPA) water quality regulations which require the monitoring and permitting of all wastewater discharges. Much of Guam is sewered with secondary treatment provided in most locations. The larger plant Agana provides only primary treatment (assumed from discharge monitoring report).

The study only calculated pollutant loading for sewered areas as the population served by these areas, 151,040 approached the population of the last census. Military populations are included in the served population and not necessarily the residential population, thus, many residents are served by individual facilities. The discharge from the treatment plants accounts for far greater loads, making the contributions from the individual facilities insignificant.

For treatment plants actual loading as reported on U.S. EPA discharge permits were used. Population was calculated based on a per capita flow of 125 US gallons per day. Nitrogen and phosphorous loadings were then calculated using the WHO method. Baza Gardens included, however, discharges to a stream so some self-purification may occur before flows reach marine waters.

The sewerage facilities, populations served and resultant pollutant loadings are presented in Table B.7. Total pollutant loading to the marine environment from sewerage was estimated as 2,565 tonnes of B.O.D.; 1,013 tonnes of suspended solids; 78 tonnes of nitrogen; and 80 tonnes of phosphorous.

Solid Waste

Solid waste disposal on Guam is of concern because of the limited availability of suitable land. The major disposal site is at Ordot Landfill. This landfill has been in use for over 40 years, mostly as an open dump. Surface water from the site drains into the Pago River and discharges into Pago Bay, causing concern about direct human contact with the wastes and possible contamination of marine life.

Industrial Wastes

Industrial activity in Guam is of small to medium scale. There are a number of small manufacturing plants, commercial printers, garment manufacturing, auto repair shops, and laundries, etc. Guam is subject to the U.S. EPA and it's own pollutant discharge permit system. The only permits for Guam are for the municipal wastewater plants and bulk fuel storage plants indicating all other liquid wastes are discharged into the domestic system. Thus, pollutant loadings from these activities are accounted for in the municipal discharge calculations.

The Guam Environmental Protection Agency (GEPA) reports that the types and amounts of hazardous wastes generated and stored on Guam each year are the following: 1) flammables and combustibles - 40.5 tonnes, 2) poisons - 13.9 tonnes, 3) corrosives - 97.8 tonnes, 4) etiologic agents - 18.25 tonnes, 5) oxidizers - 0.25 tonnes; and 6) other regulated materials - 1.35 tonnes (Branch, 1984).

Summary

Marine pollution problems in Guam do exist. Major point sources of pollution are from domestic wastewater facilities, however, these plants provide reasonable treatment. Though not assessed in this study, non-point sources of pollution are probably a large contributor of pollutant loading to the marine environment. The lack of significant point sources and the existence of water quality problems suggest non-point sources as significant contributors.

Additional data is necessary to quantify industrial sources and identify their potential sources of marine pollution.

KIRIBATI

Kiribati is composed of 33 islands that are divided into three island groups; the Gilbert (contains 93 percent of the population), Phoenix, and Line Islands. Of a total land area of 810.5 km^2, Christmas Island is the largest island with a total area of 388.4 km^2. Kiribati has 1,143 kilometers of coastline and a total marine area of 3.55 million square kilometers.

The 1990 census reported the population of Kiribati to be 72,298 of which 47,144 (65%) people live in rural areas and 25,154 people (35%) live in the 15.8 square kilometers of urban area. Twenty of the 33 islands are inhabited. The growth rate is 2.24 percent and the population density of Kiribati is 89 people per square kilometer. South Tarawa, the capital, contains 34.8 percent of the total population.

Natural resources on Kiribati consist of copra and pelagic fishing. Approximately three percent of Kiribati is forest land. Banaba or Ocean Island was one of the three great phosphate rock islands in the Pacific, but has been almost completely denuded of phosphate.

The economy is primarily based in subsistence agriculture with a small commercial and service sector. Employment opportunities, primarily in government service and small private commerce, center on islands of Bairiki, Betio, and Bikenibeu.

Sanitary sewage disposal and solid waste disposal are critical environmental issues in Kiribati. Lagoonal water quality shows heavy contamination from human waste. The southern lagoonal area of Tarawa shows increased nutrient levels and bacteriological quality has generally not improved. No specific information on solid waste management was provided to allow specific recommendations for this area.

Industrial wastewater and other sources of marine pollution are insignificant.

Domestic Wastewater

Numerous studies have traced the poor lagoonal water quality to inadequate domestic wastewater disposal (Johannes et al, 1979; Naidu et al, 1991). A serious cholera outbreak occurred in 1977 and diarrhoea is endemic. The high population density in the atoll setting has overwhelmed the ability of the shallow soils to absorb the waste discharged to them. In addition, much of the population still uses the beach as their "sanitary facility". A sewerage system was constructed in 1983 to serve a population of about 9,000 persons. It was hoped that this would improve the water quality situation, however, Naidu et al (1991) found no improvement over the 1978 situation. This is probably due to the fact the population continues to grow and are reluctance to use the toilet blocks that were constructed.

The importance and critical nature of dramatic improvements to domestic wastewater

disposal in Kiribati is evident without the actual quantification of the pollutant loadings. The calculated loading for the different areas and facility types, presented in Table B.8, however, do highlight the high loadings. It was assumed that in those areas where no piped sewerage system is used that more than twenty percent of the population used the beach.

Loadings predicted were 409 tonnes of BOD, 405 tonnes of suspended solids; 174 tonnes of nitrogen, and 21 tonnes of phosphorous. The situation in Kiribati also points out that the method does not predict pathogenic microorganism loadings, the primary concern for public health. The loadings do demonstrate the magnitude of sewage disposal.

Summary

It is apparent that issues of domestic waste remain an urgent concern in Kiribati. Continued efforts to develop culturally acceptable sanitation facilities need to be encouraged and assisted. The sewerage system should be maintained and the outfall upgraded or relocated so that discharge is located in areas of adequate circulation and away from poulation areas.

NAURU

Nauru is a single raised coral island with a circumference of 19 kilometers. Phosphate bearing rock covers approximately three-fifths of the island. This high-grade phosphate is the basis of the country's economy. The remaining commerce supports the mining activities and administration of the island. There are no rivers.

The mining wastes are controlled and remain on land and limited so no discharge occurs to the marine waters (Morrison, 1992). Hence, the only significant source of marine pollution is domestic waste from the population of approximately 8,000. The waste water is collected in a piped sewerage system, but no waste treatment is provided. The calculated pollutant loadings to the marine population from this population are as follows: BOD, 102 tonnes; suspended solids, 160 tonnes; nitrogen, 26.5 tonnes; and phosphorous 3.2 tonnes. The data are found in Table B.9.

While important environmental issues are present in Nauru, major marine water quality problems have not been identified. Local water quality impacts probably exist in connection with domestic wastewater disposal.

No response to the draft report was received from Nauru. Thus the above information has not been confirmed by country representatives.

NEW CALEDONIA

New Caledonia consists of one large and several small islands including the Loyalty and Huron groups. The group is located between 19 and 23 degrees south latitude and 163 and 168 degrees east longitude. The main island is called La Grande Tenre on which the capital, Noumea, is located. The island group is a French overseas territory.

The population of New Caledonia is 164,226 with approximately 69,564 persons residing in the capital Noumea. Other smaller urban areas include Thio, Bourail, and Kone, with their total population of approximately 31,992. The remainder of the population is found in rural areas.

New Caledonia is mineral rich. The main island has approximately 40 percent of the world's nickel deposits and 20 percent of the world's oxidized ore deposits. The economy is based on mining this mineral wealth. The open-cut mining of the nickel far overshadows the agricultural and small manufacturing segments of the territory. The manufacturing and industrial sector is primarily based in Ducus (Douglas, 1989).

Environmental issues in New Caledonia also centre around the mining industry. Over 500 million tonnes of ore has been extracted in less than 100 years (Dupon, 1986). To get to this ore millions of tonnes of overlying material was removed. This waste material was dumped down slopes, into valleys, where it entered the rivers and streams. The strip mining and dumping of the waste has resulted in massive loss of vegetation and sedimentation of rivers and bays. No fewer than 40 valleys and streams, and the bays to which they flow have been significantly modified. The rivers and bays are polluted with a red-brown sediment (Dupon, 1986).

Discharge of untreated sewage into lagoon waters has also been noted as an important problem. This is particularly the case in areas around Noumea.

No response was received on the draft summary, therefore most of the comments are quite general and calculations are made based on assumptions from available material.

Domestic Wastewater

The type of community and individual wastewater facilities used, and by what population, was estimated using the International Water Supply and Sanitation Decade Directory, (World Water, 1988) and an assumed population of 164,226 (1983 census population of 145,368 adjusted with growth rate of 1.8 percent) . The calculations assumed that planned coverage was achieved and that planned improvements took place. As such, it was assumed that 90 percent of the urban population is sewered and remaining 10 % is served by septic tanks. It was also assumed that 52% of the rural population with adequate sanitation have latrines, and that the remainder have over-water latrines.

Solid Waste

No information was obtained on specific solid waste problems in the territory. It may be assumed that the issues are the same as throughout the region. Based on the per capita generation rate of one kilogram per day, New Caledonia's solid waste generation is estimated as 60,225 tonnes. This per capita generation may be slightly low for Noumea and other urban areas because of the industrial sector and tourist contribution.

Industrial Wastewater

Again no specific data appropriate for applying the WHO method was received. Data from other sources, (Douglas, 1989) allowed the calculation of brewery waste loads. Brewery waste contribution is estimated to be 4,240 tonnes of BOD and 37,402 tonnes of suspended solids. This analysis assumed that at least primary treatment (sedimentation) was provided for the effluent.

Other industries were identified, and in some case production data available, but not for industries included in the WHO method. Examples of these are the cement works (50,154 tonnes/year); sheet iron manufacturing (3,147 tonnes), and paper goods manufacturing (including 100,000 boxes of tissue, 3.6 million rolls of toilet paper).

Agricultural Runoff

The agricultural economy is overshadowed by the mining industry. No fertilizer or pesticide import data was available to estimate usage quantities. Due to the great impact of the mining industry, agricultural runoff is not considered a significant contributor to marine pollution.

Summary

The limited available data does not allow a comprehensive evaluation of the pollutant loading to the marine environment. The mining industry is clearly the single most significant activity affecting both the marine and terrestrial environment. Given that the remaining industrial sector is similar to Fiji, similar pollution problems should be expected. These would include heavy metal pollution from battery and paint manufacturers, nutrient and BOD loadings from food processing and food production, and oils and grease from a variety of industries, including bulk fuel storage areas, repair shops, and power plants. Solvents and organic chemicals from printers and photo shops may also be of concern if the wastes from these activities are not properly

disposed.

In that the industrial base of New Caledonia is similar to that of Fiji, with the notable exception of the influence of the mining industry, waste management issues in New Caledonia are also likely to be similar. Waste management needs to be provided for each sector of the economy and the population. Pollution control can be expensive and the more complex the industry, often the more complex the treatment system required. For this reason, the emerging waste management strategies should incorporate pollution prevention, or waste reduction strategies, in order to reduce the costs of treatment.

Waste management regulations include a permit system with enforcement provisions. As is discussed with the recommendations in the main body of this report, the permitting processes need not be confrontational. It should provide a means for the responsible government agency to interact with the industry to establish a database of information of wastewater generation and associated impacts. It provides valuable information for improving production processes in a manner that results in pollution prevention rather than simply utilizing end-of-the pipe solutions, or even worse, significant water quality degradation. Wastewater generating facilities should be provided with information regarding the new regulations and their responsibilities under them. Informational seminars and conferences including both government and industry representatives may be appropriate to improve industries understanding of the impact their activities have on the environment. It also provides and opportunity for joint solving of waste management problems.

Industrial waste management can also be partially addressed through the use of recycling opportunities. For example, the large quantities of waste oil that are generated can be mixed with new oil for burning in a number of types of boilers. Other recycling opportunities exist with batteries, solvents, aluminum, and other metal wastes.

Additional data for New Caledonia is critical to further assessing the present situation and planning for improved waste management strategies

NIUE

Niue is an uplifted coral island with a total land area of approximately 258 square kilometres, located at about 19 degrees south latitude and 169 degrees west longitude. The population is just over 2,500 and out-migration occurs at a high rate. The soil is worn resulting in relatively low feritility. There is no surface water, but deep groundwater occurs and serves as the country's water supply source. No significant coastal water quality problems have been noted. It has been reported that deep groundwater has high nitrate content (SPREP IGM documents, 1990).

There are few natural resources. The economy is based on agriculture with a shift towards tourism development and small cottage industries such as joineries, a beer refinery and auto shops. No data was available on the production of fruit juices.

Land -based sources of marine pollution are dominated by domestic waste,. Though the water use andwastewater production for the fruit juice manufacturing is not known, it is believed to be very small compared to domestic wastes.

There is a small harbour into which paints, solids, oil, and grease from boat operation and maintenance may enter the harbour waters.

Soil erosion is severe in the many places where errant bulldozer is used for clearing. Pesticide use is estimated to be the same as pesticide imports which is approximately 2.5 tonnes per year (UN/ESCAP, 1989). Lot of unused and outdated pesticides lying around near town water catchment (Tulega, 1992).

Domestic sewage pollutant loadings calculations are presented in Table B.11. The calculation assumes all individual facilities. There is a small visitor population about 1500 per year. The visitor population is for the entire year and therefore considered insignificant and not included. Total BOD loading was calculated to be 9.8 tonnes; suspended solids: no discharge nitrogen 6.4 tonnes ;and phosphorous 1.7 tonnes.

Summary

Niue land-based pollutants are dominated by domestic wastes and non-point sources that are primarily associated with slash and burn agriculture practices.

Non-point sources of pollution can be reduced through education and intrioduction of improved management practices to reduce exposed soils and runoff during agricultural activities. The potential effects of effluents from individual systems can reduced through proper siting and design.

PALAU

The Republic of Palau is an archipelago of some 200 islands, six of which are permanently inhabited. The main islands are Koror (actually several islands connected by causeways), Babelthaup, Kayangel, and Angaur. Palau is composed of 16 states. The capital of Koror is the main population center with approximately 10,000 of the country's population of 15,122. The rock islands of Palau and its barrier reef are recognized for their uniqueness and great biodiversity.

Principle environmental issues in Palau include the destruction of coastal resources from construction of roads, harbors, and dredging. Erosion and sedimentation of reef areas is a key environmental issue. Nearly all of Palau's solid waste landfills are located in wetlands or mangrove swamps. Koror's dump at Malakal has surpassed its capacity and a new site is needed.

Water and sanitation issues remain a priority for Palau. While the level of sewer coverage in Palau is high, much improvement in the rural areas is particularly needed.

Domestic Wastewater

Domestic wastewater disposal and sewage management in the Koror area is generally adequate. About 40 percent of the population is served by the sewer system, which provides secondary treatment. The treatment plant is meeting its permitted effluent guidelines even though its flow of 1.2 million gallons per day is greater than its design flow of 1.0 million gallons. The plant discharges approximately 36 tonnes of BOD, 70 tonnes of suspended solids, 14.5 tonnes of nitrogen, and 0.8 tonnes of phosphorous. The sewer outfall is located in the harbor channel where a strong current results in good mixing of the effluent with the ocean water. The remaining population of Koror are served with septic tanks and latrines. In low lying mangrove areas, over-the-water latrines are often used. Septic tanks and latrines in these areas are often inadequate and overflows occur. As a result, marine water quality is poor in these areas.

In rural areas, the majority of the population uses latrines, though there is an increasing number of septic tanks, particularly in Peleliu and Airai. Marine water quality problems in the rural areas are limited and where they occur are associated with poor sanitation facilities. Total estimated pollutant loading from domestic sewage to the marine environment per year in Palau is 73.3 tonnes of BOD, 73.3 tonnes of suspended solids, 38.6 tonnes of nitrogen and 3.7 tonnes of phosphorous.

Industrial Wastewater

Industry in Palau is very limited. Palau, as a United Nations Trust Territory administered

by the United States is subject to its National Pollutant Discharge Elimination System (NPDES). Presently the only facilities with NPDES permits are the wastewater treatment plant and bulk fuel storage areas. There is also a small fish processing facility that conducts only cleaning and dressing of tuna. Oil and grease runoff and solid waste from this activity enter the harbor from this facility. No production data or waste flow information is available for the plant. The plant has applied for a NPDES permit.

Other activities including, auto repair, laundries, boat repair, and lime production result in minimal localized pollution problems. Small oil spills have occurred a number of times over the last several years.

Solid Waste

The Palau Environmental Quality Protection Board (PEQPB) implemented a program requiring states to establish solid waste management plans. Several states have formulated the plans that establish community facilities or provide standards for individual facilities. The community facilities are still usually located in low lying wetlands, however the PEQPB and the states have attempted to identify less sensitive sites. Solid waste generation in Palau based on a per capita generation rate of 1 kilogram per day is 5,520 tonnes per year.

Waste Management Strategies

Palau has an established permit system for all major pollutant discharges, including solid waste, domestic wastewater, industrial wastewaters, and earthmoving activities. This permit system, when enforced, provides an effective mechanism for monitoring and mitigating environmental impacts due to the respective activity. The permit system also provides valuable quantitative information that is often not available in the South Pacific region. The information can be used to plan for future developments, design and implement waste reduction strategies, and improved treatment processes if necessary.

Palau also has a requirement for environmental impact assessment study for many types of projects. Unfortunately this process is often initiated after planning and design is completed, which often negates its value as a planning tool.

Summary

The sources of much of Palau land-based pollution remains domestic sewage and domestic solid waste. Sediment laden runoff is also of concern; however, no quantitative information is

available.

The institutional infrastructure for Palau's environmental management system and waste management system is well established with the PEQPB. Continued monitoring and enforcement is necessary for the systems to achieve their mission. Continued training for local staff is necessary as the local issues become more complex.

PAPUA NEW GUINEA

Papua New Guinea is the largest of the South Pacific island countries (465,000 square kilometres), excluding Australia. Its main land area is the eastern half of the island New Guinea, and also includes New Britain, New Ireland, and many other smaller off-shore islands. It extends from the equator to 12 degrees south latitude and from 141 to 160 degrees east longitude. It is the only country in the region where the entire land area can not be considered in, or affecting, the coastal region. The interior is rugged mountainous terrain with a massive cordillera over 2,500 kilometres long. Much of the interior is impenetrable jungle. There are considerable mangrove areas on the coastline.

Much of the population of 3,650,000 live in the rural highlands. The rural population is approximately 2,600,000. The urban population of approximately 390,000 is found primarily in the capital of Port Moresby, and provincial centers of Lae, Madang, Wewak, Goroka, Rabaul, Mt. Hagen, and other smaller provinces.

Papua New Guinea's industrial base is perhaps the largest in the region, and is definitively the largest when mining is included. Besides the mining industry, large industrial activities include palm oil production, tea manufacturing, coffee processing, cocoa, and sugar manufacturing. Other industrial activities, primarily for domestic consumption are similar to those found in Fiji and New Caledonia. Again these include beer production, soft drink production, paint factories, food processing facilities, soft drink manufacturing, printers, etc.

Environmental issues in Papua New Guina are largely associated with the mining activities, some of the smaller industries, and domestic wastes. Environmental impacts from agricultural are assumed to be local since only about seven percent of the land is under commercial cultivation. Environmental impacts from agriculture are principally the result of soil erosion and other effects of the forest clearing for cultivation (Bartelemus, 1992). Many studies have examined the environmental impacts of mining (Hughes, 1989; Hughes, 1990; Brodie et al, 1990; Bartelemus, 1992). Environmental impacts of other activities are not as well studied but coastal pollution from canning and bottling plants and soap manufacturing has been reported (Bartelemus, 1992).

Domestic waste disposal, including sewage and solid waste, is generally inadequate and threatens marine and inland water quality.

No response was received to this study's request for specific industrial production and domestic waste disposal information. The discussion is therefore based upon data from literature reviews and interviews with those knowledgeable of the country.

Domestic Wastewater

The coverage for adequate sanitation is limited in Papua New Guinea to between 20 and 41 percent (World Water, 1984, 1988). Coastal degradation from sewage disposal is evident around urban areas. Outfalls for many of the piped sewerage systems are typically too short to keep the effluents offshore (Bartelemus, 1992). In Papua New Guinea it is not appropriate to consider the entire population's domestic waste as contributors to marine pollution loadings. For the reason the study estimated coastal population and there anticipated waste loads only. This study estimated the coastal population by incorporating the entire population of coastal urban areas and the entire populations of the Gulf District and Milne Bay.

Population data was obtained from a computer atlas (P.C. Globe v.2.1) for individual urban areas. This data compared favourably with overall population data from last the last census when adjusted for growth. For determining facility types and calculating waste loads the study utilized adequate sanitation coverage from International Water Supply and Sanitation Decade Directory, 1988. This included 41% coverage with sewage for urban areas; only three percent of the population is served by adequate sanitation in rural areas. The remaining population in urban areas was described as served by household systems which were assumed to be septic tanks (60%), latrines (37%) and three percent of the population was assumed to be served by over-the-water latrines. Table B.13 presents the calculations and total estimated pollutant loadings. The calculated pollutant loadings per year are as follows: BOD is 5.655 million tonnes; suspended solids is 2.424 million tonnes; nitrogen is 3,106 tonnes; and phosphorous is 374 tonnes.

Solid Waste

Controlled and uncontrolled solid waste disposal usually occurs in the coastal environment. No quantitative information and very limited qualitative information was available to the study. The problems can be assumed to be the same as throughout the region, and perhaps of a greater scale because of the greater populations.

Agriculture Wastes

Prior to 1972 and the start of the mining industry, agriculture was Papua New Guinea's most important industry (Douglas, 1989). Commercial scale agriculture includes copra, palm oil, coffee, rubber, timber, tea, pyrethrum (plant extract used in insecticides), and some sugar. Subsistence agriculture and small-scale agriculture for local consumption includes a variety of vegetables, cattle raising, dairying, fruit, and some rice production.

The agriculture industry is found throughout Papua New Guinea from the coastal areas to the highlands as appropriate for the given crops. No information was provided on agriculture practices to determine significant sources of land-based pollutants to the marine environment. Mowbray (Mowbray, 1988) reported pesticide use quantities and some pesticide use information. A total of 143 tonnes of insecticides, 2.1 tonnes fungicides and 467 tonnes of herbicides, were reported used in 1987. Poor use and disposal practices for pesticides and pesticide containers are apparently common. Pesticide control legislation has been implemented. At the time of the Mowbray report pesticides regulations and guidelines were drafted.

Palm oil processing, a significant generator of wastewater, is discussed below in the discussion of industrial wastewater.

Industrial Wastewater

As discussed above the industrial sector of Papua New Guinea, except for its much larger mining sector, is similar to that of Fiji. Little production data was available, thus pollutant loadings could only be calculated for the palm oil, beer, slaughterhouse, and sugar refining industries. Numerous industries are present and do contribute substantial pollutant loadings to the marine environment. Environmental problems as the result of some of these industries, e.g., soft drink manufacturing and soap manufacturing have been identified. Environmental problems associated with the industries found in Papua New Guinea are likely to be similar to those found for Fiji.

The identified industries and the predicted pollutant loadings for those industries with production data are presented in Table C.13.

Beer and palm oil production were found to be large contributors of BOD and suspended solids. Palm oil production also results in large quantities of oil wastes. Pollutant loading from beer was calculated to be 48,951 tonnes of BOD and 8,000 tonnes of suspended solids per year. For Palm oil, BOD loadings were calculated to be 246 tonnes; suspended solids were 974 tonnes, and oils were 765 tonnes per year. The sugar milling industry also contributed 213 tonnes of BOD and 100 tonnes of suspended solids per year.

These calculations assumed primary treatment for the beer and sugar industries and dissolved air flotation for the palm oil industry. Dissolved air flotation reduces BOD by about 92 percent, solids 68 percent, and oils by 78 percent. It is unlikely that the facility provides this level of treatment and higher pollutant loadings should be anticipated. Primary treatment of sugar milling wastes reduces BOD by 77 percent and solids by about 95 percent. Most milling in the region provide some minimal treatment but they probably do not achieve these levels. For breweries the waste reduction is greatest for suspended solids, which are reduced by 63 percent

with sedimentation. BOD is reduced by only 16 percent with this kind of treatment.

There are regulations to limit the discharge of waste to coastal areas. These regulations, however, are not enforced and there is a lack of voluntary compliance.

Mining

Mining, as discussed above, is the activity with the greatest environmental impacts in Papua New Guinea. This issue was also discussed in Section 6.0 of Part I of this report. That discussion will not be repeated here except to provide a summary of the quantitative data.

Both the Misima and the now-closed Bougainville mines have directly impacted the marine environment. Bougainville's mine tailings and contaminated mine wastes flow into the Jaba River and eventually to Empress Augusta Bay. The Ok Tedi copper and gold mine discharges its wastes into the Fly River which ultimately enters marine waters. Severe environmental impacts associated with the Ok Tedi mine have been discussed in a number of published reports. The Ok Tedi mine discharges approximately 80,000 tonnes of mine tailings into the river per day (Hughes, 1989). Cyanide, used in gold extraction process, is found in the tailings in high concentrations.

The Misima mine's impact on the marine environment is quite direct. There is daily discharge of approximately 20,000 tonnes of soft waste rock and 15,000 tonnes of tailings per day. The tailings are washed to recover 75 percent of the process chemicals and then mixed with seawater and discharges at a depth of 75 to 100 metres on the outer edge of the coral reef. Table 1 summarizes the wastes from mining that reach the marine environment.

Summary

Mining clearly has major negative effects on the environment. In the case of mining, control measures can be very costly and the economic benefits have been considered great enough nationally to allow the environmental degradation. It is beyond the scope of this study to address that issue, but in order to reduce the pollutant loadings to the environment and the resultant short- and long-term damages, tailings storage and treatment facilities must be constructed.

Other industries and domestic wastes also clearly are not adequately controlled and result in severe coastal pollution problems. These industries and the domestic activities of the population are also economically important, but there are also costs associated with the lack of pollution control measures for these activities. Costs include increased diseases associated with sewage contamination, increased chemical contamination of the marine water and the edible resources consumed by human beings, and ecological degradation. In none of these areas is waste management sufficient to minimize the pollutant loadings and thus minimize the risks to public

health and the marine environment. The limited information available to this study indicates that waste management does not really exist except as attempts to transport the wastes away from the immediate area of the activity. Further information is necessary to fully substantiate this and more importantly, develop appropriate waste management strategies.

Table 1

Summary Table for Waste Loads From Mining to the Marine Environment

Country/Mine	Non-Hazardous Solid Waste (10^3 tonnes/year)	Hazardous Solid Waste (10^3 tonnes/year)	Total Waste (10^3 tonnes/year)
Papua New Guinea Misima (1)	6,240	4,680	10,920
Papua New Guinea Bougainville(1)		46,800	46,800
TOTAL	6,240	51,480	57,720

Notes: (1) Calculated from daily production assuming 6 day work week, 52 weeks per year.

Source: Hughes, 1989

PITCAIRN

Pitcairn is a small British Dependent Territory. The Dependent Territory consists of three small islands, but the population resides on the island of Pitcairn itself. The island is three kilometers long and 1.5 kilometers wide and lies at 25 degrees south latitude and 130 degrees west longitude. The population is just 62.

Pitcairn has a subsistence economy and therefore nearly all marine waste is derived from domestic activities. Ten people are served by septic tanks and the remainder of the population uses latrines. Pollutant loading from this population was calculated as 0.2 tonnes of BOD, 0.15 tonnes of nitrogen, and 0.019 tonnes of phosphorus per year. Given the low population density the loadings to the marine environment may not even occur since the facilities are located inland and there is ample soil capacity to absorb the wastes.

No specific marine water quality problems were cited in comments received from Pitcairn representatives.

REPUBLIC OF THE MARSHALL ISLANDS

The Republic of the Marshall Islands (RMI) is an island group consisting of 30 atolls and 1,152 islands. The major atolls are Kwajalein, Rongelap, Enewetak, and Maloelap. The RMI is located in the North Pacific Ocean, approximately 800 km southwest of Honolulu (approximately two-thirds of the way between Hawaii and Papua New Guinea) and has a total land area of 181.2 square kilometers with 370.4 kilometers of coastline. In July 1989, the population of the RMI was reported to be 46,188 with a population growth rate of 4.2 percent. The urban and rural population densities are 19,336 and 626 people per square hectometer respectively.

Approximately 60 percent of the land in the RMI is cultivated. The RMI's major natural resources are marine products. Deep-seabed mining is not economically viable at this time. The islands are raised coral islands with low elevations.

The United States formerly used both Bikini and Eniwetak for nuclear testing. Kwajalein is a U.S. military base and was used as missile-test range.

The most serious environmental problems in the RMI are caused by overpopulation and poorly-planned development. The environmental quality of the urban area is impacted by increased demand on land and water resources due to over-exploitation of food resources, over use of water supplies, and contamination of marine and fresh water. Additionally, domestic waste water and solid waste disposal also pose a serious threat to the RMI environment.

Human and animal wastes and increased concentrations of nitrogen have been identified in extremely high concentrations in lagoon waters near densely populated areas. Coastal shoreline waters have also been found to be contaminated by human and animal wastes. Contamination of groundwater by benjos and pit privies have impacted the quality and use of groundwater.

No response to the draft summary table was received. It is assumed, therefore, that the presented data is correct and that no other data is available.

Domestic waste disposal in Majuro/Ebye, including sewage and solid waste, is the major contributor to marine pollution. Industry is not present in the RMI, with the exception of some laundries and small print shops. A tuna cannery is planned for Majuro. Domestic wastewater disposal is achieved by a combination of piped sewerage and individual systems in urban areas and all individual facilities in rural areas. The piped sewerage is untreated but discharges to the ocean side of atoll. The negative environmental and public health effects of these discharges, even though the outfalls are not at great depth, are less than the cumulative discharge of the individual facilities that discharge on the lagoon side. In addition to the individual land facilities, many persons still use the beaches below the high water mark.

Total pollutant loading from the sewage facilities are as follows: BOD 419 tonnes; suspended solids: 579 tonnes; nitrogen 150 tonnes; and phosphorous: 18 tonnes.

All solid waste in the RMI is disposed of in the marine environment, either in very low lying areas or reef flats. This is true both for controlled facilities and litter, which is prevalent in both Majuro and Ebeye.

The RMI has through it's Environmental Protection Authority, a strong regulatory framework for the management and control of land-based pollution. It provides for environmental assessments, permitting, and monitoring of all major activities. The need for major capital improvements and trained personnel to operate an maintain them are necessary before such a framework can be effective in managing domestic waste disposal.

Finally, enforcement of environmental regulations is necessary, without adequate enforcement of the legislative and regulatory framework, improvement in waste management will be difficult to achieve.

SOLOMON ISLANDS

The Solomon Islands lie in the southwest Pacific between the latitudes of 5 degrees south and 12 degrees south and 152 degrees and 170 degrees east latitude. The islands run between Papua New Guinea and Vanuatu. The country consists of a double chain of six major islands, some 30 smaller islands and approximately 962 atolls and cays. The total land area is approximately 28,369 kilometers and the marine area (Exclusive Economic Zone) of 1.34 million square kilometers. Many of the islands are of relatively recently volcanic origin and the Solomon Islands are a part of the Pacific "Ring of Fire". Rivers and streams are numerous on all major islands.

The population of the Solomon Islands is approximately 330,000 with most of the population living in the rural areas. There is an increasing trend to move to the capital of Honiara located on Guadalcanal. Outside of Honiara, other urban areas are quite small with populations less than 2,000. Urban environmental issues such as solid waste disposal, littering, and sewage problems do occur in these areas.

The economy is primarily based in agriculture and industrial activity primarily produces for the domestic market. The exceptions are the tuna canning operation in Noro and the Palm oil facility on Guadalcanal. Environmental issues in the Solomon Islands include population growth, over harvesting of coastal and marine populations, land degradation, improper logging activities, waste disposal, and threats to terrestrial flora and fauna. Mining is a potential environmental concern.

Domestic Wastewater

Domestic wastewater disposal in the Solomon Islands is generally inadequate. Field inspection during site visit revealed urban sewerage in Honiara is very poor. Septic tanks and latrines leach into soils of low porosity and then to rivers, streams, and marine waters. Also, about 75 percent of Honiara's population's domestic wastewater (effluent from individual systems and some direct discharges) enters into a piped collection system which discharges to about 14 outfalls along Honiara's shore. The outfalls are on the beach or extend just a few meters into the water. The resultant bacterial in these areas is very high (Wallis, 1989; Lolemai, 1991). The situation in Gizo and Auki is reported to be very similar (Wallis, 1989). Squatter settlements use latrines, many of which are located over rivers and marine waters. The degree of coverage in urban areas was reported to be 73 percent.

Some of the raw sewage outfalls are located in areas with considerable reef fishing and bathing activities. One outfall discharges into the fishing grounds of an established fishing

village which sells the fish to Honiara residents. Adequate sanitation is provided to just 3 percent of the rural population (Guo, 1991) The study assumed that the populations in provinces other than Guadalcanal and the Western Province to use 10 percent septic tanks, 10 percent latrines and 10 percent over-the-water latrines. This assumption was made due to the lack of any other information about the degree of coverage. It is likely that many households have no facilities. These assumptions may not be precise but they provide some insight into the domestic wastewater contribution to marine pollutant loadings. Table B.16 presents the sanitary facility types found in the Solomon Islands and the assumed serviced population for each type. The data is broken down by province. Estimates for pollutant loadings resulting from these facilities is also provided. The total domestic wastewater contribution for the Solomon Islands is estimated at 2,136 thousand tonnes of B.O.D., 1,176 thousand tonnes of suspended solids, 979 tonnes of nitrogen, and 139 tonnes of phosphorous.

Solid Waste

Solid waste disposal in the country is poorly managed. There is no sanitary landfill. The Honiara dump is located in a low lying area adjacent to a river delta and the beach at Ranadi. This waste spreads into the beach area and is washed into the ocean in flood conditions. The effect of littering and other indiscriminate waste disposal is evidenced by the sediment and solid waste delta seen at the mouth of one river in Honiara. The mouth is closed by the accumulation of sediment and trash. In addition to the direct solid waste loading, leachates from the inadequate solid waste disposal sites threaten groundwater supplies and marine water.

Industrial Wastewater

While industrial activity in the Solomon Islands is limited, environmental problems occuras the result of this activity (Leary, 1990). Industrial activity at Tulagi, including the now closed fish cannery, and ship building facility, ship and vehicle repair activities resulted in obvious marine pollution problems. The past and present activity at Tulagi is not quantified in any available data. Industrial activity is now centered at the Ranadi industrial area in Honiara and the fish cannery at Noru.

The fish cannery at Noru processes approximately 8,250 tonnes of canned fish and 2,750 tonnes of fish meal. Anecdotal reports state that the cannery wastes discharge directly to the mangrove and marine areas causing serious environmental problems. The plant is designed witha secondary treatment system. A secondary treatment system for cannery wastes should

resultin pollutant reductions of 95 percent. If the treatment system at Noro provides such treatment, the pollutant loadings to the marine environment per year are: B.O.D.: 5.53 tonnes, suspended solids: 4.29 tonnes, nitrogen: 17.35 tonnes, and oils: 3.05 tonnes. If the plant is not functioning these loading become: B.O.D.: 110.6 tonnes, suspended solids: 85.8 tonnes, nitrogen: 17.35 tonnes, and oils: 61 tonnes per year. This conflict demonstrates the importance of adequate treatment to the management of industrial waste.

The palm oil factory on Guadalcanal also discharges wastewater with major pollutant constituents of B.O.D., solids, and oils. The palm oil production of 19,700 tonnes results, with no treatment provided, in a waste production of 490.53 tonnes of B.O.D., 484.62 tonnes of suspended solids, and 555.57 tonnes of oils per year. The discharge plume is visible from the shoreline adjacent to the outfall. Ranadi, on the outskirts of Honiara, is the location of a number of small manufacturing plants. Metal fabrication, paint manufacturing, soft drink manufacturing, and biscuit manufacturing are among the industries located there. A brewery is also planned for Ranadi. No production data was available for any of these facilities. Some of the facilities discharge to septic tanks and most into drainage ditches.

Industrial facilities in the country contribute to the marine pollution loadings, particularly in Noru and Ranadi. Past industrial activity in Tulagi has left behind a polluted harbor. The industrial wasteflows in the Solomon Islands are not well controlled or monitored. The consequences of the lack of control and monitoring demonstrate the need for improvements in this area.

In addition to the direct pollution loading that can result from the existing industrial activities, the fresh water supplies in Honiara are limited. The planned brewery will further stress these supplies.

Agriculture Runoff

Pesticide use and disposal was reported as a concern in the Solomon Islands Environmental Management Strategy (Leary, 1991). The use of fertilizers and pesticides in the country, based on import data, is relatively high for the region. Fertilizer imports are approximately 2,398 tonnes (Stone, 1990), mostly for the oil palm industry and a little for cocoa, and pesticide imports are approximately 493 tonnes per year. This volume of agrochemical imports is second only to Papua New Guinea among the countries with available data. If the assumption is made that 5 percent of these chemicals reach the marine environment, the resultant loading is 119.9 tonnes of fertilizers and 25 tonnes of pesticide. These are formulation quantities not active ingredient quantities. The actual chemical loading to the marine loading is therefore much less, perhaps by a factor of 5 or more.

Sediment laden runoff is also reported as a serious problem due to soil erosion as theresult of agricultural and forestry activities. This loading is probably significant, but is not considered in this report. It is hoped that a concurrent river loading study may provide some quantitative insight into this problem.

Summary

Domestic wastes remain the principle source of pollutant loadings to the marine environment in the Solomon Islands. Numerous public health and environmental health problems are evident as a result of the poor disposal of sewage and solid wastes in the country. The deleterious effects of a small industrial sector on the marine environment are clearly demonstrated here. The industrial sector is small and the relative industrial contribution to pollutant is also small relative to that of the domestic sector, yet the degradation in Tulagi, and apparently, Noru, is clear. This reiterates the cautions stated in the Part 1 of this report regarding the need to examine not only the pollutant loadings but the receiving water conditions as well. The lack of adequate sewage disposal and the associated problem of a limited water supply, subject to contamination from the lack of adequate sewage disposal, requires urgent action. Environmental problems from industrial activity, though clearly requiring attention pose a less urgent threat to the public health. Present pollutant loadings from industrial activities should be monitored to confirm the quantities discharged and to improve treatment facilities where available. New industries should be required to install adequate treatment facilities on site.

TOKELAU

Tokelau consist of three atolls (Fakaofo, Nukunonu, and Atafu) with 127 atoll islets located 400 miles north of Western Samoa. The islands are built up of coral and sand fragments, generally resting on old reef of coral-limerock. Because of the high permeability of the unconsolidated material there is virtually no runoff.

Tokelau has is a subsistence economy with limited commercial activity and little industry e.g., handicraft, cooked toddy and fish. The source of marine pollution is therefore primarily from domestic waste (99.7%), the rest are from fisheries (0.2%) and shops (0.1%). Since fifity percent of the population of 1,600 uses over-the-water latrines (or shoreline use without facilities), all of this waste directly enters the marine waters. The remaining fifty percent of the population utilizes septic tanks. The calculated annual pollutant loads from this population are therefore very simple. BOD loadings are 12 tonnes; suspended solids 28.8 tonnes; nitrogen: 5.9 tonnes and phosphorous; .72 tonnes. This data are also presented in Table B.17.

Based on the information provided by SPREP (Tulega, 1992), 75 % of solid waste generated is decomposable type of waste that usually composted around trees or given to pigs. The remaining 25 % including tires, plastic containers, bottles, outboard motor engine parts, batteries, and corrugated iron roof. Some recycled wastes including as aluminum cans, bottles and batteries are shipped to Apia, Western Samoa.

The most critical issue regarding land-based sources of pollutants to the marine environment is therefore the use of over-the-water latrines and the shoreline without the use of facilities. Continued efforts to provide improved on-land facilities and public education to modify social and cultural habits in this regard is necessary.

TONGA

Tonga is located in the southwestern Pacific Ocean and is comprised of more than 50 islands, divided into four main groups with a total land area of 747 square kilometers. Thirty-six of the islands are inhabited. Most of the islands are coralline, and the few volcanic islands are most notably in the Ha'apai group. The population of Tonga is approximately 97,000.

Tonga is primarily an agriculture-based economy with little industry and a growing tourism sector. The limited industrial sector consists of small manufacturing activities, vehicle and equipment servicing, food processing, beverage production, and garment making. At present, waste management for both the domestic and industrial sectors is primarily the responsibility of the producer.

The key environmental issues for Tonga primarily occur on Tongatapu, the location the capital, Nuku'alofa. Groundwater in the Nuku'alofa area is contaminated from the outflow of septic tanks and latrines. This has resulted in the microbial contamination of some water supplies. The disposal of solid wastes in the coastal area is of concern, particularly at the present site, Pupoa which is adequate in size and located relatively the shoreline. A new site has been identified. This site is also located in a wetland area. The proposed area appears to be a dying wetland area, probably as the result of filling activities.

The great majority of waste generated in Tonga is discharged on land into septic systems, simple pits, or other land facilities. There is limited direct discharge of wastes to the marine environment. Wastes known to be discharged directly into marine waters include: stormwater drainage from central Nuku'alofa, food wastes condemned by the Ministry of Health, and solid wastes (littering) of individual households and persons. The present public dump site in Nuko'alofa is approximately 200 meters from the coastline in a wetland area.

There is only a limited capacity for monitoring and controlling of land-based pollution in Tonga. The environmental office is minimally staffed. The potential for environmental degradation is not considered in a number of government development criteria. Additional hydrogeological information is required to assess the fate and transport of wastes discharged to land.

Domestic Waste

With the exception of systems at the small industries center, the hospital and a boarding school, there is no reticulated sewage system in the country. All domestic wastewater is disposed of in individual disposal systems which range from mechanical flush septic systems to pit latrines. The collection systems at the hospital and boarding school discharge to septic systems. While some of these facilities are located in wetlands and other coastal areas, the number of facilities in

coastal versus non-coastal cannot be quantified with the information available to this study. Also, this study has insufficient hydrogeological data to quantify flow through to the marine water. Therefore, it is difficult to accurately quantify the domestic sewage entering the marine waters in Tonga. Nevertheless, the study does provide a reasonable estimate of total waste production and a rough approximation of the pollutant loading to the marine environment. The 30 percent reduction from the total pollutant loading to the marine pollutant loading applied throughout the study may be reasonable accurate for areas very near the shore, but is probably quite high for central island area. The nutritious condition in Fanga'uta lagoon identified by Naidu et al. (1990) has not been substantially affected by human activities. Thus the pollutant transport factors applied throughout this study may overestimate loadings in Tonga. Nevertheless for consistency, these same factors are used. The domestic wastewater facility types and the predicted pollutant loadings are detailed in Table B.18. Total pollutant loadings from domestic wastewater in Tonga is estimated to be 563 tonnes of BOD, 161 tonnes of suspended solids, 344 tonnes of nitrogen and 43 tonnes of phosphorous.

Industrial Waste

In Tonga, the medium size industrial base is the result of a number of small manufacturing centers which utilize imported materials, e.g., the knitwear industry. Coconut processing remains a large industry. The wastes from these industries are mostly in the form of solid waste. The processing of foods and beverages such as biscuits, milk, fruit drinks, and other soft drinks may contribute to BOD., solids and nutrient loadings. These wastes are discharged to septic tanks and dry wells. All of the wastes have the potential of adversely affecting groundwater quality and eventually reaching marine waters. As with domestic wastes the actually loading that reaches the marine environment is difficult to predict. No attempt was made to make such a prediction.

Agricultural Chemicals

Agriculture chemical use in Tonga is increasing but still of relatively small scale. The government recently established a licensing system for pesticides that if implemented and enforced may help reduce concern about the possible contamination of groundwater supplies. Presently, the greatest environmental concern with pesticide use is spills that may occur as the result of improper storage or transport. In 1991, Tonga imported some 431 tonnes of fertilizers and just 15 tonnes of various pesticides.

Summary

In Tonga, there are a minimal number of direct discharges of pollutant from land to the marine water. The discharge of pollutants appears to more directly affect ground water than marine waters. This would eventually affect the marine environment, but the magnitude and type of affect is not easily predicted. Even with this uncertainty as to the affect of land discharges of pollutants, the lack of an adequate program for the monitoring and control of pollution, the potential for significant environmental problems is always present.

In order to improve the waste management strategies in Tonga it is necessary to carry out more extensive monitoring program for ground water quality. The pollutants associated with the established industries should be targeted as priority pollutants for analysis. Once this is established further efforts should address the potential fate and transport of the identified pollutants.

VANUATU

The Republic of Vanuatu is an archipelago comprised of some 80 islands scattered over a distance of 900 kilometers from north to south and lies west of Fiji and north of New Caledonia. Most of the islands are mountainous and are relatively young geologically. There is an abundance of rainfall, averaging about 2200 millimeters per year, but there are few perennial streams. This is probably the result of their small size and rugged topography. Eighty percent of the 142,944 population live in rural areas.

The economy is primarily agricultural based and beef, copra, and fish remain the primary exports. Industrial scale logging also occurs as well as a small industrial sector that is found in Port Vila. A brewery, soft drink manufacturer, canned meat manufacturer, biscuit factory, and a number of manufacturers and commercial operations also contribute to the economy.

In Vanuatu, environmental issues include marine degradation and erosion and sedimentation that primarily affects the rural population, and sewage contaminated lagoons in the urban area of Port Vila. Industrial contribution to marine environmental problems is still quite small.

Domestic Wastewater

Domestic wastewater, or sewage, disposal in Vanuatu is one of the more serious environmental concerns in Vanuatu, particularly in urban areas. In 1990, the level of coverage with adequate sanitation in Vanuatu as 86 percent for urban areas and 34 percent in rural. The prevalence of water-related diseases in the country suggests that the public health and environment is affected by the level of coverage and type of sanitation facilities provided.

Studies identify poorly functioning sanitary facilities together with rapid groundwater flow as the causes of the microbial and nutrient pollution in the lagoons around Port Vila (Sinclair-Knight,1991; Royds Garden, 1990). The uncontrolled flow of nutrient and bacterial contamination combined with the poor natural flushing in these lagoons results in decreased oxygen concentrations, high turbidity, and contaminated marine food resources.

Table B.20 shows the pollutant loadings to the marine environment. These calculations utilized facility data from the previous studies (Sinclair-Knight, 1991; Royds Garden,1990); however, WHO method loading rates were applied. It is interesting to note that the previous studies used a pollutant transport rate of 85 percent rather than the 70 percent used by this study. The method predicted total annual pollutant loadings from domestic waste as 817.8 tonnes of BOD, 560 tonnes of suspended solids, 457 tonnes of nitrogen, and 58.4 tonnes of phosphorous.

Industrial Wastewater

Vanuatu's industrial sector is relatively small but is approaching medium-scale on a regional level. With the exception of the beef, fish freezing, and timber industries, the manufacturing industry is almost exclusively for local consumption. Industries for the domestic market include, soft drink manufacturing, printing, small cement works, brewery, soap manufacturing, garment manufacturing, baked goods, milk production, boat building. Table C.20 lists the industries included in the WHO method and the resultant pollutant load calculation for these industries where production data was available.

Waste management in the industrial sector is minimal. The exception to this is the abattoir at Port Vila (Santo abattoir was not visited). The Port Vila abattoir provides secondary treatment for its wastes in anaerobic lagoons. The facility itself is kept very clean. This is necessary to meet international food sanitation requirements. The brewery and soft drink manufacturing facilities utilized septic tanks for their waste effluents. Simple treatment through septic tanks or settling tanks can be effective for these kinds of waste, however, the septic tanks at these facilities appeared to be undersized. Overflow and seepage was observed at both facilities. Overflow from the area enters allow marshy area with eventual discharge into the nearby bay.

Numerous small wastewater producing activities such as laundries, printers, restaurants, and photo shops discharge their wastes to overflowing septic tanks or directly to storm drains. Quantification of this waste was not possible. As with the domestic waste flows, better designed septic tanks and individual systems would reduce the pollutant loadings from these sources.

The industrial contribution to the marine pollutant loading appears to be relatively small. The present marine water quality problems around Port Vila, however, warrant reductions wherever possible. Few studies have been conducted for other than nutrient and sediment pollution in the marine areas of Port Vila.

Solid Waste

Solid waste disposal, as elsewhere throughout the region, is poor in the urban centers of Vanuatu. The Port Vila dump at Fres Wata is of particular concern as it is located over a water supply. Also, in Port Vila, debris from a hurricane was allowed to be dumped directly into the harbor area. Presumably this filled area could then be used to extend the public works yard area. The high organic content of this largely green waste contributes to the nutrient loading of the harbor. (Sinclair-Knight, 1991).

Agricultural Runoff

Agrochemical use in Vanuatu is small considering the large agricultural sector. Only some tonnes of fertilizers and approximately tonnes of pesticides are imported each year. (Stone, 1992). Agrochemical use is not encouraged by the Agriculture Department nor its Plantation Project, which encourages integrated pest management procedures, using the right crops and grasses together to minimize weeds. The study estimates that less than 6 tonnes of fertilizers (nitrogen and phosphorus) and less than 1 tonne of pesticides per year enter the marine environment. The heavy use of DDT and other mosquito-control pesticides that are sprayed as part of a malaria prevention program may contribute greater quantities of pesticides to the environment than agriculture. This was not calculated, but might be considered for future study.

Summary

Domestic wastes, sewage and solid wastes are the major contributors to marine pollutants. This is illustrated in Figure 1 below. As in other countries of the region, industrial contributions appear to be growing but large loadings from this sector have not been identified. Waste management practices should continue to be improved in both sectors. Simple management practices in the present industrial sector are probably sufficient, if properly designed. It is also critical that data on industrial activity be collected and analysed routinely to monitor the importance of this sector to environmental quality.

WALLIS AND FUTUNA

Wallis and Futuna has a population of approximately 9,500. The total land area of the country is 26 square kilometers. Funafuti, the capital, is made up of 30 islets and is 20.8 kilometers by 16 kilometers.

The economy is subsistence based with only a few retail shops to support the local populations. As such the land-based contribution is limited to domestic waste. No information was available on the types of facilities and populations using them. It was assumed that all persons use latrines. All calculations were based on land-based latrines. It is expected, however, that there is a great use of over -the-water latrines and direct disposal to the beach. Therefore, the calculated annual pollutant loadings of BOD 36 tonnes; suspended solids 16 tonnes; 23 tonnes of nitrogen and 2.8 tonnes of phosphorous, are probably low. These data are also presented in Table B.21.

WESTERN SAMOA

Western Samoa consists of two major islands and several smaller islands including a total land area of approximately 2,934 km^2. The main islands are Upolu and Savaii. Western Samoa has a population of around 165,000 with over seventy percent of the population living on Upolu. Apia, with a population of approximately 33,000, is the capital and urban center. It has no official status a municipality and is made up of a number of traditional villages.

The islands are mountainous and volcanic in origin. These high islands also have a flat to gently sloping coastal plain. Rainfall varies 2,200 mm in northwesterly parts of the main island to over 6,000 mm in the highlands of Savaii. The hydrogeologic properties of the island are highly variable. Systemic collection of hydrological data only began in 1971 (UN DTEC, 1983). There is significant spatial and temporal variations in the elevation and characteristics of the groundwater table. These variations make it difficult to predict rainfall-run-off regimes (UN DTEC, 1983).

Employment is generally based around a subsistence economy. Apia also has a more urban economy with government employment and a number of small industries and manufacturers. Land-based pollution sources in the rural areas centre around land clearing activities, agriculture, and domestic waste. Land-clearing likely has the greatest effect. Transport of pollutants from domestic wastes from land-based individual systems (eg. latrines) can be somewhat mitigated by the low population densities. However, problems may occur where populations are concentrated in small coastal areas. Pollution of marine areas around Apia results from ongoing discharge of urban waste from a variety of sources. Urban waste sources include domestic waste, sewage, small industry wastewaters, and larger facilities such as breweries and bottling plants.

Identified land-based pollution sources in Western Samoa are discussed below. As with the regional study, only on-going activities are included. Land clearing for construction and agricultural activities while significant are not specifically included. It is expected that a reasonable estimate of the magnitude of this source will be provided through the river inputs component of this study.

The relative contribution and importance of these various sources are discussed after the discussion of the specific sources.

Domestic Wastewater

The Apia area is the only urban area of Western Samoa and the greatest volumes of domestic waste are discharged from this area. There are limited details regarding the location and type of sanitary facilities and determination of the pollutant loadings potentially reaching marine waters from rural areas is difficult to calculate. In most rural areas it may be assumed that the assimilative capacity of receiving soils and waters will minimize environmental problems. However, since the population in rural areas is concentrated in coastal areas, and ifacilities are concentrated near the shoreline, localized pollution problems may occur.

There is no existing public sewerage system in Apia and the majority of the population is served by on-site facilities. Small individual sewerage treatment systems are in-place at the hospital, hotels, brewery, and some commercial facilities. Residential facilities are served by simple on-site facilities.

Residential facilities include four main types, septic tanks, water-seal latrines, pit latrines, and primitive latrines without pits (usually located at drains and streams). The types of facilities and the estimated population using each type are shown in Table B.22. Septic tanks and associated soakage facilities are rarely properly designedand usually consist of single compartment tanks which are not adjusted for number of persons connected. Soakage pits, if used are also not sized for population using the facility and inlet and outlet piping to the facilities are often incorrectly placed. Treatment efficiencies of properly designed septic tanks is on the order of 30 percent. As such, the groundwater in the Apia region is highly contaminated from the septic tanks and other individual facilities. The septic tanks function without visible problems because of the high percolation rates in most areas. In areas with high percolation rates, groundwater movement is likely to result in the pollution of near-shore waters. According to SPREP, no serious attempt has been made to determine and identify water tables amd water lenses throughout the country (Tulega, 1992).

In low lying areas in Apia, such as Fugalei and Saleufi, poor percolation rates in conjunction with poor drainage results in wastewater ponding and flowing on the surface. Much of this polluted surface water makes its way to the nearshore waters.

In order to estimate the loading from domestic wastewater to marine areas, some broad assumptions must be made regarding the composition of the wastewater, treatment efficiencies, and potential for the wastewater to reach the marine waters. The composition of wastewaters follows that used throughout the study and described in Section 3.1 of the main body of this report.

The only institution served with a sewerage system plant is the hospital; all other institutions are served by septic tank or latrine systems. The hospital system consists of an imhoff tank and trickling filter. The plant dates from the first half of this century and presently provides

absolutely minimal treatment. Replacement of the plant is now underway and should be completed before this report is issued. Discharge from the plant enters the Mulivai stream. Much of the wastewater reaches the near-shore area with little self-purification occurring. Wastewater flows from this facility are based upon an assumed average patient population.

The Tusitala Hotel and Vailima Brewery operate small sewage treatment systems. The Tusitala Hotel utilizes an oxidation ditch and the brewery a sedimentation tank. Mechanical difficulties result in poor to no treatment of the wastewaters. The brewery's sedimentation tank is overloaded and the wastewater overflow discharges directly to Vaiusu Bay. The Aggie Grey Hotel utilizes a septic tank and soakage field system; there have been no problems reported at the facility.

Industrial Wastewater

There are only approximately 75 manufacturing businesses in Western Samoa. In 1986, the food and beverage industries accounted for 36 percent of these businesses. Wood and paper industries were 31 percent of the total which was approximately 73 businesses (UNIDO, 1989, pg 131). The veneer industry has reported no production since 1987 and production in the timber industry declined 40 percent between 1986 and 1989. There has also been two new developments that effect the composition of manufacturing industries in Western Samoa. These are the establisment of a second brewery and a wire harness plant. Thus, the food and beverage industries account for a greater share of the manufacturing in Apia and a much larger share in the assembly sector. Other smaller industries include, paint manufacturing, printers, photo shops, cigarette manufacturing, shoes and industrial gas production.

These smaller facilities are significant to the study of land-based pollution sources of marine pollution. Some of these industries have "wet processes" which involve the use of chemicals and other toxic materials. Printers, for example, utilize solvent, acids and alkalis, silver, and inks that are discharged directly into drains withour treatment. Another example of relatively small facility with potentially significant wastewater flows is the abbotoir. Wastewater from the abbotoir flows directly to the ocean with no treatment. Due to the lack of community sewerage system, these discharges enter at the coastline. Other small industries have "dry processes". Waste from these industries contribute to the required capacity of community solid waste disposal sites. In an uncontrolled or poorly sited landfill this may contribute to marine pollution problems through changes to leachate quantity and composition. Metal wastes, battery disposal, and dye or solvent contaminated materials may contribute heavy metals, acids, alkalais, and solvents to leachate. These industries also contribute to wastewater flows through the sanitation facilities for employees.

Petroleum and lubricant products are distributed from two locations in Wester Samoa, Mobil and British Petroleum. Bulk fuels such as aviation fuels, gasoline, and diesel are pumped

from the tankers to land via a submarine pipeline. This pipeline must be cleared of seawater before each shipment prior to the pumping of fuels to shore storage tanks. The seawater is contaminated with oils and other petroluem products. The contaminated water is treated in an oil water separator prior to discharge to the marine environment. The separation process is not complete and some oil remains in the effluent discharged to the ocean. Total discharge is estimated at 70 tonnes every month (Perval report through Tulega, personal communication, 1992).

Limited information on the production rates and information on waste water flows form the industries is available (see regional report for discussion on industrial statistics and data needs). As noted in the regional discussion, the quantification of pollution sources is thus very difficult. This is particularly true for the smaller industries where production rates are generally not maintained, e.g., printers. Table C.21 provides a summary of the major industries identified and information on production and waste volumes, if known.

Solid Waste

Solid waste contributes to land-based pollution through the direct discharge of the waste to the marine environment, litter waste carried to nearshore waters with runoff, and leachate production. It is difficult to quantify the amount of solid waste reaching the marine environment through any of these means. Therefore, the contributions must be discussed in more qualitative terms.

The current dump at Vaitola is being closed by the government. This dump is located in a mangrove area. There is no operation or maintenance of the facility and this facility is considered a significant pollution source. A new tipping site at an inland location has been identified and should be operational prior to issuance of this report. This site should should have much lower impact on near-shore waters. The leachate flow to the groundwater and on to the nearshore waters will depend on the local soil conditions and hydrogeological conditions which have not been determined. No estimates of waste volumes were available for this report.

Agricultural Runoff (Pesticides And Fertilizers)

As in the regional repor,t the risks from pesticide use appear to rest primarily with occupational health rather than environmental damage or risk to the general public health. Fertilizer use in Western Samoa is very limited. Only 22 percent of all farm holdings reported using fertilizers in 1989 (W.Samoa, Agriculture Department, 1990). Pesticide use was greater, with some 59 percent of the holdings using pesticides. This level of use is not very high by world standards.

Lacking detailed information regarding location of use, application rates, and other information for modeling concentrations in runoff, agricultural chemical loadings on the marine environment were estimated using a percentage of the quantity of applied chemicals. The volume of chemicals applied is assumed to be the same as the volumes imported. Official totals for the amount of pesticides imported was not available, however, one report indicated pesticide imports totalling 252 tonnes and 44500 litres (Taylor, 1991). This report also indicated that excess pesticides are poured into ditches and on the ground near streams. However, the relatively high costs of pesticides and the low average income likely minimizes the amount of excess pesticides that are disposed of in this manner.

Summary

The land-based pollution sources survey in Western Samoa provides a foundation for analysis of waste management and marine pollution control strategies. Though the information is qualitative in nature, it provides a description of the magnitude of a number of sources and their relative importance.

Domestic wastewater, as expected, remains the primary contributor of wastes to the marine environment. Industrial and manufacturing contributions, while small in quantity are of concern because of the chemical and toxic nature of the waste. The cumulative effect of these discharged chemicals is unknown. No testing has been conducted in regards to quantification of waste flows nor in regards to determining contaminant concentrations in streams and near-shore waters. Pesticide and fertilizer contributions are slight.

Domestic wastewater contributions to the pollutant loading of the marine waters of Western Samoa should be addressed. A sewerage collection system is necessary for significant improvement around Apia. Primary treatment should be provided, if feasible. If this is not feasible, the discharge outfall should be sited and design so that effluent is discharged below the thermocline in areas of good circulation. Major business such as the brewery, wire assembly plant, and large hotels should be required to improve their individual systems.

In residential areas that cannot be sewered, designs and location for new facilities should be approved prior to construction to determine the appropriateness of the system and the capability of soils at the site to accept the wastes. This should apply to rural areas as well as Apia.

As a start to managing industrial wastes, it is encouraged that the local industries be required to submit annual reports to the environment department that include information on the industry process, raw materials used, waste generated, water use, and waste generation. Government officials should work with industry representatives to determine appropriate management practices based on the collected data. A permit program may be established to ensure

compliance with these procedures. To the extent possible the use of hazardous materials should be limited through materials substitution, recycling, and good housekeeping or maintenance procedures. For example, silver recovery is possible, and profitable from x-ray films and photographic processing. Solvents used in paint production, dry cleaning, and printing industries can be recycled and used in the same facility. The discharge of chemical wastes into storm drains should be prohibited since these often lead directly to the ocean or other surface waters.

The two large facilities for petroleum products should be monitored to determine the amount of petroleum products that pass through, or bypass completely, the oil water separator. If the oil water systems are determined to be ineffective, the companies should be required to upgrade the system as necessary. The current practice of waste oil reuse should be monitored to determine if sny improper disposal is occuring or if the reuse might result in the dishcarge of oil to surface waters.

The new solid waste landfill (dump) should be monitored to determine types and quantities of wastes disposed. This information can be used to determine life of the facility, potential characteristics of leachate, and management practices that may be rewuired at the facility. Daily, or as often as practical, cover should provided.

SELECTED REFERENCES

Regional

Baines, G.B.K., and R.J. Morrison. *Marine Pollution from Land Use in the Pacific Island Region*. Marine pollution Bulletin vol.21, no.11, pp 506-515, 1990.

Birkeland, C., and D. Grosenbough. *Ecological Interactions Between Tropical Coastal Ecosystems*. UNEP Regional Seas Reports and Studies No.73. UNEP. 1985.

Branch, J. *Hazardous Waste Storage and Disposal in the South Pacific*. UNEP Regional Seas Reports and Studies No.48. UNEP. 1984.

Brodie, J.E., C. Arnould, L. Eldredge, L. Hammond, P. Holthus, D. Mowbray, and P. Tortell. *State of the Marine Environment in the South Pacific Region*. UNEP Regional Seas Reports and Studies No.127. UNEP, 1990; and, SPREP Topic Review No.40, South Pacific Regional Environment Programme. 1990.

Brodie, J.E. and R.J. Morrison. *Topic Review No.16: Coastal and Inland Water Quality in the South Pacific*. South Pacific Regional Environment Programme Nouma, New Caledonia. Dec., 1984.

Cannerella, R.. Oral presentation in EPA Pacific Island Conference Kauai, Hawaii, June, 1992.

Carpenter, R.A., and J.E. Maragos. *How to Assess Environmental Impacts On Tropical Islands and Coastal Areas*. Environment and Policy Institute, East-West Centre, Hawaii. 1989.

Carpenter, R.A. and R.R. Cirillo. *From Grave to Cradle: Trends in Hazardous Waste Management*. An edited compilation of papers from the 1990 Pacific Basin Conference on Hazardous Waste of the Pacific Basin Consortium for Hazardous Waste Research, Honolulu, Hawaii, USA. 1990.

Carpenter, R.A., J. Maragos, K.Z. Meier, N. Convard, S. Edgerton, K. Smith. *Environmental Risks to Hawaii's Public Health and Ecosystems*. A Report of the Hawaii Environmental Risk Ranking Study to the Department of Health State of Hawaii. 1992.

Clark J., Veissman W. , and Hammer M.. *Water Supply and Pollution Control*. Harper and Row Publishers. 1977.

Doleman. Personal Communication. May, 1992.

Douglas, Norman, Ngaire Douglas. *Pacific Islands Yearbook* 16th edition. Angus and Robertson Publisher. United Kingdom, 1989.

Dupon, J.F. *Environmental Case Studies: South Pacific Study 1.* South Pacific Regional Environment Programme, Noumea, New Caledonia. 1986.

Dupon, J.F. *Environmental Case Studies: South Pacific Study 4.* South Pacific Regional Environment Programme, Noumea, New Caledonia. 1986.

EPA. *Process Design Manual for land Treatment of Municipal Wastewater.* US E.P.A.Center for Environmental Research Information, Cincinnati, Ohio. EPA 625/1-81-013. October 1981.

EPA. *EPA Guidelines for Water Reuse. Office of Wastewater Enforcement and Compliance,* Washington, D.C. EPA/625/R-92/004. September, 1992.

EPA. *Discharge Monitoring Report (EPA) 3320-1 for 2nd quarter of 1989 for the Ponape Bulk Plant.* Report receive from Office of Territorial Programs (W-1-1). 1992.

Fuavao, V., M. Maata, M.R. Naqasima, and R.J. Morrison. *Marine Pollution Problems in the South Pacific.* UNDP South Pacific, Regional Office, Suva. 1989.

Guo, P., Dr. *Progress and Problems in Water Supply and Sanitation in the Pacific Island Countries.* First Pacific Islands Environmental Health Conference. Aug., 1991.

Hughes, P.J. *The Effects of Mining on Island Environment.* UNDP Regional Workshop on Environmental Management and Sustainable Development in the South Pacific. 1990.

Johannes, R., et al. *The impacts of Human Activities on Tarawa Lagoon.* Report to South Pacific Commission. 1979.

Lau, L.S. et al. *Groundwater Recharge with Honouliuli Wastewater Irrigation: Ewa Plain, Southern Oahu, Hawaii.* Water Resources Research Center University of Hawaii. August 1989.

Lindeburg, M.R., P.E. *Civil Engineering Reference Manual,* Fourth Edition. 1986.

Metcalf and Eddy, Inc. *Wastewater Engineering.* McGraw-Hill Book Co. New York. 1979.

Morrison, R.J. (a). *A review of Water Quality in the South Pacific.* Draft. 1992.

Morrison, R.J. (b). Personal Communication. May, 1992.

Mowbray, D.L. *Pesticide Use In the South Pacific.* UNEP Regional Seas Reports and Studies No.89. SPREP Topic Review No.26, 1988.

Naidu, S., W.G.L. Aalbersberg, J.E. Brodie, V.A. Fauvao, M. Maata, M. Naqasima, P. Whippy, and R.J. Morrison. *Water quality Studies on Selected South Pacific Lagoons.* UNEP Regional Seas Reports and Studies No. 136, UNEP, 1991; and SPREP Reports and Studies No.49, South Pacific Regional Environment Programme, 1991.

Newel, L. Personal Communication. 1992.

Ogawa, H. *Key Issues on Solid Waste Management in the Pacific Island Countries*. May, 1992.

Sand, Allen. Personal Communication. May, 1992.

Shuval, H.I., "Public Health Considerations in Wastewaters and Excreta Re-Use for Agriculture" in Feacham, McGary, and Mara *Water, Wastes and Health in Hot Climates. 1977.*

South Pacific Regional Environment Programme. *Technical Publications*. April, 1992.

Stewart, David. SPREP. personnel communication April, 1992.

Stone, L. *Waste Generation and Prevention Opportunities in the South Pacific*. January, 1990.

Sugrim, 1988. Interview in *Sugarcane Farming News,* May. 1988.

Swinstead, G. *Pacific Islands*. Monthly magazine of the Pacific Islands. April, 1992.

UN. *Groundwater in the Pacific Region*. Natural Resources/Water Series No.12. United Nations Publication. New York, 1983.

UNEP. *Convention of the Protection of the Natural Resources and Environment of the South Pacific Region and Related Protocols*. 1987.

UNEP. *GESAMP: The State of the Marine Environment*. UNEP Regional seas Reports and Studies No. 115. United Nations Environment Programme. 1990.

UNEP. *Strategy for the Reduction of the Degradation of the Marine Environment from Land Based Sources of Pollution and Activities in Coastal Areas*. October, 1991.

Unger, S.G. *Environment Implications of Trends in Agriculture & Silvicultur. Trend Identification and Evaluation.* EPA-600/3-77-12. U.S. EPA, Wash. D.C. Environmental Impacts of Agricultural Production Activities. Oct., 1977.

UNIDO. *Statistical Yearbook for Asia and the Pacific*. 1989.

Venkatesh, S., and S. Va'ai. *Topic Review No. 13: An Overview of Environmental Protection Legislation in the South Pacific Countries*. South Pacific Regional Environment Programme, Noumea, New Caledonia. June, 1981.

Wauthy, B. *Physical Ocean Environment in the South Pacific Commission Area*. UNEP Regional Seas Reports and Studies No.83. UNEP, 1986.

WHO. *Management and Control of the Environment*. A document describing the approach and providing the requisite working tables to develop an environmental management scheme for an area under study. 1989.

WHO. *Rapid Assessment of Sources of Air, Water, and Land Pollution*. WHO, 1982.

Wiseman, R., G. Baker, A. Bingham, A. George, B. Gunnell, H. Hannah, S. Highnam, and G. Power. *The International Drinking Water Supply and Sanitation Decade Directory, Edition 3*. World Water. Nov., 1987.

World Water Magazine. *The International Drinking Water Supply and Sanitation Decade Directory, 2nd Edition*. This catalogue of external support and consultants directory. March, 1984.

Vermont Public Advisory Committee. Environment 1991: Risks to Vermont and Vermonters. A Report by the Public Advisory Committee, The Strategy for Vermont's Third Century. Vermont Agency of Natural Resources. 1991.

American Samoa

Weigman, S. Personal Communication. May, 1992.

CNMI

Duenas & Associates, Inc. Environmental Services. *Section 301(h) NPDES Waiver Application For The Agingan Wastewater Treatment Plant, Saipan, CNMI.* Saipan, CNMI. April, 1992.

Duenas & Associates, Inc. Environmental Services. *Section 301(h) NPDES Waiver Application For The Sadog Tasi Wastewater Treatment Plant, Saipan, CNMI.* Saipan, CNMI. April, 1992.

Fiji

Bronders, J.,Ph.D., (a). *Water and Tailings Chemical Analysis, Vatukoula Gold Mine*, Ministry of Land and Mineral Resources Department, May, 1991.

Bronders, J.,Ph.D., (b). *Waste Disposal in Fiji, Part 1: Site Inventory,* Ministry of Land and Mineral Resources Department, April, 1991.

Bureau of Statistics for The Government of Fiji, *Current Economic Statistics*, December, 1991.

Cripps, K. *Survey of the Pont Sources of Industrial Pollution Entering the Port Waters of Suva.* Prepared for the Ports Authority of Fiji by the Engineering Dept. Ports Authority of Fiji. Jan., 1992.

Fuavao, V. M. Maata, M.R. Naqasima and R.J. Morrison, *Marine Pollution Problems in the South Pacific.* UNDP Regional Workshop on environmental management and sustainable development in the South Pacific, 1990.

Gangaiya, P., Ph.D., J.E. Brodie, and R.J. Morrison, *Baseline study of the Vitogo River and Associated Environment,* UNEP 1988.

Gangaiya, P., Ph.D., and D.Green, Ph.D., *Monitoring of Trade Wastes Entering Suva and Lautoka Harbours.* Report prepared for the Ports of Authority of Fiji, May, 1991.

Gawader, J.S., *The Constraints and Opportunities of Sugarcane Production in Fiji:Nutrional Aspects.*

Green, D.R.,PhD., E.R. Lovell, M.Sc., *Pacific Fishing Company: Environmental Monitoring Report,* 1991.

Green, D.R.,PhD., E.R. Lovell,M.Sc., and C.R.Lloyd, *Environmental Impact of the Extension of the PAFCO Cannery*, August, 1990.

Institute of Natural Resources, The University of the South Pacific, *Effect of Rarawai Mill Effluent Discharge on the Ba River*, July, 1991.

Institute of Natural Resources, The University of the South Pacific, *Disposal of Calcium Hydroxide from Acetylene Production at CIG Fiji Ltd.*, May 1990.

Lautoka City Council, *Annual Report*, December 31, 1991.

Maata, M., *The Current Status of Management of Hazardous Wastes in Fiji,* Report prepared for ESCAP, Jan., 1992

Morrison, R.J.*Agricultural Development in Fiji In The 1990's*, Lautoka, March, 1990.

Morrison, R.J. and J. Seeto, *Tributyltin (TBT) Compounds in the Marine Environment around Suva.* A report prepared for the Fiji Environmental Management Committee. University of the South Pacific, 1992.

Nair, B., Letter with comments on draft report., 1992.

Public Works Department, *Report on Receiving Water Study,* The Ministry of Works and Communications, August, 1982.

Pamphlet, *Greater Suva City Sewerage Scheme.*

Sugarcane Farming News, *Soil Erosion in Fiji, Fact or Fiction,*May 1988.

Suva City Council, *Analysis and Interpretation of Analytical Data Collate by The University of The South Pacific,* Memo from Shi I. Verenakadavu to City Health Officer, July, 1989.

Suva City Council, *Result of Survey of Pollution into Walu Bay Sea Front Stream,* Memo from N.B. Kotoiwasawasa, Acting S.H.I., Sanitation, to the Director of Health Services, Feb. 1991.

Guam

EPA. *Discharge Monitoring Report (EPA) 3320-1 for 2nd quarter of 1989 for the Ponape Bulk Plant*. Report received from Office of Territorial Programs (W-1-1). 1992.

Kiribati

Johannes, R., et al. *The impacts of Human Activities on Tarawa Lagoon.* Report to South Pacific Commission. 1979.

New Caledonia

Dupon, J.F. South Pacific Regional Environmental Programme, South Pacific Commission. *Environmental Case Study*. Noumea, New, Caledonia: ORSTOM, 1986.

Niue

Tulega, L. Letter with comments on draft report. 1992

SPREP. *Report of the Fifth Consultative Meeting, Suva, Fiji*. 1990.

Palau

Birkeland, C., R.H. Richmond, E.A. Ernest. *Palau Resources Survey (Phase 1: Babelthaup and Koror-Selected Sites)*. Palau: South Pacific Regional Environment Programme, South Pacific Commission. 1990.

Maclean, C., T. Cole, C. Whitesell, K. McDuffie. United States Department of Agriculture, Forest Service. *Timber Resources of Babelthaup, Republic of Palau.* Palau: Pacific Southwest Forest and Range Experiment Station. May, 1988.

Papua New Guinea

Bartelemus, P., E. Lutz, S. Schweinfest. *Integrated Environmental and Economic Accounting: A Case Study for Papua New Guinea*. United Nations Statistical Office (UNSO). 1992.

Hughes, P.J. *Environmental Case Studies. The effects of mining on the environment of high islands: A Case Study of Gold Mining on Misima Island, Papua New Guinea*. SPREP Apia, Western Samoa. 1989.

Republic of Marshall Islands

Louis Berger Intenational, Inc., Barrett Consulting Group, Inc., U.S. Department of the Interior, U.S. Army Corps of Engineers. *Plan of Action Operations and Maintenance Improvement Program. Republic of Marshall Islands*. December, 1990.

Marshall Islands Office of Planning and Statistic. *National Population Policy*. July, 1990.

Marshall Pacific Management Services Corporation, The Marshall Islands Development Authority and Trust Territories Office of Capital Improvements. *Laura Island Wastewater Study*. Majuro. June, 1988.

Republic of the Marshall Islands: Presidential Task Force on Environmental Management and Sustainable Development. *United Nations Conference on Environment and Development*. Majuro. July, 1991.

U.S. Environmental Protection Agency. *Environmental Assessment: Majuro Wastewater Treatment and Disposal System Project No.C750003010*. Majuro, Marshall Islands. March, 1981.

Solomon Islands

Lam, M., M.R. Naqasima, R.J. Morrison. *An Initial Study of Microbial Pollution of the Marine Environment Around Honiara, Solomon Island. INR Technical Report No.90/3.* Honiara, Solomon Island: Institute of Natural Resources, The University of the South Pacific. April, 1990.

Leary, T. *Solomon Islands, State of the Environment Report.* Solomon Islands: Environment and Conservation Division, Ministry of Natural Resources. September, 1991.

Lolemai, T. *Sewage and Solid Waste Disposal Problem in Honiara and Other Provincial Urban Centres (Solomon Islands).* Paper presented at First Pacific Island Environmental Health Conference: Mobilising Resources for Effective Environmental Health Programmes. New Caledonia. August, 1991.

Lum, J.A., A.L. Clark, P.J. Coleman. *Gold Potential of the Southwest Pacific. Papua New Guinea, Solomon Islands, Vanuatu, Fiji*. East-West Center. July, 1991.

McNamara, C. *Environmental Management Plan for Proposed Brewery in Honiara*. Cameron McNamara Limited. July, 1990.

Morrison, R.J., M. Lam, M.R. Naqasima. *An Initial Study of Microbial Pollution of the Marine Environment Around Honiara, Solomon Islands.* INR Technical Report No. 90/3. Institute of Natural Resources, University of the South Pacific. April, 1990.

Solomon Islands Ministry of Natural Resources. *A National Environmental Management Strategy for Solomon Islands*. Ministry of Natural Resources. 1991.

Solomon Islands Statistic Office. *Statistical Bulletin (No.4/92). Primary Production-3rd Quarter 1990*. Honiara. Statistic Office. 1990.

Solomon Islands Statistic Office. *Statistical Bulletin (No.6/92). Tourism Statistic-4th Quarter 1991*. Honiara. Statistic Office. 1991.

Solomon Taiyo Limited. *Publicity Information Sheet*. Solomon Taiyo Limited Canned Product. Honiara, Solomon Islands: Solomon Taiyo Limited.

South Pacific Commission. *Sewage and Solid Waste Disposal Problem in Honiara and Other Provincial Urban Centres (Solomon Islands).* First Pacific Islands Environmental Health Conference: Mobilizing Resources for Effective Environmental Health Programmes. Noumea, New Caledonia, 19-23 August 1991.

UNEP. *Hazardous Waste Storage and Disposal in the South Pacific.* UNEP Regional Seas Reports and Studies No.48. South Pacific: UNEP, South Pacific Commission. 1984.

Wallis, I.G., Dr. *Assignment Report 6 to 21 December 1989. Marine Outfalls at Honiara and Gizo.* Honiara, Solomon Islands. December, 1989.

Tonga

Chester, R. Ph.D. *Pollution Sources Survey of the Kingdom of Tonga.* Tonga: South Pacific Regional Environmental Programme, South Pacific Commission. November, 1984.

Government of Tonga Statistic Department. *Statistical Abstract 1989.* Nuku'alofa, Tonga. June, 1991.

Prescott Fifita, N. *Current Status of Management of Hazardous Waste. Tonga: Country Report.* Tonga: Ministry of Lands Survey and Natural Resources. February, 1992.

United Nations, Economic and Social Commission for Asia and the Pacific. *Environmental Management Plan for the Kingdom of Tonga.* July, 1990.

Vanuatu

Abbott, M.A.W. *Hydrogeological Record No. 13: A Review of Water Quality Monitoring of Port Vila Harbour and the Erako Lagoons.* February,1991.

Cheney, C.S. *Technical Report WD/91/28R Hydrogeology Series.* Port Vila, Vanuatu: British Geological Survey. 1991.

Royds Garden Limited. *Port Vila Sewage Treatment Options Study, Final Report.* Port Vila, Vanuatu: Royds Garden Limited. March, 1992.

Sinclair Knight & Partners Pty. Ltd. *Report on Water Quality Improvements for Port Vila.* Port Vila, Vanuatu. World Bank, Gov. of Vanuatu. June, 1991.

Statistic Office, Port Vila. *Report on the Smallholder Agricultural Survey 1990.* Port Vila, Vanuatu: Department of Agriculture Livestock and Horticulture Port Vila, Office of Statistics Vanuatu. July, 1991.

Western Samoa

Anzdec Limited Consultants. *Land Resource Planning Study Western Samoa. Final Report.* Western Samoa: DSIR Division of Land and Soil Sciences. January, 1990.

Department of Trade, Commerce and Industry of Western Samoa. *Annual Report 1990.*

Division of Environment and Conservation, Department of Lands and Environment of Western Samoa. *Report of the UNDP Workshop on "New Challenges to Western Samoa's Environment".* Nov., 1990.

GKW Consult, Murray-North Partners Ltd., and G.M. Meredith & Ass. *Apia Water Supply and Sanitation Project. Phase III Master Plan for Sewerage and Storm Water Drainage Final Report.* Gov. of Samoa, Public Works Department Western Samoa.

UN DTEC. *Report on a Mission for Hydrology/Water Resources Assessment of Planning in Western Samoa.* 1983

United Nations Conference on Environment and Development Western Samoa. *National Report for United Nations Conference on Environment and Development Western Samoa.* August, 1991.

Taylor, L. *Western Samoa: An Investigation into the Sources and Regulations of Marine Pollution.* July, 1991

Western Samoa Department of Statistics and Department of Agriculture. *Report on the 1989 Census of Agriculture Western Samoa.* December, 1990.

Western Samoa Department of Statistics Apia. *Quarterly Statistical Bulletin 3rd and 4th Quarters July-December 1990.* Apia, Western Samoa. 1990.