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1. Background

1.1 General Approach

A systematic sampling methodology based on the qualitative and anecdotal information utilized by Montgomery Watson Harza (MWH) for the Initial Inventory on Persistent Organic (POPs) and Persistent Toxic Substances (PTS) for Samoa (2003) was also again used in this inventory. This methodology examined in detail geographical and environmental media applicable for determining POPs and PTS in Samoa

1.2 Qualitative and Anecdotal information

Major Sources of qualitative and anecdotal information included

1) MWH report "Preparation of an Initial Inventory of Persistent Organic Pollutants (POPs) and Persistent Toxic Substances (PTS) Presence, levels and Trends in humans and the Environment in Samoa"
2) Discussion with Project Coordinator, POPs (Bill Cable of PUMA,MNRE)
3) The SPREP publication "Management of Persistent Organic Pollutants in Pacific Island Countries" (SPREP)
4) Discussion with National Task Team
5) Workshops held with National stakeholders and National Task Team members.
6) Chemical inventories by companies dealing with chemicals in Samoa

1.3 Quantitative Sampling

From published and ad hoc information, various sites were identified as potentially or proven to be contaminated. Other potentially contaminated sites have been identified through their continued use as storage sites or through past association with POPs chemicals

Several sites and environmental media were selected for sampling for the purposes of providing some quantitative information for the inventory. The tools used for the sampling were similar to the approach used by MWH to ensure conformity to international scientific standards of repeatability and consistency.

The selection of sites for sampling was based on

- Information obtained on a range of sites suspected or known to be contaminated
- Soils, marine sediments, shellfish, water and animal fat as environmental media
- Potential presence of a range of individual contaminants, based on POPs/PTS known or suspected to have potential impacts within the selected media;
- Potential for adverse effects of contamination at the selected sites on human receptors, as well as the general environment.

From the analysis and based on the outcomes of the Independent Review of the Initial Inventory on POPs and PTS for Samoa (MNRE 2003), the following sites and environmental media were selected

- 6 soil sampling sites
- 8 animal (pig) fat samples from various villages around Upolu
- 10 human breast milk samples

1.4 Dioxin and Furan Questionnaire

In addition to POPs and PTS analysis, an extensive survey for the estimation of dioxins and furans emissions was undertaken through the employment of the "Standardized Toolkit for identification and quantification of dioxin and furans releases" as published by UNEP (2003).

2. Sampling Methodology

2.1 Scope of Sampling work Undertaken

2.1.1 Selected Environmental Media

The 3 environmental media selected (soil, animal fat and human breast milk) were considered essential in providing the missing information and completion of a broad cross-sectional view of POPs contamination in the environment and possibly human health. The possibility of human exposure to contaminants, and possible associated human health impacts was considered, and justified the inclusion human breast milk in the analysis.

2.2 Selected Determinands

The selection of determinands is based on information about the known or suspected historical and current use of POPs and PTS in Samoa. On this basis, the following determinands were chosen.

Pesticides: The widespread usage of pesticides in Samoa is well documented. Although the current ban on organo-chlorine pesticides expunges any recent contamination, the persistent nature of these chemicals in the soils and other biological media makes detection possible. Organo-nitrogen and Organo-phosphorous pesticides presence were also undertaken simultaneously.

Polychlorinated Biphenyls (PCB): PCBs use in electrical transformers in Samoa has been well documented. The bulk of PCBs have been identified in casings of obsolete electrical transformers that have been stored in various sites around Upolu and Savaii. Previous studies have identified PCB contamination in certain storage sites and the impact on soils by known or suspected spillages was investigated.

Timber Treatment Sites (PCP/CCA): Although PCP has been widely associated with timber treatment, limited or no information is available on its historical use in Samoa timber mill industries. More importantly the use of Copper, Chrome and Arsenic (CCA) in timber treatment mixture is eminent. Previous studies on a certain timber treatment site indicated the need for more extensive investigations to delineate the extent of contamination by CCA on this particular site.

2.3 Sampling Methodology

Sampling at known sites: Known and suspected contaminated sites were identified by previous work or anecdotally with the investigations at these sites aimed firmly at identifying the presence of contaminants and if possible delineating the spatial extent of contamination in each case, given that a defined boundary of the investigation area could be established. At these sites judgmental sampling was used. This method involved generally taking 5 to 6 samples per site particularly

around areas most likely to have been contaminated. Sometimes, site constraints meant fewer samples were obtained.

Sampling at Representative Plantations: There is ample evidence indicating widespread use of POPs-type pesticides in Samoa predominantly in rural areas. Constraints on resources negated the possibility of extensive investigation into all known and suspected sites of pesticide use. Previous surveys concluded that similar surveys were needed into other historical sites on Upolu and especially on Savaii to compose a national outlook on past usage on these sites considered most likely to be contaminated.

Identical methodology as those used by MWH in regards to plantation sampling area and sample numbers was engaged to enable data compatibility and comparison. This methodology ensured a 95% detection of a "hotspot" within a radius of 11.8m as defined by the New South Wales EPA sampling design guidelines.

2.4 Animal Tissue/ Human Breast Milk Sampling

The tendency for Organo-chlorines to bio-accumulate is a direct indicator of the possible impact on human health. Pig meat including fat is a very important part of the traditional Samoan diet. The prevalence in pig fat from various localities around the island would verify the widespread use and bio-accumulation property of these chemicals. This would also serve as an entry port for these chemicals into the next trophic level. Limited surveys by MWH called for more extensive and informative surveying of pig fat. To establish possible impact of these chemicals on human health, human breast milk was surveyed for POPs chemicals (in particular Organo-chlorine pesticides) as a direct indicator.

2.5 Sampling Methodology Details in Various Environmental Media

2.5.1 Soil

As stated earlier, the need for data comparison and compatibility necessitated the adoption of the sampling methodology as used by MWH with variation depending on site conditions. This strict sampling regime ensured accurate results and minimization of any potential sample cross contamination.

Samples were typically obtained using a stainless steel hand auger washed in Decon 90, rinsed in clean fresh water prior to collection of each sample. Samples were placed and sealed in 120 ml glass jars or 100 ml sterile plastic containers (head space eliminated) and kept chilled until transportation.
The target depth for each sample was between 350mm-400mm below existing ground surfaces. This depth was chosen to avoid any introduced covering layers or soil that is regularly disturbed but potentially shallow enough to be accessible to human exposure.

Whenever basement rock or impenetrable material was encountered within 350mm-400mm target depth range, the samples were collected from material that was available.

2.5.2 Animal Tissue and Human Breast Milk

Fatty tissue samples were collected from pigs sold to a local butchery in Apia. Information concerning owner, age of pig, village and conditions it was raised in was also recorded. The pigs were selected to give an even distribution across Upolu. One hundred grams of fatty tissue was collected from each pig, labeled, and frozen until analysis.

Mothers who were not more than 6 months post partum were selected for the study. In addition, the mothers were from various locations to give a broad cross sectional view of any possible organo-chlorine contamination. From each mother, 100ml of breast milk was collected and frozen until analysis. Detail of mother's age, village of residence, baby's age, mothers diet were all obtained using a standard questionnaire.

2.5.3 Transport of Samples

As per sampling methodology, identical conditions were used for transportation as required by Hills Laboratory, Hamilton, New Zealand. Samples were either frozen or chilled until ready for transportation by aircraft to New Zealand and delivered by courier to Hills Laboratory within 24 hours of leaving Samoa.

2.5.4 Sample Analysis

All analysis was carried out by R J Hill Laboratory of Hamilton New Zealand. The limits of detection varied depending on the sample weight and media analyzed. Soil samples were analyzed to a screen detection limit of 0.001-0.4mg/kg, animal tissue between 0.001-0.005mg/kg and breast milk between 0.001-0.09mg/kg.

2.6 Assessment of Contaminated sites

The need for a complete exposure pathway in order for persistent pollutants to pose as health risk has been elucidated by previous reports. This complete pathway consists of a contaminating source, a pathway or transport mechanism and a receptor. The main transport mechanism in human exposure is involuntary ingestion or inhalation of contaminants, dermal exposure or through direct contact with contaminated media or consumption of dietary components that have exposed to contaminants, e.g. pig meat, water, etc.

The means by which the receptor is exposed to contaminants can influence the acceptance criteria which specific guidelines set for that particular extent of exposure. Acceptable soil concentrations for a particular contaminant will differ between a commercial site where human exposure is limited to only working hours and those for a residential site where exposure is almost 24 hours.

Hence, various guidelines depending on the type of contaminant, environmental media detected in, transport mechanism and type of receptor were used. As acknowledged before, due to reasons of data compatibility and comparisons, reference guidelines used by MWH was used where appropriate

These included

- United States Protection Agency (USEPA) region 6 risk based human health screening values
- National Environmental Protection Measures for assessment of Site Contamination-1999 (NEPM)
- Canadian Environment Quality Guidelines (Canadian Council of Ministers of the Environment-1999)
- Health and Environmental Guidelines for Selected Timber Treatment Chemicals-1997
- Center for Food Safety and Applied Nutrition-1993
- New Zealand Food Safety Authority "Food Standards 2002"

The Results Section provides individual site reports, including tables listing the analytical results. Included in those tables for comparison reasons, are guideline values taken from relevant documents that

have been discussed before. Wherever possible at least two sets of guidelines have been included to show that various international agencies can sometimes view the health or environment impacts of certain contaminants in its own context.

Concentrations that exceed one of the guidelines that are listed in the results table are highlighted in bold font. The criterion for exceeding a guideline value is based on the most conservative or lowest value of the guidelines that have been included.

2.7 Assessment of Results and Reporting

Based on the comparison of analytical results with guidelines, a regime of general options for further action has been invoked and results for each site has been discussed as follows.

No further Action – indicated levels are so low that no significant human health risks or environmental effects can be realistically anticipated, based on this site investigation

Risk Assessment Required – Elevated contaminated concentrations at this site (while generally at or below guidelines) indicate that the context of exposure in terms of human or biota absorption pathways, and exposure time frames

Further Information Required – In some cases extra sampling would be valuable/and or more exposure data or other information is necessary before an action plan can be developed.

Remediation – Sites where data (include site observations) clearly indicate a quantified significant risk, with analytical results in excess of relevant guidelines, the outline of necessary remediation strategies, on a case-by-case basis is included in the site reports.

Before implementing any remedial actions, it must be noted that results of this study have been based on judgmental sampling methodologies and on a statistically limited number of samples per site.

The Results section (section 4) includes detailed descriptions, methodological variations, and results and discusses findings for each site. Tables of analytical results have only been included if contamination levels were found above limits of detection. All analytical results tables are included in the Appendix, presenting laboratory results as received.

The site reports are presented in such an order that places those where soil samples were analyzed first and then Pig and Human Breast Milk second.

Each site has been assigned a sequential number using the above general ordering system and the tables and site sketch plans use this number. For example 4.1 (William Arp Plantation) has table 1 and figure 1.

3. Independent Review of Initial Inventory

3.1 Introduction

The Planning and Urban Management Agency (PUMA) of the MNRE commissioned the consulting firm of MWH of New Zealand in 2002 to prepare an initial inventory of Persistent Organic Pollutants (POPs) and Persistent Toxic Substances (PTS) found in Samoa. The POP's inventory is a requirement for Samoa as a party to the Stockholm Convention on POPs it signed on 22 May 2001.

The study is part of a broader initiative - the POP's Enabling Activity project – which objective is:
"… to create sustainable capacity and ownership in Samoa to meet [Samoa's] obligations under the Stockholm Convention, including initial preparation of a POP's Implementation Plan, and broader issues of chemical safety and management… . The implementation plan describes how Samoa will meet its obligations under the Convention to phase out POP's sources and remediate POP's contaminated sites."

The inclusion of PTS in the study reflects PUMA's concern that the problems posed by substances strictly defined as true Persistent Organic Pollutants (POPs) is relatively limited, whereas a wider range of other substances categorized as Persistent Toxic Substances (PTS) have been used historically in Samoa and that detailed attention needs to be paid to its environmental effects as well. Thus the scope of the MWH Review is both POPs and PTS.

In July 2003, the Government of Samoa commissioned the Pacific Environment Consultants Ltd (PECL) to undertake the development of Samoa's National Implementation Plan (NIP) for POP's. One of the outputs of this assignment is to undertake a desk review the MWH Initial Inventory Report. This document constitutes that review.

3.2 Approach:

The following review looks at the methodology and findings of the MWH report. It discusses the basic approach adopted by MWH as well as makes comments on site selection and the results and interpretation of chemical analyses. The review also identifies gaps and makes recommendations of actions for addressing them.

As a desk exercise, the report draws on the expertise and personal experiences of the PECL team of consultants several of whom have direct experiences as users of various chemicals investigated in the study over many years, both in Samoa and in other countries.

3.3 Initial Inventory: objective and Scope

The objective of the MWH study was to develop an initial inventory which broadly scopes the environment of Samoa in terms of assessing POPs and PTS concentrations. Within this objective, the stated scope is to assess and quantify the 'presence, levels and trends of POPs and PTS in the Samoan environment.

3.4 Comments on the Initial Inventory Report

3.4.1 Comment on Methodology

The general approach is summed up in this statement of the report – [the study] involved "obtaining as wide a view as possible of POPs and PTS contamination across Samoa geographically and in selected media, and which would give the broadest environmental assessment".

MWH however is quick to point out that while the ideal of a 'wide as possible view' is desirable, due to constraints of time and money, MWH had to make some decisions on the levels of analytical precision, sites, and determinands. Bearing these constraints in mind, the following comments on the methodology used are made.

3.4.2 Alternative approaches - Limitations on the sources of information -

To prepare an initial inventory of POPs and PTS' presence, levels and trends in human and the environment in Samoa, MWH suggested as ideal the widest possible casting of the net. However, to be expected, the constraint of a limited budget restricts the geographical extensiveness of the sampling, and the range of environmental media. MWH took the next logical step of scoping the sampling to obtain an optimal geographical and media coverage. In this scoping exercise, it had to depend on information that was largely qualitative and anecdotal, and in many cases, resorted to what it called 'judgmental' sampling in deciding where best to sample. The level of precision in this methodology is an issue but in the context of the information and budget constraints faced, understandable.

This approach places the onus of determining the presence or absence of POPs and PTS in Samoa's environment depends significantly on the intensity of sampling – the greater the sampling intensity, the higher the likelihood of discovering the presence/absence of POPs and PTS. In this context, the limits imposed on the study by the budget take on significant dimensions. At best, therefore, results indicating presence or absence can only be considered provisional, pending more intensive (follow-up) studies. For the purpose of an initial inventory, one can argue that this is adequate.

PECL considers this approach less effective and the results inevitably needing more follow-up investigation. It suggests that for every POP or PTS, failure to detect the presence of any do not necessarily mean their absence from Samoa's environment, but that a statistically significant sampling is needed before a conclusive determination can be made.

3.4.3 The value of a historical inventory of POPs/PTS –

PECL considers that the methodology could have been made more precise had a historical inventory of PTS been compiled as a starting point. A historical inventory would have allowed the study to identify specific chemicals that were brought in and others that could be safely ignored and would have indicated what was brought into the country, its intended uses, possible users and sites of applications as well as active contents, importer details etc... Working off this information would have given the study better clarity and focus, with more time and resources to allocate to locating hotspots, more environmental media, as well as levels and trends of contamination.

The basis for this argument is simply that – other than furans and dioxins which are produced unintentionally through combustion – Samoa does not manufacture but imports all of its chemicals. A search for historical records of what was imported and a simple review of their active ingredients would have produced invaluable and conclusive data into what had been brought into the country and what to look for.

3.4.4 The historical inventory as a basis for estimating total POPs and PTS –

Both SPREP (2001) and MWH provided estimates of the total volume of POPs/PTS in the country. SPREP's estimated 150 tonnes, while MWH's was only 11 tonnes. The significant disparity raises more questions than answers, particularly with regards the basis for both calculations.

PECL considers that a historical inventory would have contributed significantly to coming up with a realistic estimation.

3.4.5 Comment on selection of sites

MWH collected sample specimens from 17 sites for soils, 5 sediment sites, two shellfish sites and 10 water sampling sites. In additional, a total of 8 pig fat samples were collected from various localities. Were adequate sites sampled? Was sampling sufficient at selected sites? Were the sites selected for investigation likely to be those contaminated?

MWH's statement of limitations accepts that the level of sampling is sub-optimal and a result of the budgetary constraints faced. The recommendation for additional sampling is therefore logical and to be expected.

Site selection by MWH was systematic to the extent allowed by the limited available information, and made practical sense. For instance, a basic level of stratification was applied – (1) known or suspected sites based on previous reports or anecdotal evidence, and (2) representative plantation sites. Sampling sites were not selected randomly but based on known and suspected sites identified in previous reports and through anecdotal information.

Given the fundamental approach used by MWH (and commented on previously) this basis for site selection is logical and hard to fault. Also given the preliminary nature implied in the way the output of the study is defined, i.e. an 'initial' inventory, there really is no minimum requirement below which the level of investigation may be deemed inadequate.

3.4.6 Comment on result of analyses

Based on the sampling and chemical analyses undertaken, MWH's initial inventory listed the following five POPs as present in Samoa –

- Chlordane
- Heptachlor
- Dieldrin
- DDT
- PCB

The following are some comments regarding the other POPs and PTS, based on the consultants experience and drawing on existing accepted knowledge in this field.

3.4.6.1 Aldrin -

MWH reported no aldrin was present in any media tested. In our view, the presence of dieldrin in one MWH sample suggest three possibilities – (1) the presence of aldrin, given that dieldrin is a by-product of aldrin, (2) just dieldrin itself or (3) both. This possibility is buoyed by anecdotal evidence that aldrin had been heavily use with dieldrin in banana plantations in the past in Samoa. This possibility was not mentioned by MWH.

Historically, DDT and dieldrin were the two POPs widely used in Samoa in the 1960s to 1980s. They were household chemicals for the control of banana pests. The discovery of DDT contamination in pig fats in the MHW report was not a surprise but is a major concern since pig consumption is fairly high in Samoa. We fully endorse MWH's recommendation for further sampling of pig fat to further ascertain the extent of this contamination.

3.4.6.2 Hexachlorobenzene -

Hexachlorobenzene was not present according to the MWH study but, according to our research, chemicals such as chlorothalonil (Bravo 50) and atrazine are generally known to contain impurities of HCB. Both Chlorothalonil (Bravo 50) and atrazine were reported in a SPREP study (SPREP, Jan. 2003) to have been used in Samoa. This possibility was neither discussed nor investigated by MWH.

3.4.6.3 Mirex -

Mirex, while more widely known as a termiticide, is commonly used in canisters of fire retardants for fire fighting in the United States. It is possible that it is in similar fire retardants being used by the local Fire Department. This possibility was not discussed.

3.4.6.4 Dioxins and Furans -

No direct analyses were conducted for dioxins and furans by MWH due to their 'almost prohibitive costs'. Instead MWH used 'marker' determinands to detect their likely presence, based on the premise that both PCBs and PCPs may contain low-level concentrations of dioxins and/or furans as by-product of original manufacture. Inevitably, because of the relatively low levels of PCPs detected, no other logical conclusion could be derived other than dioxins and/or furan levels are negligible.

It is an accepted scientific fact that dioxins and furans are generated via combustion into the atmosphere. PECL considers this ample grounds for shifting the focus from presence or absence of dioxins and furans, to estimating the levels of dioxins and furans generated in the country, which could be done by assessing the major sources of combustion in Samoa and using this information with reference to known values derived for dioxins and furans calculated for combustion sources in other countries (e.g. USA).

3.4.6.5 DDT/DDE -

The occurrence of DDT/DDE in 7 of the 8 pig fat samples is a concern. The 8 samples were collected without information of the conditions in which the animals were raised (in a sty or free roaming), which could determine the source of contamination (pig feed or foraging). Furthermore, the pig fat samples were gathered on Upolu and do not present a true distribution pattern of DDT/DDE levels in the foraging animals across Samoa. Additional sampling of pigs at sites across both islands would be a more reliable estimate of pesticide presence in food chain environmental vectors.

A more accurate estimate would involve the analysis of human fatty tissues or blood serum. PECL proposes that PUMA should consider this possibility.

3.4.6.6 Timber treatment site - Asau

MWH findings of excessive CCA contamination at the TVC-owned former Samoa Forest Corporation mill in Asau clearly designate this site as a hotspot for priority action. The serious threat to human health is well reflected in the comparisons drawn against US-EPA and New Zealand criteria. PECL however considers that sampling other media (especially pig fat) would have added significantly to the total picture, and should have been done in this case. This said, it is noted that the MWH report recommends further investigations at this site.

3.4.7 Comment on recommendations made by MWH –

The issue of how far along the food chain DDT contamination has progressed requires further investigation despite the relatively low level of contamination detected and reported by MWH. MWH's call for sampling of breastmilk is supported. It is also proposed that additional media of freshwater shrimps and eggs is considered.

PECL also proposed the following additional sites for investigation and sampling - the old Marist banana plantation at Alafua, the old Tanumalala banana plantation, the existing Agriculture Store banana plantation at Nuu, and Mr. William Arp's old banana plantation at Alafua.

The recommendations made above re further investigations into PTS should not detract from the initial point that POPs remain the priority. We believe that more investigation needs to be carried out to finalize the status of POP's absence, levels and trends of usage in Samoa.

3.5 Conclusions

Within the constraints of budget, information and time, the MWH report and its findings is the result of a systematic and scientifically sound investigation.

PECL considers however that the study would have been better focused and with greater clarity on the PTS and POPs being investigated had there been an effort to compile a historical inventory of what was imported over the years into the country.

The recommendation for further studies and investigation is a logical step given the limited sampling undertaken, and the need to investigate other environmental media.

While chemical analyses of collected samples revealed the presence of five out of twelve POPs, the possibility of the presence of aldrin, hexachlorobenzene (HCB), and mirex exists but was not investigated. The latter was not detected in two breast milk samples in Fiji (Aalbersberg, 2003).

While MWH's mandate may have been to investigate both POPs *and* PTS, considering the budget constraints, the inclusion of the latter clearly detracted from a more thorough investigation of POPs as the priority.

3.6 Recommendations

1. MWH's call for additional sampling is warranted to produce a definitive and comprehensive inventory. In addition to sites and environmental media proposed by the MWH report, and within the constraints of available resources, PECL proposes further investigations for DDT, dieldren and aldrin in the following sites –
    - old Marist banana plantation at Alafua,
    - the old Tanumalala banana plantation,
    - the existing Agriculture Store banana plantation at Nuu,
    - Mr. William Arp's old banana plantation at Alafua.

2. The possible presence of HCB and mirex in the various pathways indicated earlier should be looked into.

3. Assessment of dioxins and furans levels generated from selected combustion sources is recommended, including for existing incinerators at the Health Ministry.
4. Compiling a historical inventory of all POPs imported into the country as a basis for determining their volume used and disposal.

4. Site Assessment and Results

4.1 William Arp Residence/Old Banana Plantation

Site Description

William Arp's pesticide storage is located in Moamoa tai (Alafua). This residence/farm area is approximately 10 acres which contains a residential place approximately inland from the main road. The property slopes gently towards the east with the Alafua/Sinamoga river approximately 500m east of the property. Structures on the property include the Arp family residence, a vegetable garden adjacent to the main road, a traditional cook house which was constructed on top of the site of the old chemical storage shed stands about 10 meters behind the main residence towards the right hand side.

Most of the land was used for intensive farming of banana and cocoa in the past. Currently a fraction of the land is used for small scale farming of vegetables and banana, cocoa and coconuts but is predominantly uncultivated. There was reportedly a high use of Dieldrin and Aldrin in the banana plantation. There were also instances of accidental and intentional spills of these chemicals in the past resulting in destruction of the vegetation and crops although these sites could not be clearly identified. The old storage shed site which the cook house now stands on top was where chemical storage and mixing were done. The soils were of brown silty volcanic type.

Methodology

The most likely area which would be susceptible to contamination from the presence of pesticides at the Arp estate is the area on which the old storage shed was. This is now partially covered by the cook house although the area where much of the mixing of powdered product or the dilution of the concentrate was still exposed.

Five samples were collected at sites determined to be most likely contaminated (Table 1). Sample depth was 40 cm below surface. All soil samples were analyzed for organo-chlorine, organo-nitrogen and organo-phosphorous pesticides

Table 1: William Arp Old Banana Plantation Sampling Results

mg/kg	**MOA 1**	**MOA 2**	**MOA 3**	**MOA 4**	**MOA 5**	**USEPA**	**NEPM**
Depth (m)	40 cm	40 cm	40 cm	40 cm	40 cm		
Organo-chlorine Pesticides:							
2,4'– DDD	<0.01	<0.01	<0.01	<0.01	<0.01	2.4	200
4,4'– DDD	<0.01	<0.01	<0.01	<0.01	**0.02**		
2,4'– DDE	<0.01	<0.01	<0.01	<0.01	<0.01	1.7	
4,4' - DDE	**0.02**	<0.01	**0.02**	**0.01**	**0.02**		
2,4'– DDT	<0.01	<0.01	<0.01	<0.01	<0.01	1.7	
4,4'– DDT	**0.02**	<0.01	**0.01**	<0.01	<0.01		
Dieldrin	**0.02**	<0.01	**0.07**	**0.23**	<0.01	0.13	
Organo-nitrogen pesticides not detected							
Organo-phosphorous pesticides not detected							

Results

Analysis show elevated levels of DDT and its metabolites (DDD and DDE) in 4 of the 5 samples both although none exceeded guidelines for USEPA and NEPM for residential land use. Dieldrin was found in elevated amounts in 3 of the 5 samples and exceeded the USEPA guideline in the southeast corner.

Discussion

Analytical results show absence of both organo-phosphorous and organo-nitrogen pesticides, although subsurface samples show elevated levels of both Dieldrin and DDT and its metabolites. This supports the anecdotal information provided by the residents on the extensive use of DDT and Dieldrin on their banana plantation. As the guideline for dieldrin is exceeded, it is recommended that the residents of the property be notified of the laboratory results and made aware of the potential risks they might be exposed to especially with children on the estate. The low ratio of DDT to DDE as seen at the site suggests an exposure in the more distant past as reported by Radomski et al in 1971.

Further site specific investigations may be warranted especially in the areas of chemical spillage and remediation options include removal of material from the area of the old storage shed or covering the contaminated area with concrete. Due to the relatively close proximity of the Sinamoga/Alafua river it may be prudent to investigate the possibility of surface water contamination to determine possible risk to human health.

4.2 Agricultural Stores Corporation (Vaitele warehouse)

Site description

The following full site description has been adopted from the MWH report.
ASC warehouse is located in the industrial area of Vaitele. It is the supply warehouse for all local ASC outlets. The site includes a large building and a number of smaller purpose built structures. The main building is used to store agricultural supplies, including pesticides and other chemicals. The total area of the site is about 2500 square meters, with the actual stores building being approximately 375 square meters in area. The site is flat and secured on all boundaries by a 3 meter high fence. The gate is monitored during work hours and locked when it is not attended. Staff and designated visitors are the only people that have access to the site. Chickens range freely over the site. Inside the main warehouse are a variety of agricultural goods available for distribution to ASC retail outlets. At the rear of the building along the southern wall is a separate, smaller storage room that has a variety of old disused or damaged chemical containers in it. The floor of this store room is concrete. However the back wall, made of timber is old and in disrepair. At the back of the small store room is the remains of an old loading ramp. Soils are silty clay with some gravel.

Methodology

Previous field sampling by Morgan Watson and Harza in early 2003 significant levels of Chlordane and heptachlor which well exceeded guideline values for industrial properties in 2 of the 5 samples. One of the samples contained Heptachlor more than 240 times the USPA guideline value. Recommendations included securing this contaminated area to deny access by all workers and foraging animals. As part of the long term future management of the site, delineation of the extent and depth of the contamination particularly towards the east was recommended.

Together with members of the MNRE sampling was conducted in this contaminated area. On the south side of the main building the samples were taken at varying depths (0.35-1.5m) at 3 different sampling sites. The 3rd sample was taken at 0.35m due to presence of bedrock.

Table 2. ASC chemical storage Vaitele

mg/kg	ASCW3	ASCW 5	ASCW 6	USEPA	NEPM
Depth (m)	0.65	1.50	0.35		
Organo-chlorine Pesticides:					
Cis-chlordane	0.13	0.98	0.04		
Trans-chlordane	0.09	0.78	0.04		
Total Chlordane (cis+trans) x100/42	0.50	4.18	0.18	10	250
Heptachlor	0.03	<0.01	<0.01	0.79	50
Heptachlor epoxide	0.05	<0.01	<0.01		
No organo-phosphorous pesticides detected					
No organo-nitrogen pesticides detected					

Results

The results show presence of both forms of Chlordane in all 3 samples, Heptachlor and Heptachlor epoxide in ASCW 3 sample only although levels are far below those of both USEPA guidelines for both industrial outdoor worker without dermal contact and NEPM guidelines for commercial land use.

Discussion

The samples were collected at the depths of 1.50, 0.65 and 0.35m respectively for the 3 sampling sites on ASCW Vaitele. These depths were significantly deeper than those in the MWH report (0.37, 0.30, 0.34, 0.43 and 0.34m). Analysis of results by PECL and MNRE indicates that the gross contamination by Chlordane and Heptachlor in the upper levels of the soil profile is not seen in the deeper soils, rather the higher levels of contamination seems to be restricted in subsurface.

This finding suggests that the chemical nature of these pesticides limit their movement within the soil profile even over extended periods of time. Although leeching of these chemicals into the soils seems slow, it must also be brought to attention that this side of the building is highly susceptible to buildup of runoff rain water and may pose a concern as it may be an important exposure pathway for human and animals given the close proximity to the cook house as well as possible contamination of subsurface waters. These findings reinforce the concerns voiced earlier by MWH that since these pesticides are both environmentally persistent and potentially carcinogenic effective site management is essential in reducing these health risks. This would ideally constitute a plan for removing contaminated material.

4.3 Mulifanua Former WSTEC Plantation

Site Description

This former WESTEC plantation is located off the main west coast road on the eastern coast of Upolu. The access road is almost opposite the entrance to the Faleolo international airport terminal. The plantation is situated about 4 km inland and was a significant banana producing plantation up until the late 1970's-early1980's. The ground slopes gently towards the north with moderate to heavy vegetation. There are no known residences with in the plantation and it is dominated by coconut trees with a few remaining banana trees which the locals are know to use periodically. The soil type is dark brown silty clay mixed

with basalt gravel. Near the old processing shed, concrete or bedrock was intercepted at less than 40 cm below surface. With in the old plantation bedrock was intercepted at less than 1.0m below surface.

Methodology

7 sampling sites most likely to be have been contaminated by or areas of pesticide storage were selected around the plantation. The sampling sites were actually situated on and around the banana packing shed. This area also had storage areas for pesticides chemicals and soaking pit for banana suckers, although the caretaker could not pin point the exact spot due to abundant overgrowth.

Seven samples of subsurface soil were collected at both 40cm and 80 cm depths and analyzed for organo-phosphorous, organo-nitrogen and organo-chlorine pesticides. Site selection was based its historical use of organochlorine pesticides as it was a common practice before its ban in the early 1990's.

Results

No organo-phosphorous or organo-nitrogen pesticides were detected in all 6 samples. Dieldrin was detected at 0.06 mg/kg in only 1 of 6 samples (M3b1) this sample was taken within remnants of the old plantation at a depth of 40 cm. The detected levels do not exceed USEPA or NEPM guidelines for Industrial outdoor workers or commercial use respectively (0.13 and 50). This site was located about 20m NE of where the processing shed stood.

Discussion

Historically, Dieldrin and DDT were used extensively on old WESTEC banana plantations including Mulifanua, and results suggest relatively low concentrations of dieldrin persisting in the soil (M3b1). These levels do not pose any health risks but are in agreement with conclusions by MWH that although detected levels of organo-chlorine pesticides in old plantations are well below international guidelines there is a potential for greater concentrations at other sites.

4.4 Limited Government Partnership Samoa Forest Corp. (Asau)

Site Description

The following site description has been adopted from the MWH report.
The limited Government partnership Samoa Forest Corp. is a former timber treatment plant located on the north west coast of Savaii, just outside Asau village. A timber mill still operates on part of the site and is run by Tui Vaai Corporation. The site was chosen for investigation given its history of using copper/chromium/arsenic (CCA) concentrate to treat milled timber. The local ground conditions are believed to be a result of reclamation. The region around Asau subjected to recent lava flow, resulting in vast areas of barren volcanic rock. In such areas gravels of volcanic origin are laid down and then thinly covered with topsoil. These conditions were apparent at this site, as heavy gravels were intercepted at about 200mm below the surface.

The site is reasonably flat: however towards the east the topography is more undulating and is slowly being infilled with saw dust. There is no specific neighboring land use. The site is surrounded by thickly vegetated open space. There is small airport towards the west of the site and further west is Asau harbour (<1km). There is a small bulk fuel storage facility located between the harbor and the site. The extent of contamination at the timber treatment site was delineated by the poor condition of the chemical storage

tanks, the presence of a pressure treatment cylinder and from the extensive green staining observed around these structures. Large rust holes were observed in the storage tanks and the concrete bund around the pressure cylinder appeared to have been deliberately broken to allow the free discharge of collected storm water and/or chemical spills. Along the north side of the storage tanks, running east to west is a small drain/creek. At the time of sampling the creek was dry. There was significant rubbish and construction debris with in the channel.

The site is currently not fenced or secured in any way. It was noted that stock (cattle, pigs and chickens) had free range over the site. There was evidence that cattle have been directly adjacent to the contaminated site in recent times.

Methodology

Sampling methodology was based on the findings by MWH for the purposes of determining the extent of spatial contamination by copper, chromium and arsenic as previously reported. Five samples were collected (Table 3). Three were taken at with in 5m of the storage tanks at soil depths of 40cm or less due to presence of bedrock. Two were collected from the drain about 10 and 20m the from storage tanks. Both samples were taken from 80cm below the surface. Each of the samples was analyzed for CCA and organo-chloride, organo-phosphorous and organo-nitrogen pesticides.

Table 3. Limited Government Partnership Samoa Forest Corp. (Asau-CCA)

Sample number	Total Recoverable Arsenic (mg/kg dry weight)	Total Recoverable Chromium (mg/kg dry weight)	Total Recoverable Copper (mg/kg dry weight)
A1	**6380**	2850	4490
A2	**21400**	7520	**20700**
A3	**4090**	1800	3410
A4	**2990**	13500	**27000**
A5	**8100**	6530	**10800**
US EPA	380 (*2.4)*	100000	47000
NEPM	500	72500	5000
NZ Timber	500	860	NL

US EPA - Risk based screening levels - industrial outdoor worker without dermal contact;
NEPM - Commercial land use
NZ Timber - Health and Environment Guidelines for selected timber treatment chemicals
Arsenic 380 = non-cancer end point
2.4 = cancer end point

Results

All seven samples showed no signs of organo-chlorine, organo-phosphorous or organo-nitrogen contamination above detection limits. Therefore no tables for pesticides are included. No PCP or TCP residues were detected in the soils.

The tabulated results indicate extremely high levels of CCA in the sampled soils. Arsenic exceeded the NEPM and NZ timber guidelines by up to 16 times. Although Copper and Chromium levels were elevated they were still inside the guidelines and are not to be considered to be of a major health risk.

Discussion

The findings support those by MWH in that there were only trace amounts of PCP in the soil matrix. In response to one of the recommendations by MWH, the extent of contamination in the surrounding area of

the storage tanks was investigated. Samples A4 and A5 was approximately 10m and 20m from the storage tanks respectively and both samples were taken at approximately 1meter below subsurface. Both sites showed extremely high concentration of Copper and Arsenic suggesting leaching of these PTS into the soil at depths which could potentially affect the underlying water table and any surrounding water bodies. The higher values for A5 for both Chromium and Copper hints at possible long distance transportation in flowing streams possibly during release from tanks or storm water as A5 site was 20m from the storage tanks. As noted in the earlier report poultry and cattle were able to roam unhindered within the contaminated area which poses as health risk in the case these animals are slaughtered for consumption.

In summary, the area has ceased to be operational but there remains a significant risk especially to the underground water supplies and because of access of animals to the area a high risk for human contamination. Immediate remedial measures must be considered and implemented in the near future.

4.5 Pig Fat Animal Tissue

The tendency of POPs pesticides chemicals to persist in the environment has been documented in previous studies. Their ability to bio-accumulate has also been suggested and preliminary results by MWH indicate low levels of bio accumulation of DDT in pig fatty tissue samples. Although the levels detected did not exceed health guidelines, it poses a real concern that it could possibly exist in the food chain at much higher levels, even in humans. Pig meat is a major protein component of Samoan diet. Traditionally pork is eaten frequently and the larger the size of the animal the more culturally significant it is. Such animals are most likely to bio-accumulate organo-pesticides given the opportunity to roam free and forage.

The evaluation of health risks associated with pork meat consumption achieved by more extensive sampling of pig populations in Samoa and sampling at the top of the food chain i.e. Humans.

Methodology for Pig fatty tissue

Fatty tissue samples were collected from pigs which were sold to a local butchery in Apia. Information concerning owner, age of pig, village and conditions in it was raised was also recorded. The pigs were selected to give an even distribution across Upolu. Fatty tissue samples were collected from the pig labeled and frozen until analysis.

Table 4 - Animal fatty tissue analysis

No.	owner	village	Age months	Raised in Sty or free ranging	Organo-phosphorus Pesticides	Organo-nitrogen Pesticides	Organo-chlorine Pesticides
1	Asoleaga	Lotofaga	9	Roam free	None detected	None detected	None detected
2	Sanerivi	Saoluafata	7	Roam free			
3	Pio	Tafagamanu	9	Roam free			
4	Mu	Nuusuatia	8	Roam free			
5	Tiresa	Fausaga	7	Raised in sty			
6	Maá	Leulumoega	8	Roam free			
7	Faavae	Matautu (Lefaga)	8	Roam free			
8	Palepa	Aleisa	10	Roam free			Total PCB 0.06mg/kg

Results

Of the 8 Pig fatty tissue sample, one sample (no.8) showed elevated levels above detection levels for Polychlorinated Biphenyls (0.06mg/kg). No other organo-chloride, organo-nitrogen and organo-phosphorous pesticides were detected for all other samples.

Discussion

The primary route of exposure to PCBs in the general population appears to involve the consumption of contaminated foods, particularly meat, fish, and poultry. The pig meat sample (no. 8) taken from Aleisa show low levels of PCB (0.06mg/kg). This is well below the allowable daily intake set for PCBs by the Food and Agriculture Organization and the World Health Organization is 6 mg/kg per day.

Although PCB was not detected in the previous pig fatty tissue survey by MWH, PCB can be released into the environment from hazardous wastes, improper disposal of industrial of industrial wastes and consumer products, leaks from old transformers and burning of some wastes. In addition PCB do not readily break down in the environment and can travel long distances in air and can be deposited in areas far away from their release point and bind strongly to soil with half lives of some congeners half lives ranging from months to years with. They can travel up the food chain because they are readily taken up and stored in levels thousands of times higher than in water by small organisms and fish in water and thus taken up by other animals that eat these aquatic animals.

The presence of PCB in this single sample of pig meat highlights the ability of other POPs chemicals and not just pesticides like DDT to bio accumulate and create health risks. The route of uptake in this animal is unsure but taking into account the nature of PCB it most likely may have been through the soil or contaminated wastes containing PCB where it foraged. PC leeches extremely slowly as PCB translocation to plants from soil is insignificant.

Previous survey by MWH detected DDT in 7 out of 8 samples although none exceeded New Zealand Food Safety Authority Standards for total DTT concentrations in animal fat. Although the animals used in both surveys were from similar rural areas, the total absence of DTT and its isomers in the later survey by PECL may imply that DDT presence is not as widespread in its distribution across Samoa as first believed. This point can only be resolved by more vigorous sampling. More accurate recording of conditions under which the animals were raised is vital. Animals raised in a sty may be exposed to contaminated feed that might include food scraps of which were imported as food items. Other important missing information is age of the animals. It is generally accepted that the longer the life of the animal the more chance of exposure to organo-chlorine pesticides, the average life of the animals in the latter survey was 8.25 months. It can be argued that at the time of slaughter, there was insufficient time for bio-accumulation to exceed detectable levels.

It is noted that such information was missing in the MWH report; therefore both sets of data can only be compared to a certain extent and the extrapolation of results limited. The presence of DDT/DDE and PCB in pig fatty tissue in the two surveys clearly illustrates the danger humans face not only in direct exposure to PCB contaminated products but through the food chain.

4.6 Human breast milk

The bio accumulation of POPs chemicals in human breast milk is well documented. The persistence and bio magnification of these chemicals as it moves up the food chain is significant. As indicated in previous

results and studies by MWH foraging animals bio-accumulate these chemicals with human becoming the ultimate receptor.

Methodology

A sample size of 10 breastfeeding mothers was selected from around Upolu. A standard questionnaire (Annex 1) was filled for each mother and child before breast milk was collected for analysis (Table 5). All breast milk samples were frozen before shipment for analysis.

Results

Sample analysis show elevated levels of both DDE and DDT in all 10 breast milk samples with DDE levels significantly higher in proportion to DDT. Beta-Benzenehexachloride (BHC) levels were significantly higher in individuals 5 and 10 but were not detected in others. Elevated levels of PCB were seen in individuals 5, 6, 7, 9 and 10.

Analysis of DDT, DDE and DDD suggests that there is widespread contamination of human breast milk with organo-chlorine pesticides. This is consistent with human breast milk analysis in other countries, although levels found in Samoa are much lower than those reported values. More importantly the ratio of DDE to DDT is higher therefore indicating that the contamination is not recent.

Table 5 - Human Breast Milk Sampling Results

No.	**Village**	**Age (mother) Yrs**	**Age (baby) Months**	4,4'-DDE	4,4'-DDT	Total DDT Isomers	beta-BHC	Total PCB
1	Alafua	24	3	0.044	0.004	0.048	BDL	BDL
2	Malie	23	2	0.012	0.001	0.013	BDL	BDL
3	Siumu/Tiavi	23	4	0.005	0.001	0.006	BDL	BDL
4	Siusega	27	7	0.012	0.001	0.013	BDL	BDL
5	Letogo	31	2	0.074	0.010	0.084	0.0006	0.003
6	Lepea	19	1	0.042	0.003	0.045	BDL	0.001
7	Fasitoo-uta	22	2	0.107	0.020	0.132	BDL	0.001
8	Fagalii	36	4	0.011	0.002	0.013	BDL	BDL
9	Tuanai	22	4	0.083	0.007	0.090	BDL	0.003
10	Vaivase	25	2.5	0.101	0.017	0.121	0.0004	0.002

BDL (Beta BHC)= Below Detection Limits of 0.0002 mg/kg
BDL (PCB) = Below Detection Limits of 0.001 mg/kg

The discovery of beta-BHC in human breast milk samples is of concern, this finding clearly points to exposure to Lindane, which is primarily used as a pest control in lumber products. Fifty percent of the individuals sampled showed elevated levels of PCB, although levels indicated limited contamination, the presence of PCB at this level of the food chain should be of concern given that the sample size was limited. A comparison of Breast milk products from Fiji showed significantly higher levels of total DDT on average in Samoan women than their Fijian counterparts (0.0565 mg/kg versus 0.00137 mg/kg). These levels suggest gross exposure of Samoan women to DTT and its isomers. Although, no reasonable explanation can be made to elucidate this point, the difference reinforces the need for an international standard testing protocol for human breast milk products.

5. Dioxin and Furans Identification and Releases

Introduction:

As a Party to signing the Stockholm convention for Persistent Organic Pollutants, Samoa is obligated to reduce releases of poly-chlorinated dibenzo-p-dioxins (PCDD) and poly-chlorinated dibenzo-furans (PCDF) more commonly known as dioxins and furans. The two classes of compounds are of no commercial use but are by-products of combustion and industrial processes such as the production of pesticides, poly-vinyl chloride and other chemical substances. They are considered the most potent cancer causing chemicals known.

In assessing the need to carry out an expensive exercise of sampling for dioxin and furans in comparison to using the POPs Convention "Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases" as prepared by UNEP Chemicals (2003), several factors were reviewed. These include

- suspected low levels of dioxin and furan releases due to absence of heavy industrial manufacturing processes
- the cost effectiveness of the Toolkit compared to sampling
- using the results of the Toolkit to identify potential areas for targeted sampling if needed in the future

The option of field sampling later if results from the Toolkit analysis show areas of possibly high releases were proposed and approved by the NTT. This resulted in the Toolkit being used for assessing dioxin and furans in Samoa for the purposes of the NIP.

The benefits of the Toolkit are

- An effective methodology for identifying relevant industrial and non industrial processes releasing dioxins and furans to air, water, land, and with products and residues in a country and screening these to identify the most important ones
- Guidance on gathering information about the relevant processes, which enable classification of the processes into classes with similar emissions.
- A detailed data-base of emission factors which provides suitable default data to be applied which is representative of the class into which the processes have been grouped.
- Guidance on the assembly and presentation of an inventory using both the default emission factors and any country specific data so that the resulting inventories will be comparable.

Limitations :

Although the majority of inventories are available for industrialized and developed countries, a recent review of these inventories showed some inconsistencies and may not show new data or important changes in technology. Comparatively, little is known about processes and emission factors for processes and technologies in less developed countries. Although an inventory can provide valuable information on the magnitude of releases to each environmental media and in products or residues, it is not an accurate guide to the relative impact of these releases on human or ecosystem exposure since the fate of dioxins and furans varies from one release to another. Nevertheless, the Standardized Toolkit provides a universal methodology which compiles a comprehensive outlook on the dioxin and furan releases at the national level.

To adequately summarise the dioxin and furan releases in Samoa, the Toolkit provided a comprehensive process of collection and analyzing the data. Unfortunately, efforts to obtain the necessary data through interviews, site visits and the dioxin and furan workshop organized by the MNRE and PECL were only mildly successful in obtaining the necessary data. The prime reason for not receiving the data is that several of the Agencies, companies or organizations did not have the data available. Nevertheless, enough data for the crucial areas were collected to provide an overview of the releases.

Furthermore, a good amount of time was spent on understanding the Toolkit since the consultants undertaking the were not involved with the training provided on using the Toolkit, while the personnel trained were either relocated to other duties or not available to due to circumstances.

Compilation of Inventory

In compiling the data for the inventory, several approaches were used, which included

1. a distribution of the questionnaire from the Toolkit to several of the agencies,
2. site visits and interviews with several of the Companies and Agencies identified in the Toolkit as possible agents for releasing dioxin and furans
3. consultations with the rural villages of Satapuala, Malie, Vailele, Laulii and Faleapuna as sample communities
4. national workshop on dioxin and furans

The data collected from the questionnaires and surveys were used as the basis for filling in the inventory table. Furthermore, due to the limited knowledge of the consultants of the Toolkit, discussions with the POPs Project Coordinator (who attended the Toolkit Training) and several foreign experts on the Toolkit were used to verify some of the calculations and findings of the exercise.

Within the Toolkit, 10 categories as shown in Table 6 are identified as the Main Sources of production. Of the 10 categories, it was assessed 8 are relevant to Samoa, with only five having significant releases to be added for the calculation of annual releases. Of these,

- *Waste Incineration* from the Hospital and Quarantine incinerators were the main sources
- *Power generation and heating* is mostly from the use of firewood for either for umu or cooking, which averaged around 4.five kg per family per week in the rural areas
- *Transportation* mainly from the use of 2- and 4-stoke engines, along with diesel for vehicles and power generation.
- *Uncontrolled combustion processes* is mostly from accidental fires in the homes and forests along with burning of agricultural residue from gardens and yards around the homes were seen as the main sources of releases
- *Miscellaneous* the main sources are the tobacco consumptions and dry cleaning processes

The complete breakdown of the sub-categories and information used for the calculation of Table 6 are in Annex 2 and Annex 3.

Results

From the compiled information, the highest emissions were from waste incineration. Other significant sources of emissions include uncontrolled combustion as well as power generation, disposal and transport. The total dioxins and furans emissions for Samoa totaled about 1.4g TEQ/annum which approximately on a par with the nations of similar sizes and populations such as Brunei Darussalam, while it is very insignificant to other developing countries such as Uruguay (28gTEQ/a), and Jordan (142.2gTEQ/a).

Table 6: 2003 Annual Dioxin and Furan releases for Samoa

Cat.	Source Categories	Annual Releases (g TEQ/a)				
		Air	Water	Land	Products	Residue
1	Waste Incineration	0.797	0.000	0.000	0.000	0.000
2	Ferrous and Non-Ferrous Metal Production	0.000	0.000	0.000	0.000	0.0
3	Power Generation and Heating	0.009	0.000	0.000	0.000	0.0
4	Production of Mineral Products	0.000	0.000	0.000	0.000	0.0
5	Transportation	0.003	0.000	0.000	0.000	0.0
6	Uncontrolled Combustion Processes	0.245	0.000	0.020	0.000	0.180
7	Production of Chemicals and Consumer Goods	0.000	0.000	0.000	0.000	0.0
8	Miscellaneous	0.000	0.000	0.000	0.000	0.150
9	Disposal/Landfilling	0.000	0.000	0.000	0.000	0.000
10	Identification of Potential Hot-Spots					
1-9	**Total**	**1.1**	**0.0**	**0.0**	**0.0**	**0.3**

Discussion

The estimation of dioxins and furans releases revealed low levels of emissions. The absence of industrial production of dioxin and furans containing products and the low economic development status of Samoa helps in the keeping the emissions low. The high outputs shown in the table are attributed to low technology processes involved in waste incineration. Reduction of these emissions is possible through application of proper air pollution control technology. Conversely, the output from domestic cooking requires a different approach. Traditional cooking methods entail the use of natural uncontaminated wood for heating and cooking, alternatives for this source may prove expensive and culturally unacceptable. The practice of biomass burning as a means of waste disposal has more potential for change. National awareness programs on alternatives, Best Available Techniques and Best Environmental Practices may be the best approach to reduce emissions.

Caution is needed when interpreting these results. The default factors in the tool kit were derived using information and data from developed countries. Some or many of these may not be applicable to Samoa therefore require careful consideration especially when classifying processes.

With this in mind, the high values for biomass burning, domestic cooking could be a reflection of the priority given to other heating processes, with the above burning methods non-existent. Thus a critical review of the tool kit with respect to Small Island Developing States should be considered. Actual measurement of emissions could prove more appropriate, this would give a more accurate account of emissions and these emission factors can be used by other countries with similar or identical processes and practices.

6. Summary of Results and Conclusions

6.1 Introduction

The historical use of Organo-chloride Pesticides in Samoa until their banned use in the late 1980's and early 1990's is well documented. They represent one of the three groups of the banned 12 POPs chemicals targeted by the Stockholm Convention for reduction and elimination. The ease of access to these

chemicals combined with of lack of data on their impact on the environment and human health served to only help the widespread use and contamination of different environmental and biological media.

Previous studies by MWH extended their investigations into Persistent Toxic Substances (PTS) which was continued in the current study with the addition of a preliminary inventory for dioxins and furans releases. These PTS were mostly petroleum hydrocarbons (PAH etc.) and timber treatment formulations (PCP, CCA) and heavy metals although the use, disposal of these PTS were localized and confined except perhaps lead acid batteries disposed almost everywhere especially dumpsites.

The current study was a result of recommendations by the previous study by MWH in preparing an initial inventory for POPs and PTS for more extensive investigations in order to gather a more comprehensive view of the level contamination of the environment and biological media by POPs chemicals. .

Thus the objective of this report is to assess the level of contamination at various sites aiding the compilation of a national inventory for POPs presence, levels and trends in the environment and biological media. To achieve this task, expansion on previous studies by MWH was critical especially in areas where limited sampling was done. In addition, a more geographically diverse approach was adopted in order to be truly representative of the total Samoan natural environment.

6.2 Contamination by POPs Pesticides

In collaboration with results presented in the report by MWH titled "Preparation of an initial inventory for Persistent Organic Pollutants (POPs) and Persistent Toxic Substances (PTS) persistence, levels and trends in the environment in Samoa" the following conclusions have been drawn cautiously.

The widespread storage, use and disposal of pesticides in Samoa in the past 3-4 decades have resulted in extensive contamination of various environmental and biological media. These levels have generally been shown to be low when scored against international safety guidelines. Those that exceeded relevant guidelines were primarily due to mishandling or poor storage practices.

The Agriculture Store Corporation facility at Vaitele is of particular importance. Both studies indicated a high degree of Chlordane and Heptachlor outside the storage room and in the loading bay. The presence of a cook house in the immediate vicinity poses a health hazard to those using it. It has also been indicated that past management practices have been unsatisfactory and as of present no sound management protocols have been initiated.

Contamination of residential properties with POPs type pesticides is noteworthy as in two instances (Island Pest Control and William Arp) where pesticides were detected due to the close proximity of storage facilities to family homes.

The persistence of these POPs-type chemicals (although below guidelines) even after decades of discontinued use is evident (presence of DDT and Dieldrin at William Arp Estate). Current use and detection of Chlordane and Heptachlor in pesticides operations, exceeding the guidelines for residential places requires urgent attention to remedy the situation. In both cases human inhabitation of both areas exposes individuals and domesticated animals to potential contamination 24 hours. On this basis alone, immediate plans for management of the contaminated area is in order.

The issue of management and disposal of old Pesticide stocks (including POPs type pesticides) has already been reported by MWH in regards to Nu'u. As of present contingency plans have been formulated

for safe removal and disposal of obsolete POPs pesticides offshore and this presents an ideal opportunity for disposal of additional obsolete stocks e.g. ASC Vaitele and possibly unknown stocks (private importers).

The initial POPs and PTS inventory as prepared by MWH listed the old Samoa College plantation as the only one (out of 3) to contain significant residues of POPs pesticides (chlordane). Additional sampling was performed on the former WESTEC banana plantation which had been out of operation for the last 15 years. One out of six samples yielded low levels (0.06mg/kg) of dieldrin which did not exceed appropriate guidelines for commercial plantations.

Site visits and discussions with caretakers of Lata plantation on Savaii and did not produce any relevant information on past or present use of POPs pesticide on this establishment. Therefore no sampling was conducted.

Despite the low levels of these POPs pesticides at both Samoa college and former WESTEC plantation at Mulifanua, the status of soil contamination on national scale with respect to commercial plantations remains vague. Although POPs pesticide use has been discontinued, the historical and widespread use merits continued sampling of potential hot spots to establish a broad view of the presence and trends of pesticide contamination in the environment. The continued monitoring of the sites already known to be contaminated should so be considered especially when bearing in mind the possible interconnection between contamination of soils and domesticated foraging animals and other biological species.
Inconclusive evidence on contamination of other biological media such as shell fish reinforces the notion that POPs pesticides can be transported through other media and be deposited in terminal receptors (possibly human).

The human body being a terminal receptor for possible cross contamination from other contaminated sources is of utmost concern. The presence of DDT/DDE in analysis of pig fatty tissue by MWH is a clear indication of possible contamination through the food chain. Although the investigations did not ascertain the possible source of contamination, the fact that pig meat is a major source of protein in traditional Samoan diet, it poses as a vector in the passage of contamination into the human body. Polychlorinated Biphenyls (PCB) presence in 1 of 8 pig fatty tissue samples also highlights the ability of other POPs chemicals to bio-accumulate in the food chain.

These results corroborate with the survey findings on human breast milk. Random sampling of 10 breast feeding women revealed the prevalence of DDT/DDE (100%), PCB (50%), beta-BHC (20%) in breast milk. The ratios of DDT to DDE again indicate distant contamination, where beta-BHC suggests implies contamination by Lindane a popular pesticide and treatment for scabies.

It is not possible at this stage to pin point sources of contamination or limit them to pig meat. Thus the presence of three POPs chemicals in human breast milk reinforces the need for more comprehensive sampling to identify possible food chain vectors before any possible remedial plans may be implemented

6.3 Contamination by PCBs

Previous testing of soils around discarded or obsolete electrical transformers by MWH showed PCB residues for 1 sample in Savaii and in several samples at Vaitele although of low levels. Recent follow up studies at Salelologa EPC compound showed no positive results for PCB in all 5 soil samples taken from around discarded electrical transformers. As with POPs chemical stock piles, there are already plans for the proper disposal of these potentially hazardous equipment offshore. PCBs have also been detected in

pig fat and human breast milk as already been discussed above. The containment of contamination at known sites as well as denying access to both humans and foraging animals is of paramount importance now before the intended disposal program.

6.4 Estimation of Dioxins and Furans Releases

The prohibitively expensive costs of analyzing environmental media for levels of dioxins and furans is the major hurdle in compiling country data specific data for Samoa's inventory. Alternatively, the UNEP chemicals "Tool kit for the estimation of dioxins and furans releases" was used to compile an inventory for Samoa. Emission default factors were assigned to each process and a table was generated.

The most noted sources of emissions were waste incineration, biomass burning and power generation. In compliance with our obligations with regards to the Stockholm convention, every effort must be taken to utilize Best Environmental Practices (BEP) as already mentioned above. This might entail the adoption of more environmentally friendly technology or a change in behavior in terms of intentional biomass burning and overdependence on fossil fuel.

It must be noted that the table was generated with data available at the time of writing this document. When there is such a time when all the necessary data is made available, a more accurate inventory can be made available. Even more desirable is the production of country specific data through direct sampling and analysis of appropriate environmental media.

6.5 Contamination of sites with TPH

Three contaminated sites identified in the MWH report have different contamination levels. These sites are localized and contained and the main issue of concern is management of these contaminated areas. Therefore ongoing contamination is of little concern compared to the need to implement clean up activities by the management hierarchy responsible for each site. In that sense, an awareness program aimed those managing these sites seems to be the appropriate course of action.

6.6 Heavy Metals Presence in Sediments and Shellfish

The presence of heavy metals in shellfish and sediments above guidelines for safe aquatic habitats was revealed by MWH. Tri-butyl tin was also present in sediment samples. It is thought that the study by MWH, although comprehensive, a more representative picture of Samoa's aquatic environment could be obtained through more intensive sampling. These additional studies could help identify sources and pathways of contamination and delineate the extent of contamination.

7. Recommendations

It is clear that after the two studies that there are significant gaps necessary to compile a complete POPs inventory for Samoa. The historical widespread and extensive use of POPs type pesticides in the past was confirmed in these studies.

The impact on human health is well documented and analytical results confirm the presence of these chemicals in the food web at the highest level, which is of concern. Despite this finding, the available data in itself is not enough to formulate a national outlook on the presence, levels and trends for POPs chemicals in biological media. More data is needed in order to achieve this, both for pig fat and human

breast milk. In addition other typical food chain vectors should be investigated to determine possible sources of contamination. This may include

- Local and imported chicken
- Local and imported beef
- Imported mutton
- Local and imported (canned) fish

Furthermore, a more comprehensive sampling protocol such as the composite sampling protocol as recommended by WHO. Such an approach will allow the comparison of these study results with those from similar studies elsewhere.

The use of human breast milk illustrates the fact that humans are the terminal receptors for these chemicals and their levels present in or absence is a direct measure of their impact on human health. In this context human breast milk can be also used measure gauge other POPs chemicals such as dioxins and furans.

Admittedly there is much work needed for compilation of information and data for an accurate estimation of dioxins and furan emission in Samoa. More detailed assessment and identification of processes is required. Co-operation between agencies, stake holders and those responsible for data collation and inventory compilation needs to improve dramatically.

The predominant use of POPs type pesticides for decades has resulted in widespread contamination of soils including residential, commercial and industrial sites. The possible exposure of humans to contaminated soils for prolonged periods especially on residential properties together with the consumption animals foraging in these areas presents a major dilemma. Denial of access both human and animal to contaminated commercial and industrial areas should be seriously considered.

There is an immediate need to clean up contaminated residential properties because their frequency of use. These include the William Arp estate at Moamoa and Island Pest control at Vaivase.
Commercial and Industrial sites needing remedial clean up plans include

- ASC (Vaitele)
- TVC (Asau for CCA)

Monitoring of former plantations for levels of POPs pesticides must be continued on a regular basis to help determine their fate in the soil. Grossly contaminated sites should undergo similar clean up activities to other sites previously discussed. Further identification and investigation of potential hotspots is a requirement in compilation of an meaningful data on POPs type pesticides presence, levels and trends in soils in Samoa.

Introduction of proper management protocols for disposal of Total Petroleum Hydrocarbon for storage site such as Sogi is urgently required to prevent loss of mangrove habitats adjacent to these storage facilities in part due to contamination by PAH.

Similarly additional studies in the identification of Pesticide dump sites (such as those at Nu'u) and implementation of proper disposal procedure is a priority when considering the possibility of contamination of surface water and of leaching into the ground water supplies.

Specific site management plans for identified grossly contaminated areas should be prepared. The responsibility for development of these plans should rest with the site owners/occupiers with assistance from appropriate sources.

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Annex 1

QUESTIONNAIRE FOR MOTHERS (Breastmilk survey)

Biophysical Data (Mother)

1. Country: _____

2. District/Village: _____ _____

3. Sample Identification _____

4. Samples collected From: _____/ _____ /_____

   To: _____/ _____/ _____

5. Date Completed _____

6. Mothers Age _____

7. Mothers Height _____

8. Mothers pre-pregnancy weight _____

9. Mothers weight prior to delivery _____

10. Area of residence during last 5 years _____

11. Previous are of residence (list all) _____

Biophysical Data: (baby)

1. baby's age _____

2. baby's sex M / F

3. babys birth weight _____

4. Baby's weight on day of sampling _____

Lifestyle factors (mother)

1. Mother's dietary habits:
   a. Mixed diet
   b. Vegetarian but with mild and eggs
   c. Strictly vegetarian
   d. Other (explain) _____

2. Any changes of diet during pregnancy ? Y / N
   If yes please explain _____
3. How often does the mother eat fish
   a. Never
   b. Less than once a week
   c. Twice a week
   d. More than twice a week: if ticked please explain species of fish eaten

4. How often does the mother drink milk products:
   a. Never
   b. Less than once a week
   c. Twice a week
   d. More than twice a week: if ticked please explain species of fish eaten

Milk fat content ____ low fat _____ medium fat _____ high fat (full cream)

Consumption per day ____ half a cup _____ one cup _____ over one cup

5. How often does the mother eat cheese products
   a. Never
   b. less than once a week
   c. twice a week
   d. everyday

cheese content _____low fat _____ high fat

6. how often does the mother eat beef
   a. Never
   b. less than once a week
   c. twice a week
   d. more than twice a week

7. Current smoking habits
   a. non-smoker
   b. ex-smoker
   c. smoker, what is smoked _____ and how many per day _____

Environmental Data

1. Does the mother work? Y / N : if yes, please state where

2. Has mother ever worked in Asau village? Y /N

3. Have you ever used pesticides or insecticides (chemicals used to kill insects and other pests) Y /N

4. What type of water supply does your house have
   a. town supply
   b. roof collection/rain water
   c. private well or bore
   d. other: please specify _____

Is there any other information you would like to share

_____

Thanks you for answering these questions and for helping us with this study

Annex 2: Dioxin and Furan Inventory Survey

In conducting the inventory for dioxins and furans, the "Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases" was the basis for the information collection.

Methodology

To compile the data needed for the inventory, the consultants utilized the questionnaire provided in the Toolkit as the basis for information collection. To obtain the information, the tool kit was used to assess the possible organizations and companies which could contribute to the release of dioxin. Based on this information, the consultants than

- Conducted sites visits or phone interviews with the different company representatives using the Tool kit Questionnaire
- Visited and conducted interviews for rural communities in five villages taken as a random sample
- Conducted the national workshop on dioxin and furans in collaboration with PUMA of MNRE, in which additional information was collected from the participants either from additional data or through filling out the questionnaire
- The results were than reviewed by Experts that conducted the Pacific Regional Training on the use of the Toolkit

The Toolkit's main purpose is to estimate the average annual release to each vector (air water, land products and residues) for each process identified. The estimate can be calculated by the following equation:

Source Strength (dioxin emissions per year) = Emission factor x "Activity Rate"

The release of PCDD/PCDF (e.g. in ug I-TEQ) per unit feed of material processed or product produced (e.g. ton or liter) is referred to as the **Emission factor**

The amount of feed material processed or product produced (tons or liters per year) is referred to as the **Activity rate**

Dioxins and furans emission per year is calculated and presented in grams of toxic equivalents (TEQ) per year.

A 5 step standardized process to develop consistent and comparable inventories is listed below

1. Apply Screening Matrix to identify Main Source Categories
2. Check subcategories to identify existing activities and sources in the country
3. Gather detailed information on the processes and classify the processes into similar groups by applying a standard questionnaire
4. Quantify identified sources with default/measured emission factors
5. Apply nation-wide to establish full inventory and report results using guidance given in the standard form.

Using the first step for screening Main source categories and main release routes the following table was generated

Subcategories of Main Sources

With in each of the main sources there are subcategories, which establish the presence or absence of the activity in the country. Refer to the main dioxin and furans emissions inventory table for the details of subcategories for each main source and estimated emission for each process.

Table 5 - Main Source Categories and Subcategories

No	**Main Source Categories and Subcategories**	**Air**	**Water**	**Land**	**Product**	**Residue**
1	**Waste Incineration**	X				X
2	Ferrous and Non-ferrous metal production	X				X
3	**Power Generation and Heating**	X		X		X
4	Production of Mineral Products	X				X
5	**Transport**	X				
6	**Uncontrolled Combustion**	X	X	X		X
7	**Production and use of Chemicals and Consumer Goods**	X	X		X	X
8	**Miscellaneous**	X	X	X	X	X
9	**Disposal**	X	X	X		X
10	**Identification of Potential Hot-Spots**	registration only and site evaluation				

Note that the main categories in Bold are those which apply to Samoa**.**

Information Sources

Accurate detailed information on processes was gathered with respect to size and scale, (e.g. tons of waste burnt) and process information relevant for the assessment is gathered.
Data on the magnitude of activity in each category was collected from the following sources

- Ministry of Finance, including Statistics Division
- Ministry of Health
- Ministry of Police, Prisons and Fire Services (MPPFS)
- Ministry of Natural Resources and Environment
- Electric Power Corporation
- British American Tobacco Company
- Shell Oil Company /Petroleum Process Services
- BOC Gases
- Origin Energy
- Residents of the following Villages: Vailele, Laulii, Faleapuna, Malie, and Satapuala.

Some of the information needed from the following Agencies and private sector organizations could not be completed at the conclusion of the inventory

- Samoa Shipping Corporation (the amount of fuel used for boats and disposal methods of waste oil)
- Yazaki Samoa EDS (industrial processes such which releases dioxin and furans)
- Ministry of Agriculture, Forests, Fisheries and Meteorology, Quarantine Division (amount of rubbish burnt at the quarantine incinerator)
- Ministry of Natural Resources and Environment (estimates on extent of the 2003 Aopo forest fire, for which data is required from MPPFS above)
- Asphalt…

Process Classification and Source Quantification

Emissions from listed as sub categories can vary depending on process technology or operation. Each Class has a set of default emission factors provided.

Sources of Information and Figures

The emission figures shown in the table were calculated from information given through a standard questionnaire provided by the "Standard tool kit for the estimation of dioxin and furan releases" January 2001 draft. Alternatively, interviews with appropriate people were conducted to obtain data.
This information was collected from the relevant government agencies, industries or villagers.

1. Waste Incineration
The main waste incineration output is from the two Hospital incinerators at Motootua and Tuasivi. The Tuasivi Hospital incinerator is a Controlled-batch type with good air pollution system while the Motootua Hospital incinerator does not have any air pollution control.

The main rubbish dump at Tafaigata does not allow burning but the MNRE is currently working with the Ministry of Health to install a new incinerator at Tafaigata that will have a good air pollution control system to be used for all the Motootua hospital waste and other burnable wastes deposited at the Tafaigata dump.

The following data for the two medical waste incinerators was obtained and calculated as in the emissions table.

Motootua National Hospital
Medial wastes from wards and theatres = approximately 120 lbs per day is equivalent to 19,909 kg annually or 19.91 tons annually.
Type of incinerator = Low technology, no APCS.

Tuasivi Hospital
Medical wastes from wards and theatres = approximately 5 lbs per week an equivalent of 236kg annually or 0.236 tons per year
Type of incinerator = Controlled batch type with good APCS.

Quarantine Division (Ministry of Agriculture, Forestry, Fisheries and Meteorology (MAFFM)
No information was available from for their incinerator.

3 Power Generation and Heating

To obtain data for power generation and heating, the main power natural gas suppliers were interviewed with data collected on amounts imported and used annually. Additionally, several villages were also visited and interviews conducted with villagers as a sample to ascertain an estimated amount for domestic fuelwood burning.

The main source of information for energy production was gathered from the following departments, agencies and villages.

- BOC Gases, Vaitele – Liquid Petroleum Gas for Natural gas fired stoves. The data obtained was for the 12 month period ending December 2003. This figure represents the total Liquid Petroleum Gas imports into Samoa. Approximately 750 tons of LPG was imported into Samoa, This has a total heating value of 34.5 TJ.
- Sales figures for Kerosene used in domestic heating from January 2002-December 2002 equaled 12,301815 liters. This is equivalent to 10,456.54 tons. It is assumed that this figure represents total usage in domestic heating. There is no reference to use of aviation fuel.
- Residents of Satapuala, Malie, Vailele, Laulii and Faleapuna were interviewed for data on virgin wood/biomass stove. Data from the Statistics Department and from interviews with residents of above villages was used in the calculations below. These figures are as of December 2003 as per interviews conducted.
    - Number of house holds in Samoa = 25,000
    - Approximately two thirds of this number (16,500) live in rural areas and assuming use virgin wood daily (for cooking)
    - Mass of virgin wood/biomass used in stoves per week = 10 lbs or 236.36kgs per household per year
    - Total usage per year (tons) = 3,900 an equivalent of 54.6-74.1 TJ of heating value when applying the heating values for coconut shells and coconut husks (14-19MJ/kg). This result in a higher value of 0.0074 g TEQ (for 19MJ/kg) has been included in the table as a conservative estimate.

3 Minerals

Information for asphalt used were not obtained during the course of the survey

5. Transport

Figures used in this main source category were unleaded fuel for 4 stroke engines and diesel engines (for both vehicles and diesel power generators) for the period January 2002-December 2002. The sales records were obtained from Ministry of Finance, and Ministry of Works, Transport and Infrastructure. No reliable data could be obtained for sales of 2 stoke oil to assist in the estimation of the emissions from 2-stroke engines such as weed eaters, chainsaws etc.

For unleaded petrol use in 4 stroke engines the total sales volume for the above period equaled 26,141430 liters. An equivalent of 19344.66 tons

Diesel fuel used in motor vehicles and power generation equaled 33,369818 liters. An equivalent of 28,364.34 tons

6. Uncontrolled Combustion Processes

Forest fires are a regular occurrence in the vast vegetated areas of Samoa especially in Savaii. Although the last fire occurred in the later quarter of the year 2003 no data has been available for the quantification of dioxin and furans emission from this event at present.

Biomass burning of gardening wastes and in the field (plantations) is a common occurrence in Samoa. Information relating to these events is classified as agricultural residue burning. The figures are presented below.

- Assuming again those two thirds of total households (16,500) in Samoa regularly burn cuttings and field residues.
- Weight burnt per family = 5lbs or an equivalent of 1,950 tons annually (Samoa total).

Information collected through questionnaires from the Ministry of Police, Prisons and Fire Services enabled the emission calculations for accidental house fires.

During the period January-December 2003, four accidental house fires in which total contents of the buildings were totally destroyed. Two of which was a Mormon temple and the other a chocolate factory. These were considered significantly more important due to the diverse nature of the contents. The figures given are an approximation of burnt material without reference to type. It should be noted that the figure given might not be a true representation of an average year in which mostly residential houses are burnt. Furthermore, the final calculated value is a single indicative figure to cover all the accidental fires.

6. **Use of Chemicals**

Information was obtained for the import of 2,4-D butoxone in the past but not in 2003 when the information for the survey was used

8. Miscellaneous

British American Tobacco Company, Vaitele is the major cigarette producer in Samoa. Recently a new tobacco company was established and sales figures since its start of operations in the last few months have not been released. Similarly, sales figures for imported cigars are not available. Cigar smoking is restricted to a small fraction of the population and the numbers should be considered insignificant. The following production figures have been provided by British American Tobacco Company at Vaitele for the year ending December 2003. These represent both pre-rolled tobacco sticks and unrolled tobacco. In addition, all production is for the domestic market.

- Approximate number of cigarette sticks per ton = 1 million.
- Production total for 2003 = 154 tons or and equivalent of 154 million sticks

9 Land filling and Waste Disposal

Data previously collected for hazardous and non hazardous wastes from the Ministry of Health and Ministry of Works Transport and Industry was related to solid waste. The main waste disposal site at Tafaigata lacks liners or caps to control the infiltration of water. Therefore leachate and gases could not be collected and any related dioxin and furans emission could not be quantified.

Similarly, Samoa lacks a central sewerage system to collect domestic and industrial effluents. Instead the use of septic tanks for the collection of mainly human waste is prevalent. These septic tanks are periodically emptied and disposed of at Tafaigata with out further treatment in an open pit. Wastewater from other sources such as laundry wastewater, kitchen, showers, industrial effluent and storm water typically end up in a pit in the earth or into a nearby stream. Only a few industries and institutions are known to biologically treat their wastewater. Data for these few examples is not available.

10 Hot-spots

No hotspots were identified for for Samoa from the dioxin and furan inventory

Annex 4: List of People, Companies and Government Agencies Consulted (justified)

Sources of information for the compilation of the Dioxins and Furans emissions inventory

1) **Ministry of Finance**
   Treasury Department (Planning Division) - Litara Taulealo
   Ierome Paletasala
   Statistics Department (Human Resource Division) - Taiaopo Faumuina

2) **Ministry of Health**
   Biomedics Division (Motootua) - Penetekoso Tomane
   (Tuasivi) - Talalelei Suesue

3) **Ministry of Natural Resources and Environment**
   Project Coordinator POPs - Bill Cable
   Senior Waste Management Officer - Faafetai Sagapolutele

4) **Department of Police, Prisons and Fire Services**
   Senior fire officer - Uelese Lolo

5) **British American Tobacco Company**
   Environental Safety Officer - Tagaloa Elisara Gale

6) **A&A Laundromat and Dry Cleaning Services.**
   Proprietor - Pouono Tafiga

7) **BOC Gases**
   Chief Executive Officer - Maurice Fisher

8) **Electric Power Corporation**
   Savaii Manager - Tafu Leaoa
   Environment Officer, Tamaligi - Sale Faletolu

9) **Residents of the following villages -**

Vailele
Pati Lale
Tafua Namulau'ulu
Kalolo Vaai

Laulii
Failelei Pauga
Tominiko Leniu
Asotolu Faasoa

Faleapuna
Farani Molio'o
Valasi Fereti
Petelo Natia

Malie/Afega

Si'u Safiti
Sione Tulasunu'i
Toatolu Leafa

Satapuala

Filipo M
Uelese Uelese
Matauaina Kitiona