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South Pacific Regional Environment Programme

Environmental Impact Assessment Report

Augmentation Phase of Afulilo Hydro Power Scheme, Samoa

Prepared by **Komeri Onorio**
and **Bale Tamata** for
the Government of Samoa

Published by
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Contents

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EXECUTIVE SUMMARY

The Proposal

The Afulilo Hydro Power Augmentation Project was designed specifically to assist with the Upolu power system stability. Demand for energy has been growing in line with growth in maximum demand and, while the Afulilo scheme is producing more energy than anticipated, the sustainable energy outflow of the present scheme is limited by water inflows, reservoir storage volume and installed generation capacity. Because the Afulilo scheme is the only hydro scheme in Samoa with carry over storage, augmentation of the Afulilo scheme is particularly important to increase dry season capacity, to reduce the amount of installed diesel capacity, to reduce overall fuel consumption and to lessen the dry season peak in fuel consumption.

The Electric Power Corporation (EPC) of Samoa, having prepared and submitted the Afulilo augmentation project funding proposal for co-financing by the Asian Development Bank and the European Investment Bank, have requested (through the Samoan Ministry of Foreign Affairs) the South Pacific Regional Environment Programme (SPREP) for assistance with the environmental impact assessment of the proposed project. SPREP was able to accommodate this request by utilising its own in-house capability and hiring a technical consultant from the University of the South Pacific in Fiji, to undertake water quality studies and record noise measurements.

The proposed augmentation project will see installation of the third turbine engine at the Ta'elefaga station, the raising of the Afulilo dam to increase water storage capacity of Afulilo reservoir and the construction of an eastern diversion channel, behind Alafou village, to take advantage of additional surface run-off water in the locality, which will be channeled under gravity, into the reservoir. The augmentation project also include the installation of a new diesel generator at Tanugamanono station to assist with the Upolu system stability.

Main Impacts

All major components of this project have significant social impacts. The Alafou community will lose approximately 32 percent of its normal surface water drainage. This proposed canal will prove drastic to Alafou villagers whose main problem in the area is shortage of water supply. Fagaloa Bay, on the other hand, which receives the tailrace waters or the outflow from the trubine engines, have seen some fish species disappearing, especially shellfish. Continued inundation of beaches and reef flat and pools with silt particles and continued influx of freshwater into the sea may have caused the disappearance of these fish species (identified in the text of the report) but it is possible that because of the new flow regime into the bay, marine life growth may have changed also and or adapted to the new environment.

The raising of the dam height by 1.7 metres will increase the surface area of the Afulilo basin that will be inundated by water a further 19.4 hectares to a total maximum area of 270.4 hectares. It is considered that minimal impacts will be caused by the increase in the surface area of the reservoir as most places along the fringes of the basin have high bank walls but there are some low lying areas. The additional vegetation that will be under water is therefore also

mininmal. But, because there is additional vegetation that will contribute to the rotting vegetation at the bottom of the reservoir, the smell and coloration of the Afulilo water will continue for many more years to come.

The installation of a new diesel generator at the Tanugamanono power station will not have significant impacts on the already unacceptable environmental condition of diesel power generation. Currently, noise pollution and exhaust fumes are causing major concerns with the nearby households. Waste water and oil pollution from the powerstation have also caused concerns for the villagers down the valley and downstream of the powerstation.

Conclusion

The augmentation project is a particularly important phase of the Afulilo hydro power project to improve the efficiency of Upolu power supply. There are likely major impacts of the project that need to be addressed prior to the commencement of the project, some will require further studies to determine the likely effects.

The diversion canal will drain approximately 33 percent of surface water from the Alafou village area which already has water problems. The project must make sure the existing streams are not drained out completely as the villagers depend on the stream flow for their water supplies. Also once the stream beds and pools are allowed to dry out then all marine life dependent on this water supply will be affected and may be destroyed altogether. The Alafou villagers should be compensated for the loss of surface water and it is recommended that the project provides a simple but reliable water system for the village. Providing a reliable water source for the village might provide incentives during negotiations, for the villagers to give consent to the use of their land to lay the diversion canal.

The increased constant flow of fresh water at the Ta'elefaga tailrace into Fagaloa Bay could possibly have negative environmental effects on the marine communities, but these are difficult to predict in advance. There are already changes within Fagaloa Bay due to the Afulilo project, according to Ta'elefaga villagers, but again it is difficult to ascertain that the cause is entirely the result from the tailrace waters. It is therefore, recommended that an environmental audit of Fagaloa Bay be undertaken prior to the commencement of the augmentation project to provide the current environmental status, and thus record baseline data, of the bay to better determine the likely impacts of the project. The Fisheries Division together with the Department of Environment and Conservation could undertake this task and also design a follow up post commissioning monitoring programme. The fisheries and marine study at Fagaloa Bay should take priority over the proposed government's fish stocking of Afulilo reservoir with exotic species.

Recent studies have considered the operation of the Tanugamanono powerstation to be increasingly non-viable as a major diesel generating facility. This environmental assessment study identified that proper disposal mechanisms for waste oil and water have not been operated adequately. There are very high levels of noise and exhaust fumes pollution to the nearby households which are unfortunately, very close to the powerstation. The installation of another diesel generator is considered to cause minimal impacts depending on how the Tanugamanono powerstation structured some improvement schemes prior to the new installation. The waste oil reduction plant should be operated efficiently and an efficient waste oil collection and disposal system should be implemented immediately. The noise pollution can be abated by installing a new silencer with an efficiency to reduce exhaust noise to approximately 45 decibels at the boundary fence. The height of the fume stack should be raised to ensure the exhaust fumes are dispersed at a much higher level than the roof tops of nearby houses.

GLOSSARY

The following explanations are provided for the lay reader. They are not intended to be scientifically precise.

Algae	Very simple plants
Anaerobic	Lacking in oxygen
DAFF	Department of Agriculture, Forestry and Fisheries
dBA	The average loudness of a noise source (measured in decibels)
DEC	Department of Environment and Conservation
DO	Dissolved Oxygen (measured in milligrams per litre)
EIA	Environmental Impact Assessment
EPC	Electric Power Corporation of Samoa
Fauna	Animals
Floc	A flocculent mass of fine particles
Flora	Plants
GIS	Geographic Information Systems
GWh	Giga Watt hour, a measure of the total power produced over a period of time, 1000 megawatt hours
Montane	Occurring in mountains
MW	Mega Watt, a unit of power, 1000 kilo watts
Ogee Arch	An arch with two ogee curves meeting at the apex
pH	A measure of acidity and alkalinity, a scale from 0 (most acid) to 14 (most alkaline)
ppm	Parts per million, one ppm = one gram per cubic metre
Salinity	A measure of saltiness
SL	Sea level height, normally calculated as height from the mean sea level
SPREP	South Pacific Regional Environment Programme
Tailrace	Canal leading the tailrace waters from the turbine engines
Turbidity	Cloudiness in the water
USP	University of the South Pacific

1 INTRODUCTION

1.1 The Project

The Afulilo Hydro Electric Power Development began in 1991. The construction work took about two years until March 1993, when the dam was closed and the reservoir began filling. The Afulilo scheme is a hydro electric storage scheme, it has an installed capacity of 4MW. The dam was built to a sea level height (SL) of SL 317.50 metres, the full supply level, which would hold 10 million cubic metres of water storage which would allow, with good management, maintenance of 4MW output throughout the dry season. The dam has been spilling intermittently from late December 1993 therefore, there is potential for continued steady and or enhanced output at the Ta'elefaga power plant to supplement diesel power generation.

Tanugamanono power station near Apia, provides an installed diesel power capacity of approximately 11MW. Due to age and technical factors, the diesel generators have been down-rated and as a consequence, the station capacity is currently about 8.7MW. The Upolu electricity system has a maximum generating capability of approximately 8MW of diesel and about 12MW from the five hydro power plants. The output of the hydro power schemes though is seasonal, resulting in total hydropower generation peak capability dropping from a wet season high of approximately 11.5MW to about 6MW in the dry season. The Afulilo storage scheme provides most of this capacity during the dry season. Consequently, diesel generation needs to be increased in the dry season to make up for the deficit in hydro power production.

The proposed augmentation project of the Afulilo hydro power scheme consist of the following:

i) installation of a third 2 MW hydroelectric turbine at Ta'elefaga power station;

ii) raising the Afulilo dam by 1.7 metres;

iii) construction of an eastern diversion canal to divert more water into the Afulilo reservoir; and

iv) installation of a new 4 MW diesel generator at the Tanugamanono diesel power plant.

1.2 EIA Brief

The South Pacific Regional Environment Programme responded to a request from the Ministry of Foreign Affairs of Samoa, to assist in the preparation of an Environmental Impact Assessment (EIA) of the Afulilo Hydropower Augmentation Project. The terms of reference for this EIA are:

A *With regard to the existing Afulilo hydropower scheme*

1. Review the recommendations set out in the EIA report of 1991
2. Determine any outstanding issues that need to be addressed
3. Provide a proposal for mitigating measures if required

B With regard to the Afulilo Augmentation project

1. Determine the effects of the increased surface area of the Afulilo reservoir with the raising of the dam
2. Consider additional noise at the Ta'elefaga power station with the third turbine to be installed
3. Determine the additional overflow of water into Fagaloa Bay resulting from the installation of the third turbine
4. Determine the effect of water being diverted away from natural water courses into the reservoir

C With regard to the proposed new diesel generator

1. Determine the additional noise to surrounding villages
2. Consider water and lubrication oil separation and treatment
3. Address any discharge and seepage that may occur from the generator
4. Consider exhaust emissions
5. Consider impact of the cooling systems utilising water systems
6. Consider fuel storage for the generator
7. Provide a proposal for additional mitigating measures if required

This EIA document is intended as an aid to decision making on the augmentation phase of the Afulilo scheme. It presents summary information to better understand the effects of the scheme and make recommendations on actions which could be taken to reduce the impacts.

The report reviews both the effects of the scheme, and an earlier environmental assessment carried out by Waugh *et al* in 1991 prior to the construction of the Afulilo scheme. The report incorporates material from field investigations conducted by the authors in May and July 1997, but extensive use is also made of materials drawn from the Afulilo augmentation and inception documents, the corporate strengthening reports, and the Waugh assessment.

1.3 Background

The country of Western Samoa, now called Samoa, depend on biomass for about 65 percent of its energy needs and on petroleum imports and electricity generation for its commercial energy requirements. Petroleum products account for one third of energy usage and hydro electricity generation makes up the remaining balance of two percent. Samoa have no known petroleum reserves and its relatively substantial hydropower resources are constrained by low dry season capability and limited storage availability.

The responsibility for public electric power generation, distribution and sale of electricity in Samoa rests with the Electric Power Corporation which was established under the EPC Act of 1972,

and is wholly government owned. It is governed by a Board chaired by the Minister of Public Works. EPC is managed by a General Manager, a Deputy General Manager, a Development Engineer and a Generation Engineer.

In Upolu, EPC operates the largest power system which in March 1997, consists of:

- »12MW installed Hydro Plant (4MW long-term storage and 8MW run of river)
- »8MW installed Diesel Plant (down rated from 11MW).

Much of the diesel plant is derated due to age and mechanical restrictions, and will be retired progressively in the near future. With the exception of the Afulilo storage scheme, Upolu hydro generation is highly seasonal and additional firm energy capacity is urgently required. Peak power demand for the Upolu system in December 1996, was 12MW and energy generation for the year was 69 GWh.

There has been a significant increase in power demand in the Upolu system. Developments associated with Yasaki expansion of its electrical wiring assembly plant, signing of memorandum of understanding for the establishment of an international class hotel at Lotofaga and a possible tuna cannery indicated that the load growth would be higher than previously estimated at five percent per annum.

1.4 Review of Recommendations of the 1991 EIA Report

The various issues of the Afulilo scheme highlighted in the Waugh environmental assessment report have been addressed with varying degrees of success, the main areas of concern are discussed here.

1.4.1 The Vaipu Scheme

The Afulilo hydro scheme was designed and constructed with provisions for the additional water available from the Vaipu swamp area. The intention was to install this third turbine machine when the load had grown sufficiently and that the Vaipu scheme was developed.

The environmental assessment report noted that formation of the ponding area is destroying the Punataemo'o swamp which was one of the most important natural areas remaining on Upolu. The only other such area in Samoa is the Vaipu (Fusiluaga) swamp immediately downstream. Future extension of the Afulilo scheme suggested pumping water from the outflow of the Vaipu into the headrace conduit. The report considered that the proposed Vaipu extension will result in a great loss of the last large montane wetland in Samoa. The report also weighed the loss of the Vaipu swamp to be a very high price to pay for the relatively small gain in extra power generating capacity.

The strong recommendation made were: serious consideration of the natural values of the Vaipu swamp is discussed before a decision is made on the Vaipu scheme; that no work be permitted in the Vaipu swamp; that the DEC secure long-term protection of the Vaipu swamp; and that DEC conducts an inventory of flora and fauna of the Punataemo'o basin (Afulilo scheme) before these populations are destroyed.

The EIA report plus other documented concerns, have successfully influenced the decision makers to abandon the Vaipu scheme proposal. The Afulilo augmentation project is now considering, and will be discussed in depth later in the next chapter, an eastern diversion canal which would bring more water into the

2 THE AFULILO AUGMENTATION PROJECT

2.1 Raising the Afulilo Dam

The surface drainage into the Afulilo reservoir has surpassed expectation and has resulted in the dam overflowing intermittently during 1993 to 1996. The reservoir (see Figure 1) and the whole Afulilo hydropower scheme was initially established to supply power during the dry season when the run-on-river systems were affected by low water flow in the rivers. However, the reservoir level has been sufficiently high that the Afulilo hydropower scheme has been used continuously since it began operating in March 1993. The potential for much larger volumes of water draining into Afulilo reservoir than is currently catered for has prompted the need to raise the dam. According to Mr M. Nation water lost over the dam wall is lost power resources and lost revenue to the Electric Power Commission.

The actual specification for the increase in dam wall height was determined after examining of a range of options. The Project Feasibility Study identified the best option as that of raising the dam spillway crest level by 1.7 metres to SL 319.2 metres. This new sea level height will increase the Afulilo storage volume from 10 million cubic metres to 15 million cubic metres, i.e. an increase of 50 percent. Raising the crest is accomplished with a reinforced concrete ogee crest extension that is joined onto the existing crest. The bridge deck will be raised by 0.5 metres to SL 320.9 metres which would represent a flood event with an annual event probability of 1 in 10,000 year design flood. The potential effects of such an increase on the surface area of the reservoir is one of the environmental concerns for the Afulilo augmentation project. Figure 2 shows the new surface area of the reservoir.

2.2 Installation of third turbine at Ta'elefaga Power Station

Currently, there are two turbines operating at the Ta'elefaga Power Station. However, there is already basement and tailrace outlet for a third turbine. Having three turbines allows, any one of the turbines to be taken off-line for maintenance, and for other reasons, without disrupting the scheme operation. At the same time, the option of having all three turbines operating is always available and whenever the need arises. It is most likely that all three turbines will be run full time.

Installation of the third turbine at the Ta'elefaga Power Station has implications for the environment. Noise pollution levels may increase from the current levels if all three turbines are in use. Additional volume of fresh water would be discharged at the tailrace and this would affect the stream flow, water quality conditions in the stream, and Fagaloa Bay.

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The EIA report plus other documented concerns, have successfully influenced the decision makers to abandon the Vaipu scheme proposal. The Afulilo augmentation project is now considering, and will be discussed in depth later in the next chapter, an eastern diversion canal which would bring more water into the

reservoir by gravity-feed, from the southern and eastern areas of the Afulilo catchment. There is some documentation of the plant and animal species population of the Punataemo'o basin prior to its inundation. The major management decision on the protection of Vaipu swamp include the whole Lona-Punataemo'o area has already been initiated with several conservation studies currently being conducted by DEC and SPREP.

1.4.2 Exotic species

The only lake weed present in Samoa capable of seriously affecting the operation of the hydro scheme is water hyacinth. This exotic water plant is not found in the Afulilo area and EPC is monitoring its spread to ensure it does not affect the hydro scheme.

It has been suggested that the reservoir be used for aquaculture. The environmental assessment report recommends that exotic fish is not to be introduced into the Afulilo basin. This is because any introduced species in Afulilo basin is bound to find its way through over-spillage at the dam, to the Vaipu basin downstream. There is the concern that Vaipu basin may be one of the few areas remaining in Samoa which is free of introduced fish species and therefore, the need to protect this and surrounding areas from exotic fisheries.

During mid-1996 the Fisheries Division conducted various water quality tests in the Afulilo reservoir for the purpose of fish farming and stocking of a Thailand strain (Chitralada) of the Nile Tilapia, *Oreochromis niloticus,* which was introduced to Samoa in 1991. This exotic species was to help remove and/or improve the strain of the "rubbish fish" African Tilapia, *Orechromis mossambica,* which was introduced during the 1960s (Zann, 1992). The Matsunaga and Bell, 1996 report on "Potential of Afulilo Reservoir for Fish Stocking" gave no indication that initial trials with sterile fish will be conducted. The Fisheries Division has conducted trials of the new strand of Tilapia since 1991 in various areas of Samoa and therefore, probably felt it unnecessary to direct another trial at Afulilo. Nevertheless, it is important that Fisheries Division undertake first, a full EIA of Tilapia farming in Afulilo reservoir to better understand the likely effects this proposal will have on the surrounding environment.

1.4.3 Ta'elefaga operation

The generators for the hydro power scheme are located in Ta'elefaga village. Noise levels were not recorded to determine the acceptable standards (there is no noise standard in Samoa). However, the EPC's operating procedure at the Ta'elefaga power plant is to close the sliding door during night time in order to minimise noise levels to the nearby houses. This noise abatement procedure appears to be working satisfactorily.

Water from the powerhouse is discharging into the stream which flows through the Ta'elefaga village. The amount involved is substantially more than the natural low flow of the stream. Most of the time, the water is discoloured and has an unpleasant smell. The villagers were not made aware of these likely changes at the early stages of the hydro power scheme. There was a fatal accident of a small boy being washed down the stream and drowned in the bay. The stream sides are now fenced off to avoid similar incidents, but the increased water flow is causing frequent overflowing onto the bridge and still poses danger for villagers crossing. Upgrading this bridge should be undertaken by the proper authorities as a matter of urgency.

The clarity of the water is still regarded as "dirty" by the villagers (see record of village meeting at Annex 1). There has been a "promise" by EPC to build a

swimming/washing area above the tailrace, using the normal stream flow. It is recommended that this is undertaken by EPC prior to the commencement of the augmentation project. It is also recommended that serious consideration be given to providing a holding pond to divert the tailrace flow to settle sediments and other particles, prior to discharge into Fagaloa Bay. The holding pond can be cleaned out periodically and should help reduce the inundation of the reef flat and pools with silt particles but, also limit the extent of the plume within Fagaloa Bay.

1.4.4 Social impacts

The Afulilo scheme has significant social effects particularly to the Ta'elefaga village communities hosting the powerhouse with its discharge of tailrace water into the stream in the middle of the village and flowing down into Fagaloa Bay. From the village meeting held on 28 May 1997, there appears to have been little consultation with the villagers by EPC on the proposed Afulilo project, and its potential effects on the marine resources around Fagaloa Bay. At least no documented evidence of a consultative process is available. Even the Waugh environmental assessment report provides no records of meetings with Ta'elefaga villagers which probably explains the lack of consideration for social impact monitoring in the 1991 report.

Public consultation is crucial for this important project. EPC should conduct a public meeting with the villagers prior to the commencement of the Afulilo augmentation project. Even if EPC did not acquire anything new from that meeting, the exercise should foster goodwill and support of the project by the villagers.

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2.2 Installation of third turbine at Ta'elefaga Power Station

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Installation of the third turbine at the Ta'elefaga Power Station has implications for the environment. Noise pollution levels may increase from the current levels if all three turbines are in use. Additional volume of fresh water would be discharged at the tailrace and this would affect the stream flow, water quality conditions in the stream, and Fagaloa Bay.

2.3 Diversion of surface water into the Afulilo Reservoir

Diversion of water from natural waterways into reservoirs for the purpose of generating hydropower is a common phenomena. However, the effects of diverting water away from existing uses and users must be clearly identified and assessed.

A number of diversion canal options were identified but, the options were narrowed down to the East Canal only because of concerns with the geology and topography of the other potential sites. The East Canal, shown in Figure 3, will divert run-off from the northern slopes of range extending east from Mt Savai'i. The proposed canal would intercept several prominent surface streams, at the foot of the ranges, and could produce an estimated 35 percent in yield for the Afulilo storage.

2.4 Installation of new 4MW diesel generator at the Tanugamanono Power station

The Tanugamanono diesel generation plant has five generators of approximately 8MW down-rated capacity currently in use. One of the generators has been out of service for a long time and must be replaced. The new diesel generator being proposed under the augmentation project will replace the old one.

Figure 1: Afulilo Reservoir (317.50 msl)

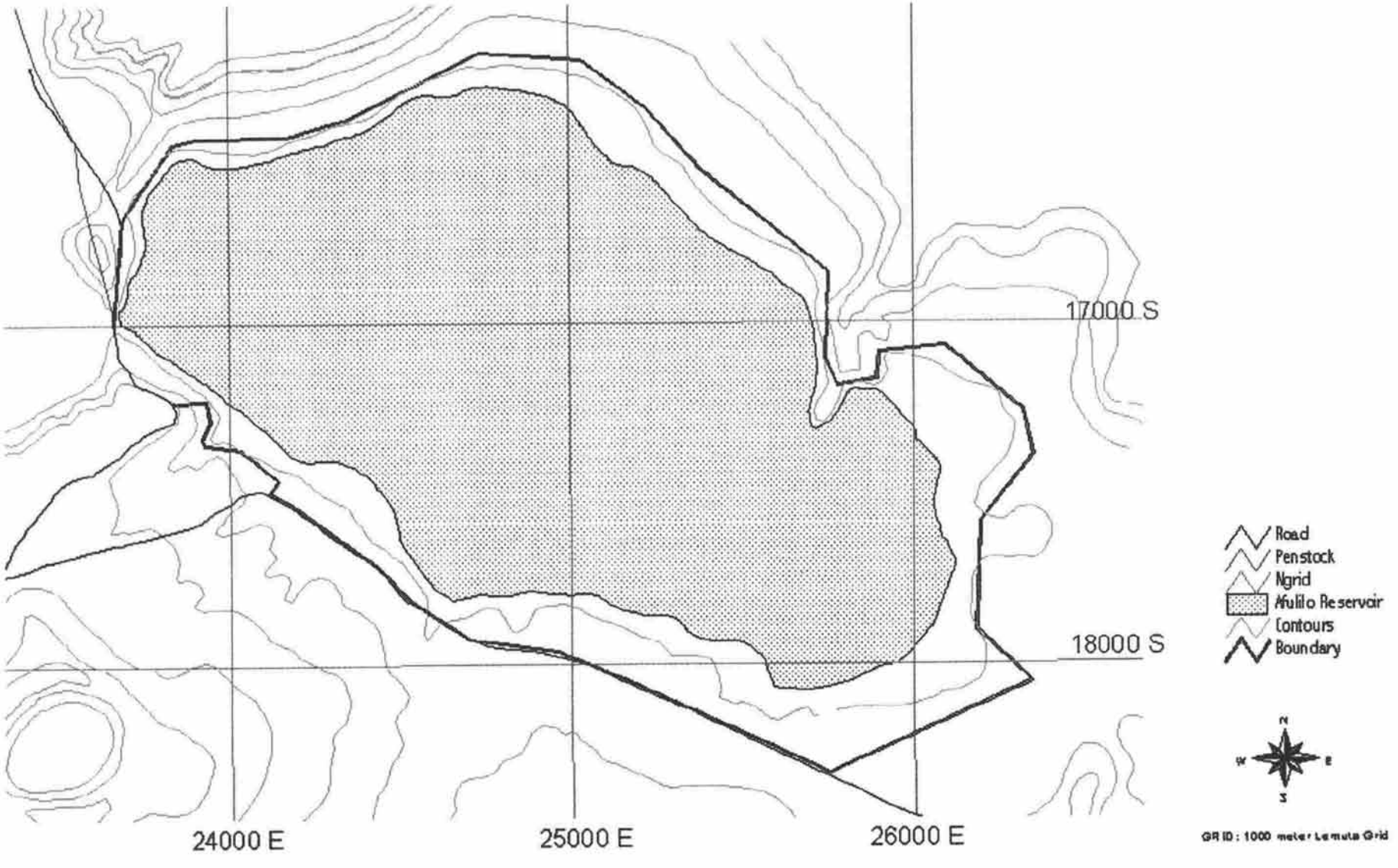


Figure 2: Afulilo Reservoir (change in surface area at 319.20 msl)

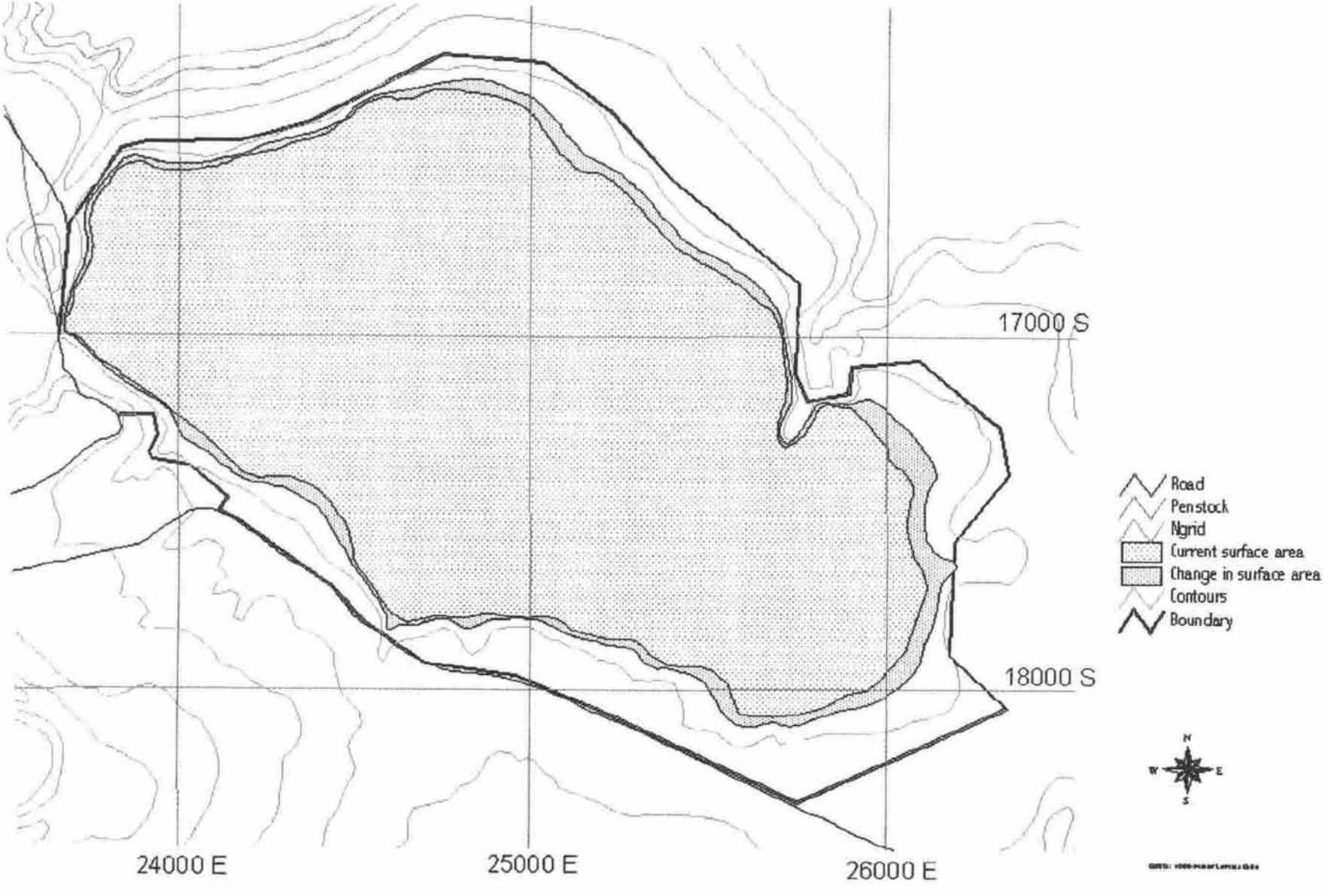
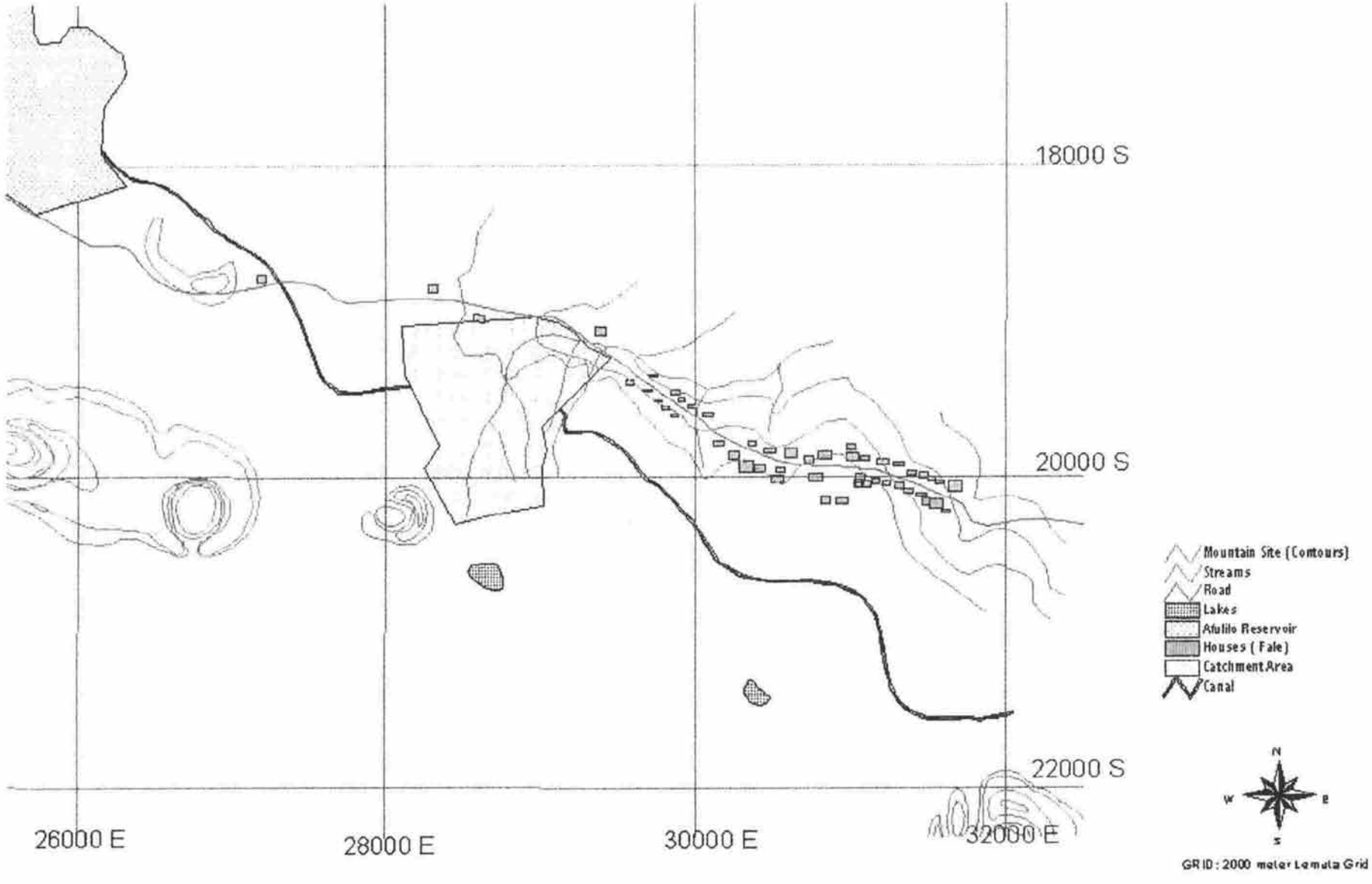


Figure 3: Eastern Diversion Canal



3 EXISTING ENVIRONMENT

In this chapter the current environmental situation of the Afulilo hydropower scheme is reviewed, four years after it was commissioned in 1993. The review includes water quality studies, noise level measurements, fauna and flora studies, and social effects of the project.

Particular emphasis was given to the current water quality situation which was assessed in the reservoir, in the creek above the tailrace, in the creek just below the tailrace and in Fagaloa Bay. Parameters assessed included water temperature, dissolved oxygen, clarity, salinity and pH. Water samples were collected from these locations, taken to the laboratory at USP Alafua Campus in Apia to stabilise them before airfreighting the samples out that evening to the USP, in Fiji for laboratory chemical analysis. Parameters analysed for in the laboratory included: total and dissolved iron and manganese; and nutrients, nitrates and phosphates. Some assessment results are tabled below but full records are attached as Annex 2.

3.1 The Afulilo Reservoir

The Afulilo Hydro Power Development began in 1991. The dam was closed off in March 1993 and by July 1993, the first test run of the whole scheme was carried out. The reservoir continued to fill and in mid-October 1993, the reservoir began to spill when the level exceeded the maximum supply level of SL 317.50 metres. Daily records of the reservoir levels indicated that the reservoir continued to spill from mid-October to late November 1993, and again intermittently from late December 1994 until early March 1995, 1996, and 1997.

The reservoir level during the field work on 20 May 1997, was SL 316.4 metres. One week later on 28 May 1997, the level had dropped to SL 316.0 metres. During the two weeks from 17-29 May, when the field work was being conducted, very little rain fell in Apia. The water in the reservoir was a dirty brown, but no foul smell could be detected during the two site visits.

3.1.1 Water quality in the reservoir

The quality of the water in the Afulilo reservoir was assessed on two occasions at two stations. The first site visit and water quality study was conducted on 20 May 1997, and the second on 28 May 1997. One station was near the dam wall and the other station was located further to the north of the wall. Figure 1 shows the location of the two water quality study stations in the reservoir.

At each site, measurements were taken of temperature, pH, water clarity and dissolved oxygen. The water depth near the dam wall was five metres and clarity measured using a secchi disc was one metre. Near the dam wall, the profile of temperature and dissolved oxygen was measured using the YSI Model 57

Oxygen Meter. While the water temperature was relatively constant with depth, the concentration of dissolved oxygen (DO) quickly decreased. At three metres below the surface, the DO levels had dropped below 5 mg/l, the minimum required for aquatic life. Near the bottom the DO was a low 2.6 mg/l. Such depleted DO levels indicated that a high percentage of organic matter are at various stages of decomposition. Table 1 lists the water quality measurements at Afulilo reservoir extracted from the full table of water quality assessment results tabled at Annex 2.

Water samples were also collected from near the surface and bottom close to the dam wall, and from the surface in the second station. The samples collected were preserved for transportation to the laboratory at USP for analysis. The elements of interest in this situation are iron and manganese, and both total and dissolved iron and manganese were analysed for. The results showed no significant difference between the surface and bottom concentrations of these elements. There was also no significant difference between the two stations at the reservoir.

Water samples were collected during the second visit on 28 May for nutrient analysis. Results showed that both nitrates and phosphates were very low, in fact below the detection limit of 34 ug/l for nitrates and below 20 ug/l for phosphates. Full results of the analysis are attached as Annex 2

Table 1: Afulilo Reservoir Water Quality Measurements

Date	GPS Location	Profile Depth	Time (hr)	Temp (°C)	DO (mg/l)	pH	Clarity (metres)
20/05/97	13 58.100 S 171 33.665 W	Surface0m	1328	26.5	7.4	6.00	1
		1 1m		26.4	7.2		
		2 2m		26.0	6.4		
		3 3m		25.5	4.8		
		4 4m		25.5	4.7		
		5 5m		25.5	2.6	5.79	
20/05/97	13 58.013 S 171 33.684 W	100m west of dam in 30cm water depth	1410	27.5	7.8	7.40	NA

3.2 Ta'elefaga Power Station

From November 1993, both machines at the Ta'elefaga power station have been in operation continuously with minimal problems. It is noted that since the commissioning of the Afulilo hydro power scheme, which took up approximately 70 percent of generation shares, diesel fuel consumption by EPC has dropped dramatically by about the same percentage.

The power station was visited four times during the two week field study, and on all occasions, the plant was neat and tidy and both machines were fully operational. The plant was well guarded and the attendant was always helpful when questioned.

3.2.1 Noise emission

Noise levels were recorded inside the plant, and outside in one of the nearest fale or local house, during the day and also at night. Noise levels ranged from 48 dBA (fale at night), to 92 dBA (inside plant, during the day with two turbines

operating). The current continuous noise level inside the plant is a high 92 dBA and therefore, ear protection gear must be worn at all times by the attendant(s). Samoa does not have specific Occupational Health and Safety Guidelines but as indicated in Section 3.5.5, it is common practise to wear ear protection at work places where the noise averages 80 dBA. Wearing of ear protection should be enforced now, before installation of the third turbine. Noise levels outside the plant were reduced significantly when the sliding door was closed. Noise levels recorded at Ta'elefaga power station and village are shown in Table 2 below.

Table 2: Average Noise Measurements at Ta'elefaga Power Station

Date	Time	Location	Noise Level (dBA)
23/5/97	1415	Inside Ta'elefaga Power Station (door open)	92
23/5/97	1417	Outside power station at the fence, 15 metres from open door	66
23/5/97	1418	15 metres outside power station at the fence, with door closed	58
23/5/97	2204	Inside power station, door closed	87
23/5/97	2207	At fence 15m with door closed	60
24/5/97	0200	Inside fale (house), 25 metres away	48

3.3 Ta'elefaga creek

The Ta'elefaga creek which now receives water from the tailrace has changed dramatically from what it was prior to the Afulilo scheme. Water flow in the creek from the tailrace to the bay was quite rapid and the resultant current at the culverts was strong enough to carry off a toddler into the bay. This is one risk that must be addressed immediately before implementation of the augmentation project. At the moment, there is no adequate fencing at the bridge to prevent accidental falls into the creek, particularly for children.

No fauna could survive the fast flow and the water was distinctly brown. Although not obvious during the study, the villagers had indicated that the creek had often had a foul smell at times. This would be consistent with the situation when organic matter decomposition took place under anoxic condition.

The quality of the water in the creek above and below the tailrace was examined during the site visits. The same parameters were also assessed in Fagaloa Bay just in front of the village. Water samples were also collected from these sites and transferred to USP for analysis. The samples were analysed for iron and manganese, and the nutrients nitrates and phosphates. The water quality test results are attached as Annex 2. Comparison of results for iron and manganese showed that water discharged at the tailrace contained significantly higher concentrations of both total and dissolved iron and manganese than the natural creek water above the tailrace. Of interest is the fact that levels in the water from the power plant are almost identical to that in the reservoir. The Afulilo reservoir is definitely a source of iron and manganese in the creek and ultimately in Fagaloa Bay. Levels of nutrients were all

low except in the creek above the tailrace. The high nitrate in the creek water may be attributed to the intensive vegetable farming in the households further up the road.

3.4 Fagaloa Bay

Fagaloa Bay is a semi-enclosed bay bordered by a number of villages including Ta'elefaga at the head of the bay. The bay is relatively well-flushed by the tides and a number of freshwater streams and creeks drain into the bay.

3.4.1 Water quality

Observation of the current situation indicate that a large amount of fine, suspended particulate matter is being added to the bay everyday The water leaving the tailrace is definitely brown in colour and this forms a plume for some distance into the bay. The origin of this coloured water is the flooded swamp which now serves as the Afulilo reservoir. Although not encountered during the field study, an associated effect of the swamp water is the smell of rotting organic matter under anoxic conditions. This problem was highlighted by the villagers to the study team during the village meeting held at Ta'elefaga village (see Annex 1).

Fagaloa Bay was sampled on two occasions by measuring a number of water quality parameters on site and collecting water samples for chemical analysis at the USP laboratory. Full details of water quality measurements are attached as Annex 2. The freshwater from the power station is a dirty brown colour with much lower pH than the receiving water. The salinity remains low for some distance out into the bay. However, the concentration of iron and manganese, and nutrients are low and no different from the other study sites.

3.4.2 Social conditions

The near-shore area was walked during low tide to assess the range of organisms in the intertidal zone. The local villagers were interviewed on types of fish gathered and changes that may have occurred since the commissioning of the Afulilo scheme. The villagers noted that the "atule" fish, a seasonal fish, is no longer available in the bay. Table 3 shows the type of fish species that are now absent from the bay.

The disappearance of these species could be due to over-fishing particularly the shellfish, but it is evident from the large number of dead juvenile shellfish that the new flow regime at Ta'elefaga stream and sedimentation, have affected the fishery resources at Fagaloa Bay.

The 1991 EIA report recorded the number of people at Ta'elefaga to be 500 people. The 1997 population figure given by the Statistics Department in Apia is now 137. The probable cause of the decrease in population at Ta'elefaga could

Table 3: List of fishes now absent from Fagaloa Bay

Samoan Name	English Name	Scientific Name
Atule	Purse eye scad	*Selar crumenophthalmus*
Alili	Turban shell	*Turbo chrysostomus*
Tugane	Venus shell	*Gafrarium sp.*
Fole	Pen shell	*Pinna sp.*
Gau	Green sea hare	*Dolabella auricularia*
Fatuaua	Thorny oyster	*Spondylus sp.*
Tuitui	Boring urchin	*Echinometra matthaei*

be migration overseas (normal for Samoans) and into urban Apia. The village population level should be monitored together with monitoring of the marine resources at Fagaloa Bay. This will determine the true cause of the changes observed at Ta'elefaga.

3.5 Diesel Generation at Tanugamanono Power Station

Although not strictly an Afulilo augmentation option, the installation of an additional diesel plant at Tanugamanono station is an essential component of the development of the EPC generation system. The current environmental situation of diesel generation is discussed in this section.

3.5.1 The diesel power station

A number of processes are required to operate and maintain the power station. In general terms these include:

- the actual process of generating the electricity through the turning of the alternators by diesel- or fuel oil-powered motors;
- a fuel storage area on site to provide regular fuel to run the motors;
- auxiliary systems such as cooling systems, exhaust systems and lubricating systems. Waste oil system of collection, storage and off-site processing should also be in operation. Electric control systems monitor and operate the motors; and
- fire systems are provided in the form of fire hydrants in various locations within the building.

The Tanugamanono power station in its present location is not totally free of problems. The Hydro Electric Commission Enterprises Corporation (HECEC), 1997 report identified that the Tanugamanono site will eventually not be viable as a major generating facility. That report recommended a new diesel power station at Vaitele industrial area. Relocation of diesel generation should be the subject of a later study and will not be discussed here.

3.5.2 Fuel storage and fire risk

Fuel is stored at the power station using two tanks with capacity for 20,000 and 40,000 gallons. These tanks are elevated on stands outside, at the back of the generating complex which is approximately less than 20 metres from the nearest household. There are a number of hazardous materials being used and stored on the power station and therefore, there will always be a fire risk. Diesel and oil spill fires at diesel plants are uncommon (the fuels used have a high flash point and therefore are relatively safe, being difficult to set alight and not prone to explosions) but the potential for fire is there and may also be caused through electric failures, transformer explosion and other normal industrial risks.

The proximity of the power station to the Tanugamanono village poses a serious threat to human lives and property in the event of a fire at the station. The fire hydrants installed around the station is not sufficient. A comprehensive fire system should be installed to include also a fire ring around the site with hydrants, as well as sprinkler systems and fire extinguishers in various locations within the buildings.

3.5.3 Cooling system

The present cooling system is heavily dependent on water supply piped down from one of the run of river hydro power schemes. The water supply is often insufficient particularly during the dry season and more often than not, the EPC has to tap into the municipal reticulated water system for its requirements. Each water cooled generator consumes approximately 4,000 litres of water per hour and even with only one of the five generators running there is continuous problem of insufficient water supply. Currently, additional water required is normally purchased and brought into the station by water trucks from the Water Authority.

3.5.4 Waste oil and Exhaust Fumes

There is approximately 50 barrels of waste oil produced every six months. This equates to about 700 litres of oil per month. The power station appears to have no proper disposal system for waste oil. It is believed that most of the waste oil is drained down the hillside into the valley and river below. Complaints have been received by DEC from villagers below that the river is often contaminated with oil from the power plant—an indication that waste oil is actually allowed todrain down the hillside.

Exhaust fumes were not measured during the study, but apart from the standby generator, all exhaust fumes are expelled through the 20 metre tall exhaust stack which just clears the top of the double storey building next door.

The Tanugamanono station is located within a village, the houses surrounding the power plant are quite close and there have been major complaints about the noise and fumes emanating from the power plant. Table 4 records that at certain wind directions, exhaust fumes from the power station are blown directly through the upstairs bedroom window of the nearest house.

3.5.5 Noise emission

Noise levels and other observations were recorded during the site visit of the Tanugamanono power station on 21 May 1997. Table 4 shows the high level of noise within the plant itself and outside. It was noted that most employees working in the control room, which had a sound recording of 84 decibels, were not wearing ear protection. It is standard practice to use ear protection devices while working around running plants. As shown in Table 4, most work areas exceeded the 80 dBA level, often regarded as the minimum acceptable noise level in work places, and therefore employees should be encouraged to wear ear protection devices at all times.

Noise emission from the generators has been and continues to be the main cause of social discontent for some villagers at the Tanugamanono area. The main complaint has come from the owner of the nearest household, who has officially lodged his complaint against noise pollution with the Department of Environment and Conservation in July 1997. The noise level taken at 2245 on the 21 May 1997 inside a bedroom of the complainant's house was 70 dBA. This level is much higher than the recommended New Zealand standard of 45dBA at the boundary for noise produced continuously at night.

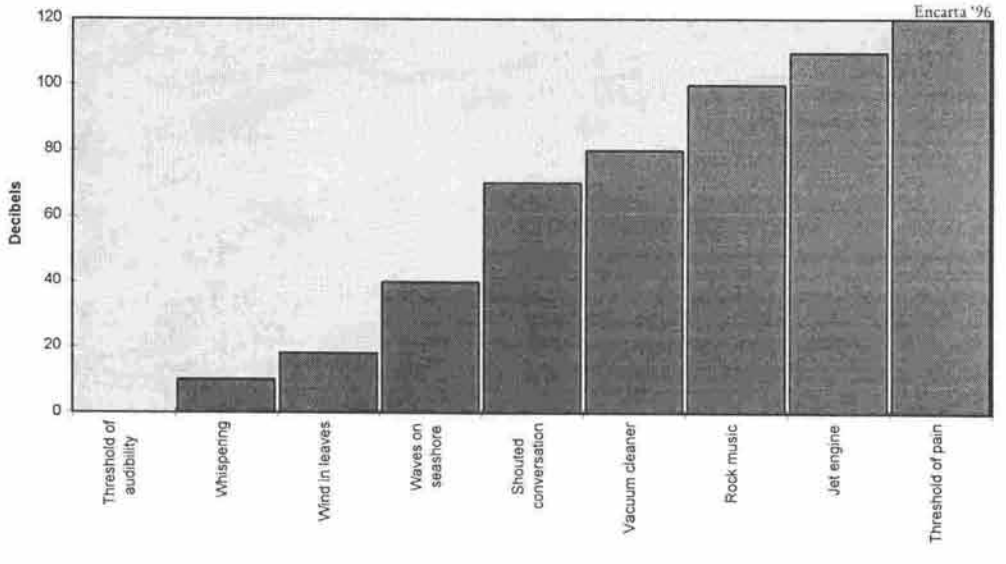
Current noise emission is at an unacceptable level and EPC should maked changes immediately. The immediate short term option would be to reduce the noise emission by replacing the current inefficient silencer with a new one capable of reducing the noise level to about 40dBA at the boundary fence.

Table 4: Average Noise Measurements at Tanugamanono Diesel Power Plant

Date	Time	Location	Noise Level (dBA)	Remarks
21/5/97	3.00pm	Outside Admin. Building	75.0	
21/5/97	3.10pm	Just outside of power plant	86.0	
21/5/97	3.15pm	Transformers station (sealed off from generators)	77.0	
21/5/97	3.20pm	Corridor, overlooking generators, sealed off	84.0	Workers without ear protection.
21/5/97	3.25pm	Inside main generating area	103.0	
21/5/97	3.30pm	Outside plant, eastern end	93.0	
21/5/97	3.35pm	Outside, near cooling tower	88.5	
21/5/97	3.40pm	Outside, near radiator fans	98.0	Added fan noise
21/5/97	3.45pm	Eastern side of plant, towards the fence.	78.0	15 metres from mechanic's house
21/5/97	10.40pm	Between power plant and mechanic's house	66.0	
21/5/97	10.45pm	Upstairs, inside bedroom adjacent to power plant	70.0	Vibrations felt through house.
21/5/97	10.50pm	Upstairs, in furthest room from power station	62.0	Exhaust smoke got into upstairs rooms
21/5/97	11.00pm	Outside at backyard of mechanic's house	65.0	
21/5/97	11.15pm	On road side near house at back of Admin. Office	65.0	Approx. 20 metres west of plant.

In the absence of noise guidelines, Figure 4 below is provided to give some examples of sound intensities for comparative purposes with the sound measurements taken at Ta'elefaga and Tanungamanono.

Figure 4: Sound Intensities



4 ENVIRONMENTAL EFFECTS OF THE AUGMENTATION PROJECT

4.1 Increasing Afulilo reservoir volume

The proposed increase in height for the dam wall is 1.7 metres. This increase would result in raising the maximum supply level from SL 317.5 metres to SL 319.2 metres. The Afulilo dam will now impound up to 15 million cubic metres of water at the maximum normal operating level of SL 319.2 metres. Afulilo lake surface area at this new level will be approximately 270.4 hectares (see Figure 2) an increase of 19.4 hectares. To determine the effect of this increased storage at the reservoir, it was necessary to mark out the new SL 319.2 metres contour around the existing reservoir boundary which currently stands at SL 317.5 metres, the maximum attainable with the present dam specifications.

The new water level (SL 319.2 metres) of the reservoir was calculated from the 325 metre contour and the current water level (SL 317.5 metres) using the 1:10,000 topographic engineering plan No. 83417 from the Electric Power Corporation, in Apia. The position of the new level was plotted on the same topographic plan and then digitised for mapping purposes and data analysis. The surface areas of the two water levels were calculated using the ArcView 3 software programme. The new water level was also checked by differential levelling using an automatic level instrument. This is to get a clear indication on the ground of the proposed SL 319.2 metre water level.

4.1.1 Land tenure

The land that will be flooded by the proposed raising of the dam is within the boundary of land taken over by the EPC for the Afulilo Hydro power scheme. The government of Samoa acquired this land by Proclamation of 27 July 1988, and landowners have been compensated for the compulsory acquisition of their lands. The area is fenced off and, except for grazing cattle, there is no other activities in the area. Land tenure therefore is not an issue with the expected surface area increase. Before the work begins however, the grazing of cattle on the grassy flat banks close to the road must be stopped.

4.1.2 Flora and Fauna

Due to the uneven height increases all around the boundary of the existing Afulilo reservoir, the surface area to be flooded will be much greater on the banks adjacent to Richardson road, than at the foot hills to the north of the reservoir. Nevertheless, much of the flat area that will be flooded is covered with grass and grazed by some cattle, with occasional bushes of "fau" *Hibiscus tiliaceus,* on slightly higher ground. On the other hand, the steeper northern banks of the reservoir have more vegetation, including a diverse community of tree species such as the "laufatu" *Macaranga stipulosa* and palm trees "niu vao" of the *Clinostigma sp.*

Other trees found include the "olioli" *Cyathea spp.*, and the "filimoto" or *Flacourtia rukam.*

The aquatic fauna in the reservoir included a number of insect species. The undergrowth contained a diverse community of arthropods including ants and gecko (*Lepidodactylus lugubris).* The grass skink *Cryptoblepharus boutonii,* was noted amongst the thick undergrowth. The only bird seen during the field study was the Pacific blue duck *Anas superciliosa* but there may be others which were not detected. Most of the flora and fauna though, identified in the Waugh 1991 report, have disappeared from the fringes of the Afulilo basin.

From a biological perspective, raising the dam will not have a significant effect on the collection of flora and fauna. The area is already disturbed, the vegetation is mainly secondary regrowth consisting of common shrubs and herbaceous plants and the common tree species identified above.

4.1.3 Construction phase

The recommended construction option is to raise the spillway weir by constructing a 1.7 metres high reinforced concrete crest over the existing weir. The main advantage of installing a fixed raised crest is that there are no significant operating and maintenance costs involved.

Construction debris should not be dumped over the steep slopes adjacent to the dam wall. Spoil debris should be placed in a designated spoils area. Ideally, the previous spoils sites used during the dam construction should be opened up for the augmentation project, but closed and revegetated after completion of construction work.

4.1.4 Forest Clearance

Further forest clearance of the almost completely inundated Punataemo'o swamp forest is inevitable. An area of approximately 19.2 hectares should be cleared of all vegetation. If clearing is not done, then as the reservoir fills to its maximum capacity, the vegetation left in the basin will die. As vegetation rots the action of bacteria will rapidly use up the oxygen in the water. Anaerobic decomposition which is very slow, will take over in the absence of oxygen and generate the gases methane and hydrogen sulphide. The water quality results taken during this study, four years after Afulilo basin was filled up, indicate anaerobic activity is still strong. Before the new maximum capacity level is filled up with water, all vegetation should be removed and placed in an appropriate waste area above the SL 319.2 metres contour level. This will ensure less anaerobic decomposition takes place once Afulilo is filled up to maximum capacity. It will also help quickly improve the water quality in the Afulilo basin.

4.2 Effect of the East Diversion Canal

The East Canal would divert run-off from the northern slopes of range extending east from Mt Savai'i. The proposed canal as seen in Figure 3, will intercept several prominent surface streams from Mt Tiatala and Mt Olomaunga ridge and could produce an estimated 35 percent increase in yield for Afulilo storage.

4.2.1 Construction

The proposed canal is to be 7,374 metres long with a base width of one metre. An access road will be cut to help lay the sub-base material for the channel. The canal will be unlined with side slope of 1 in 2, for steep areas the channel will be lined with the side slope of 1 in 1. Canal

and road protection will be provided at creek crossings.

The routes of the proposed diversion canals are covered in dense re-growth vegetation and the construction of the diversion canals should only cause temporary disturbance to this dense upland forest cover. Good construction practices should be utilised to minimise soil erosion and sedimentation. Clearing of vegetation should be to the minimum required for laying the channel and access road. All disturbed areas which will not be required must be revegetated.

4.2.2 Social effects

The proposed canal will run along the foot of the eastern hills and ridge at the back of Tiavea (Alafou) village. The area is on customary land that belong to Tiavea villagers. The EPC should begin proceedings to obtain consent from the villagers for the proposed landuse. EPC should explain the likely effects the landuse proposal will have on the village to solicit a compromise that would be of mutual benefit.

The proposal will in effect drain off most surface drainage and streams from the eastern hills, away from Tiavea (Alafou) village below, to the Afulilo catchment and basin in the west. Most village farms are at the back of the village towards the foot of the hills. Once the canals are in place most of surface drainage during the rains (approximately 35 percent) will be diverted away from the farmlands. Altering the surface flow regime will not only affect plantations, forests, swamps, streams and pools, terrestrial and fresh water animals, but it will also affect the village communities of Tiavea especially, the new expanded settlement at Alafou.

The community of Alafou expanded out of Tiavea once the Richardson road was opened. There is no reticulated water system in the village so there is complete dependence of surface water flow from streams and creeks for domestic use. Most households rely on three creeks for water supply. Most villagers, especially women and children, have to walk some distance to carry water in buckets from the main creek or do laundry washing. During the dry season only one stream receives running water from a spring close to the road. If the diversion canal taps into the source of this spring, then the only flowing stream during the dry season may dry up. Women and children will be forced to carry bucket loads of water from as far away as Tiavea proper, one kilometre down the road.

Most farm lands are at the back of the village towards the foot of the hills. Some seasonal crops may be affected by the changed water volume flow. Farmers may be forced to move their crops close to the hillsides or on the hillsides, but the effect on farmers would be that they now have to walk long distances to service and harvest their plantations. Farming up the hillsides will not be beneficial to the Afulilo project. Any disturbance to the hillsides will cause soil erosion and sedimentation downstream and when diverted to the reservoir will in turn reduce the quality of water in the Afulilo dam and at the Ta'elefaga tailrace.

4.2.3 Flora and Fauna

The actual cadastral survey for the diversion canal has not been marked out yet and therefore, a biological survey on the actual route the canal would take was not undertaken. However, a general survey of the area of the canal route showed much of the land is covered with secondary regrowth of similar floral cover as generally found along the perimeter of the Afulilo basin.

The is an abundance of fresh water fauna in the streams and pools found in the area. Eels, shrimps and prawns are found in most streams but are more abundant in the one stream that is also fed by a spring. Changes in the water flow regime either through sedimentation from the hillsides or through reduced water flow could adversely affect fresh water fauna in this area, causing a loss of resources to the Alafou community.

4.3 Increased freshwater outflow into Fagaloa Bay

4.3.1 Tailrace outfall to stream

The natural catchment of Fagaloa Bay is about 14 square kilometres and the Afulilo scheme diverted an additional 12 square kilometres into the bay, approximately doubling the freshwater inflow. The proposed augmentation project will increase the yield of the Afulilo reservoir by about 50 percent (from 10 million cubic metres to 15 million cubic metres storage capacity). This will result in an increase of approximately 20 percent of the freshwater flowing into Fagaloa Bay.

The Afulilo hydro power scheme is currently discharging through two tailrace pipes, a relatively constant flow of up to 1.7 cubic metres per second of freshwater into the Ta'elefaga stream and Fagaloa Bay. The augmentation project will put in place a third tailrace pipe which when in operation, the combined outfall flow would increase up to 2.6 cubic metres per second. The average annual flood for this stream is 15 cubic metres per second. Therefore, it is considered that an increase in the tailrace outflow will not cause significant environmental impacts since the increased flow would be within the natural variability of the current inflows into Ta'elefaga.

With the current flow rate, the stream level is more than three-quarters the height of the bridge. Villages have indicated that during the rainy season the bridge is often over flowed, the water flowing over the bridge at times make crossing the bridge dangerous. The likely effect of an increase in constant flow to 2.6 cubic metres per second would make crossing the bridge dangerous and limit access to either side of the village. A new bridge should be built before commissioning of augmentation project. The bridge should be raised higher than the current one and should have safety screen rails alongside both sides of the bridge to prevent children falling into the stream.

4.3.2 Discharge to sea

The effect of discharging a relatively constant flow of up to 2.6 cubic metres per second of doubtful quality freshwater into the head of Fagaloa Bay is difficult to assess. However, it is noted that most, if not all, elements tested previously for water quality measurements would still be present in the new flow regime and are considered below.

Hydrogen sulphide originating from rotting vegetation in the reservoir may be released by aeration of the flow in the discharge creek, and should break down before the discharge reaches the sea. The smell factor together with turbidity clouding the water have made the discharge undesirable since the commissioning of the scheme and will continue to do so for a few more years after the augmentation project. The tailrace discharge is more acidic (lower pH) than normal stream water but this is not a concern as the buffering capacity of saltwater will neutralise any acidity immediately on mixing. Concentrations of dissolved iron and manganese, although currently very low, may increase over time with more surface area of Afulilo basin under water, but these will precipitate out as floc when the tailrace discharge is re-oxygenated during the flow downstream to the bay. The floc will fill spaces in and around stones, but otherwise are relatively harmless.

The only possible issues are therefore, the effects of lowered salinity due to the addition of freshwater, and sediment suspended in the discharge. These two issues warrant further study to determine the accuracy of the claim by Ta'elefaga villagers, that the discharge into the bay not only affects the water quality but it affects as well, the communal use of the bay and the fisheries resources therein.

4.4 Additional noise at Taelefaga Power Station

Hydro-power stations are not normally noisy. The current noise levels with two turbines in use range from 48 dBA at the fale at night to 92 dBA inside the plant. Each of the turbines produce an average noise output of 85 dBA measurement inside the plant. With the proposed installation of the third machine at Ta'elefaga, one of the concerns that need to be addressed is noise level in the surrounding village, particularly the school across the road. The addition of a third turbine machine would only increase the total noise level to approximately 95 dBA at the machine area. The following formula was used to arrive at the new noise level:

Sound 1 = x decibels
Sound 2 = y decibels
Total sound = S_T

$S_T = \log_{10}(10^{x/10} + 10^{y/10})$ in bels
or $S_T = 10 \log_{10}(10^{x/10} + 10^{y/10})$ decibels

Source: Adapted from Noise Control in Industry, Sound Research Laboratories E. and F.N. Spon, London.

The additional noise level expected from the augmentation project is considered negligible. Nevertheless, the practice of keeping all doors closed during night time operations should be strictly maintained.

4.5 Installation of additional Diesel Generator at Tanugamanono Power Station

The project involves the installation of a new 4MW diesel generator to help maintain diesel generating capacity that together with hydropower, will enhance capability to cater for the energy supply demand of Upolu electricity users. The benefit from this new installation will be the improved security for generating power system stability and for use during the periods of maximum system demand.

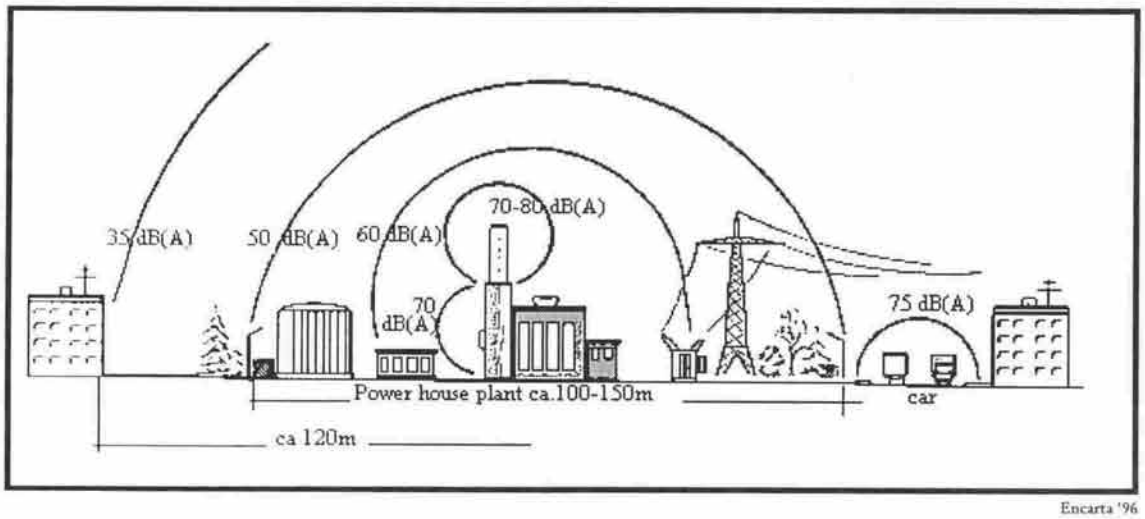
The main environmental (including social) effects of diesel generation at Tanugamanono have been highlighted in the earlier chapter. It is considered that the addition of a new diesel generator to the power station will not add further significant impacts to the already unacceptable situation of diesel generation at Tanugamanono. The additional 4MW engine, being new, should have a more efficient noise emission level than the old diesel machines currently in use. The new machine would have a lower noise level than the current noise output and therefore, based on the logarithms calculations used in Section 4.4, it is unlikely that the new machine in combination with older machines will produce noise pollution at levels higher than the current high of 103 dBA at the generating area.

Figure 5 (opposite) shows acceptable noise reduction levels at various sites or activity areas. The concern therefore, is that the current high noise levels from Tanugamanono should be reduced immediately to achieve, as near as

possible, the above reduction level shown in Figure 5.

It is assumed that the new generator will raise the consumption of diesel fuel and oil, additional water for cooling, but also would contribute to an increase in exhaust fumes and waste oil and water. However, once the Afulilo augmentation project is completed, there will be more hydropower capacity available and less diesel generation may be used. EPC may soon achieve an efficient power generation capacity where there will be very little night time diesel generation and the use of only one diesel generator during daytime operations. Thus, the introduction of another generator at this stage is not an environmental concern. What is important is that urgent measures should now be taken to improve the exhaust and noise pollution, reactivate and improve the waste oil and water disposal system and improve the cooling water supply system at Tanugamanono power station.

Figure 5: Noise reduction outside power station building



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CONCLUSIONS AND RECOMMENDATIONS

This report examines the likely environmental impacts the augmentation phase of the Afulilo hydro power scheme will have on the natural and social environments of the project area. The study makes extensive use of material reported in the environmental impact assessment (EIA) report prepared by Waugh *et al.* in 1991. It reviews that work and advances further conclusions based on new information acquired through this current study.

The 1991 EIA report has highlighted the value of comprehensive environmental impact assessment of major projects and its effectiveness in enhancing environmentally sound decision-making. The report recommended against a diversion canal option from Vaipu basin because the country would lose "the only significant montane wetland of its type in Samoa". The 1991 EIA report provided additional information of the project to successfully influence the decision-makers to abandon the proposed drainage canal from Vaipu basin. Where the 1991 report has provided insufficient coverage of issues, this report has broadened its analysis to all tractable issues and combined the treatment of these throughout the Afulilo Augmentation Project Report.

This section sets out the principal findings and recommendations of the report. The recommendations are addressed to the Government of Samoa which requested this report well in advance, and during the planning stage of the Afulilo augmentation project.

(1) The raising of the Afulilo dam will increase the ponding area from 250 hectares to 270.4 hectares. The extra 19.4 hectares that will be flooded with water should be cleared of all standing vegetation. Such clearing is necessary, both to protect the quality of water in the reservoir, and for the operation of the dam. The felled trees should be removed away from the new ponding area and cattle farming should be relocated.

(2) During dry years, the Afulilo lake level will fall and there will be large areas of rotting vegetation on exposed areas. This may cause bad smells and foul the water.

(3) The Department of Agriculture, Forestry and Fisheries (DAFF) is looking into using the reservoir for Tilapia farming. The current water quality measurements indicate the possibility of the reservoir supporting marine life.

It is recommended that exotic fish is not introduced into the Afulilo or Vaipu basins. DAFF and DEC must first undertake an environmental impact assessment of Tilapia farming in Afulilo basin to determine the need for this activity and the likely effects the introduction of the exotic species will have on the aquatic/ marine life in both Afulilo and Vaipu basins.

(4) Raising of the dam crest will require small construction work, but it will lead to exposed areas of soil and spoil,

and rubbish. EPC should reopen the old spoils area to be used for this work. EPC should require from contractors that spoils and rubbish are not dumped over the dam wall, and that all exposed soil and spoil areas are revegetated at the completion of the job.

(5) The two generators for the power scheme at Ta'elefaga village have been producing acceptable noise levels. The introduction of a third generator will not raise the noise level any higher. In fact the combined noise level of the two machines will drown the noise from the third machine. It is expected that the new noise level at evenings, will be around 48 dBA at the boundary of the nearest house in the village. This is within the New Zealand noise standard for continuous noise emission at night.

It is recommended that EPC enforce its operation procedure at Ta'elefaga station to keep the sliding door closed during night time operations. In the absence of its own regulation, Samoa should adopt the noise standard of around 48 dBA at the boundary of a home for continuous noise emission at night.

(6) The tailrace water from the powerhouse will be discharged into the stream which flows through the village and into Fagaloa Bay. The new flow level of 2.6 cubic metres per second will be substantially more than the current flow of 1.7 cubic metres per second. The water will continue to be discoloured and have an unpleasant smell for two to three years after the commissioning of the augmentation project.

It is recommended that a new bridge is built prior to the commencement of the augmentation project. The bridge should be built high enough to avoid overflowing during flood periods and should have safety rails alongside both sides to prevent accidental falls by children.

(7) It is obvious to Ta'elefaga villagers that the current flow regime into Fagaloa Bay has caused the disappearance of some marine species which provide an important part of subsistence living for the villagers. The new flow regime will have significant long-term effects and it is therefore recommended that a general mapping of the marine communities at Fagaloa Bay be undertaken before the augmentation project is commissioned. This baseline study should also design a monitoring programme to observe and record changes. It is also recommended that EPC conduct public consultation meetings with the villagers explaining the augmentation project, the likely effects and the actions/studies that will be undertaken to mitigate the likely impacts.

(8) The construction of the eastern diversion canal will drain surface water from the mountain and ridge at the back of Tiavea village away from the village and into Afulilo basin. Tiavea's main water supply is from three streams, two of them dry up during dry periods.

It is recommended that a water reticulation system for Tiavea villagers be constructed first before the canal construction.

(9) Canal construction will involve movement of trucks and construction personnel to lay the canal and build access road. Construction work will lead to exposed areas of soil and spoil which should be revegetated after completion of the job. Land clearance should be to the minimum required for the canal laying and the access

road. All construction rubbish should be placed in a designated spoils area, closed and revegetated after use.

EPC will need to discuss the project with Tiavea villages to obtain permission to build the canal on Tiavea land. EPC should monitor the work of the contractors on the canal to ensure the drainage canals do not drain all surface water flows away from the streams supplying the village.

(10) It has been determined in the Afulilo augmentation and inception report that the Tanugamanono diesel power station is becoming a non-viable operation and has recommended relocation. Relocation may be a long term plan but it must be subject first to an environmental impact assessment. In the meantime, the current situation of the power station should be improved.

It is recommended that the unacceptable noise level be reduced by EPC purchasing a new noise reduction devise, a silencer with an efficiency to reduce the noise level to around 45 dBA at the nearest house. The exhaust fumes stack should be extended higher to ensure exhaust fumes do not flow directly into the upstairs rooms of the nearby houses but are dispersed at a much higher level. The waste oil and water collection and disposal system should be reactivated. This system is in place but has not been operated efficiently.

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Annexes

Water analysis results for water samples taken on the 23/05/96

Description	Above tailrace creek	Fagaloa Bay	Below tailrace creek	Reservoir water
Lab No.	97/754	97/755	97/756	97/757
Nitrate (µg NO_3/L)	60.5	< 34	< 34	< 34
Orthophosphate (µg PO_4/L)	< 20	< 20	< 20	< 20
pH	7.22	7.82	6.45	6.24

Water analysis results for samples taken on the 23/05/96

Description	Above tailrace	After tailrace	Creek/Bay sample	Bay at low tide	Dam wall surface	Dam wall bottom	Reservoir Station 6
Total iron (µg/L) (x 10^3)	0.3	1.5	1.7	1.3	1.4	1.5	1.3
Dissolved iron (µg/L) (x 10^3)	0.3	1.1	1.0	0.5	0.9	1.0	0.9
Total manganese (µg/L)	20.4	72.9	80.4	73.4	60.0	78.4	57.4
Dissolved manganese (µg/L)	18.1	41.0	28.5	35.0	34.0	38.0	29.0
Lab No.	97/682	97/683	97/684	97/685	97/686	97/687	97/688

Summarised dissolved oxygen values taken at depth on different days (DO mg/L)

Dates	0m	1m	2m	3m	4m	4.6m	5m
09/07/97	8.41	7.04	5.96	5.32			
20/05/97	7.4	7.2	6.4	4.8	4.7		2.6
28/5/97	7.4	6.2	3.8	3.7	3	2.8	

The source is dead. The Afulilo project has drastically affected the Ta'elefaga stream and catchment.

(vii) Fisheries Resources

Fagaloa Bay : any observed changes since 1993?

type of fish - atule (iatali). Theres no more atule but there was a lot before the Power house was built. According to the villagers the following shellfish are not found anymore: alili, tugane, fole, gau, fatuaua, tuitui

any reef? Yes.

Bathing in the Bay? Not a popular place for bathing as the water is very dirty and smelly. (skin infection) Not clear.

(viii) How reliable is the tap water supply for drinking/bathing/ washing?

Not very good in sunny season.

(ix) A pond was supposed to be excavated above the tailrace for the villagers' use. Has this been done and how useful is it?

This hasn't been done.

(x) Any other observations/comments to add?

When the river flooded, there's a lot of sedimentation and mud in the bay and this spreads out on the beaches on both sides of the river. They said that the depth of the mud is about one foot when the river is flooded. It also gives a very bad smell and it can go for two months. One said that smell is worst than the smell of the septic tank.

One Matai said that the EPC was supposed to build six feet concrete banks on both sides of the river as a part of the contract but this hasn't been done.

The following Matais were present on behalf of the villagers of Taeleafaga.

Gago Masani Fuiava (village mayor)
Leuta Sialafau
Sua Ofisa
Fuivailili Saitu
Sua Aitupe
Sinamaitai Apete Sanerivi.

The village meeting was conducted by Mr Petelo Ioane on behalf of the assessors.

Physiochemical Water quality measurements

Site No.	Location GPS	Description	Sampling Date	Time (h)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)
1.	Taelefaga Creek 13° 56. 649 S 171° 34.236 W	15m above Tailrace, clear, slow flowing creek; small pebbles, some filamentous algae. No fauna.	20/05/97	1115	25.0	8.0	7.50	0
2.	Taelefaga Creek, bridge over culverts. 13° 56.578 S 171° 34.224 W	Very dirty brown, fast flowing water; covering 1/2 culvert height. (Two turbines operational)	20/05/97	1130 (low tide)	25.0	8.2	6.84	0
3.	Creek outlet into Fagaloa Bay 13° 56.511 S 171° 34.131 W	Low water mark, 100m seaward from culverts; definite plume flowing out into the Bay. Pebbles of all sizes, encrusting bivalves, mostly dead.	20/05/97	1200	25.0	7.8	6.61	0 (in plume)
4.	Fagaloa Bay	Low tide mark, 50m in front of village. Murky water, Fine sediment, silty bottom.	20/05/97	1230	25.0	6.4	8.68	23
5.	Afulilo Reservoir 13° 58.100 S 171° 33.665 W	Dam wall. Water level at 316.4m. asl Dam wall depth: 5m Clarity: 1m Profile Depth Surface 0m 1 1m 2 2m 3 3m 4 4m 5 5m	20/05/97 20/05/97	1325 1328	 26.5 26.4 26.0 25.5 25.5 25.5	 7.4 7.2 6.4 4.8 4.7 2.6	 6.01 5.79	 NA
6.	Afulilo Reservoir 13° 58.013 S 171° 33.684 W	100m north of the Dam wall, in 30cm deep water.	20/05/97	1410	27.5	7.8	7.40	NA

Physiochemical Water quality measurements

Site No.	Location/GPS	Description	Sampling Date	Time (h)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)
1.	Taelefaga Creek	15m above Tailrace (same as Before).	28/05/97	0825	23.5	8.2	7.22	0
2.	Taelefaga Creek	Bridge below Tailrace	28/05/97	0843	24.2	8.4	6.45	0
3.	Creek outlet into Fagaloa Bay	Brown water, distinct plume; Thick green filamentous algae in ditinct zones between culverts and creek mouth. Thick brown deposit (flocculated particle matter) on pebbles at creek mouth. Rock oysters on larger rocks on eastern creek bank only.	28/05/97	0855	27.9	5.2	7.82	29.9
4.	Afulilo Reservoir	Dam wall. Dam water level: 316.0m. Depth of water: 4.6m. Profile Depth Surface 0m 1 1m 2 2m 3 3m 4 4m 5 4.6m	28/05/97	1127	 25.0 25.0 25.0 25.0 25.0 25.0	 7.4 6.2 3.8 3.7 3.0 2.8	6.24	NA

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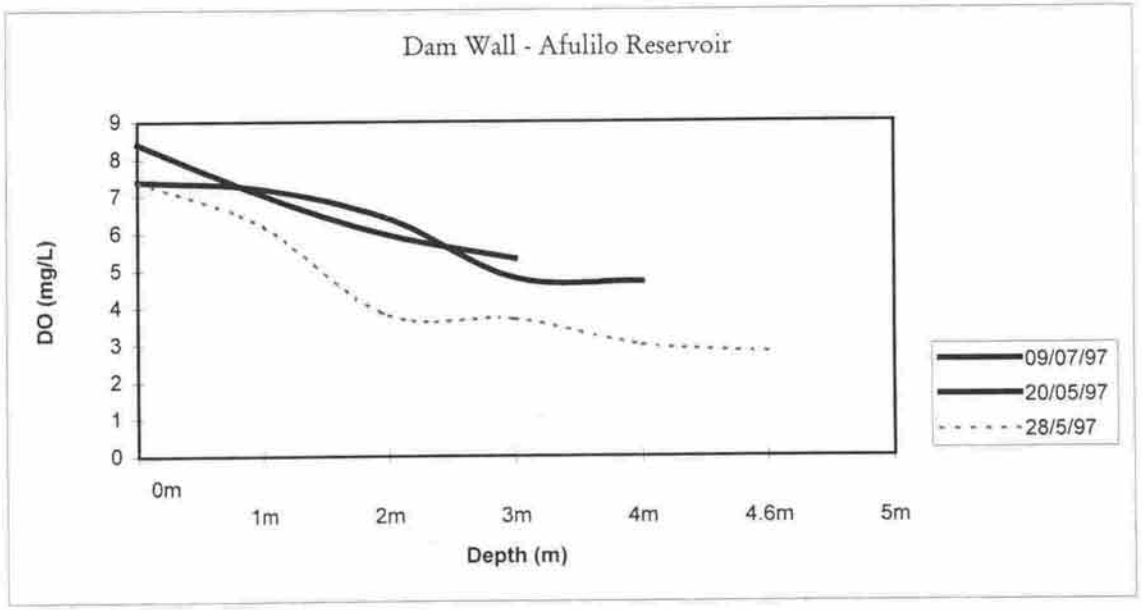
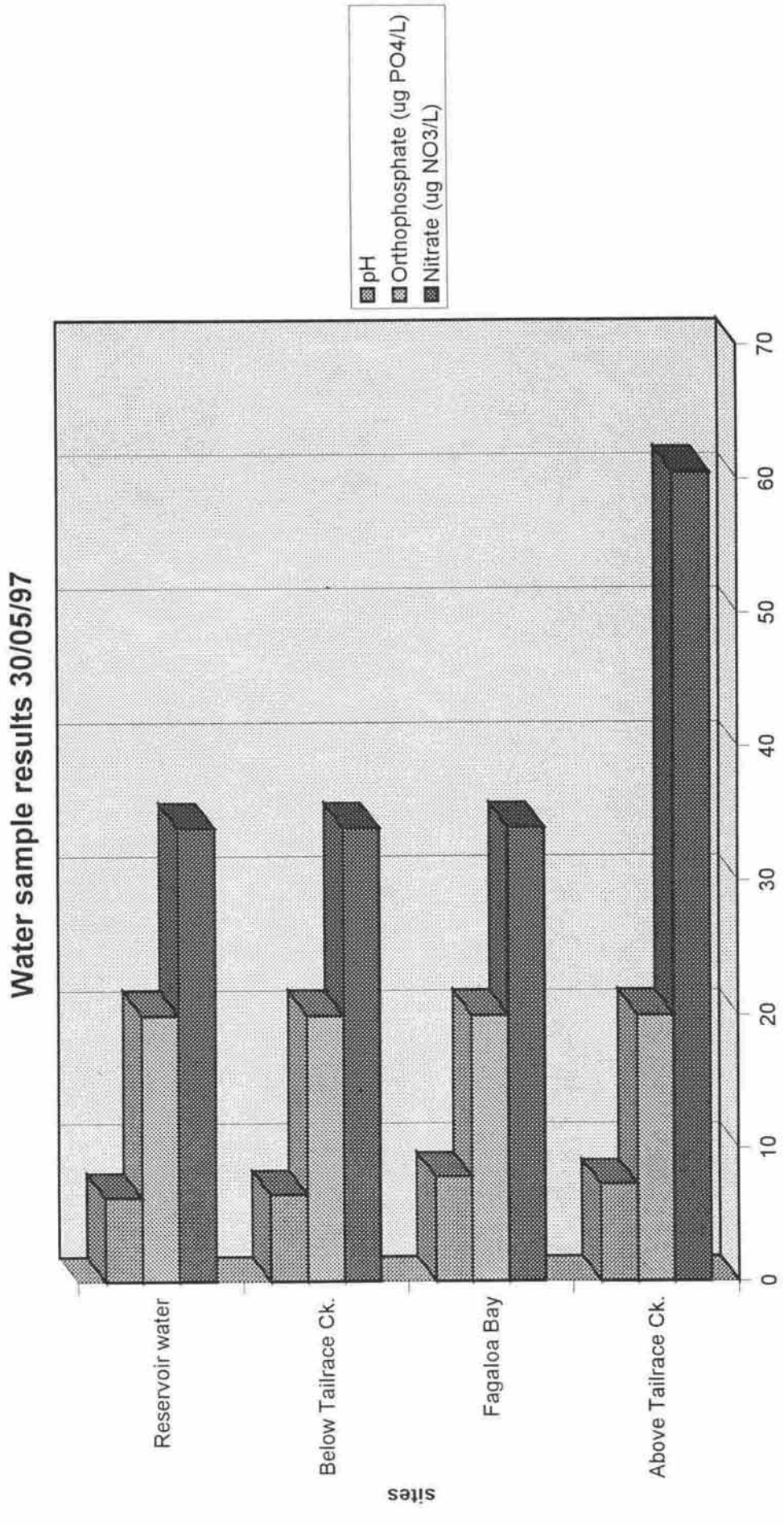
28/5/97	7.4	6.2	3.8	3.7	3	2.8	

Graphs of Water Quality results: DO levels at depth for three dates




Water sample results 30/05/97
pH
Orthophosphate (ug PO4/L)
Nitrate (ug NO3/L)
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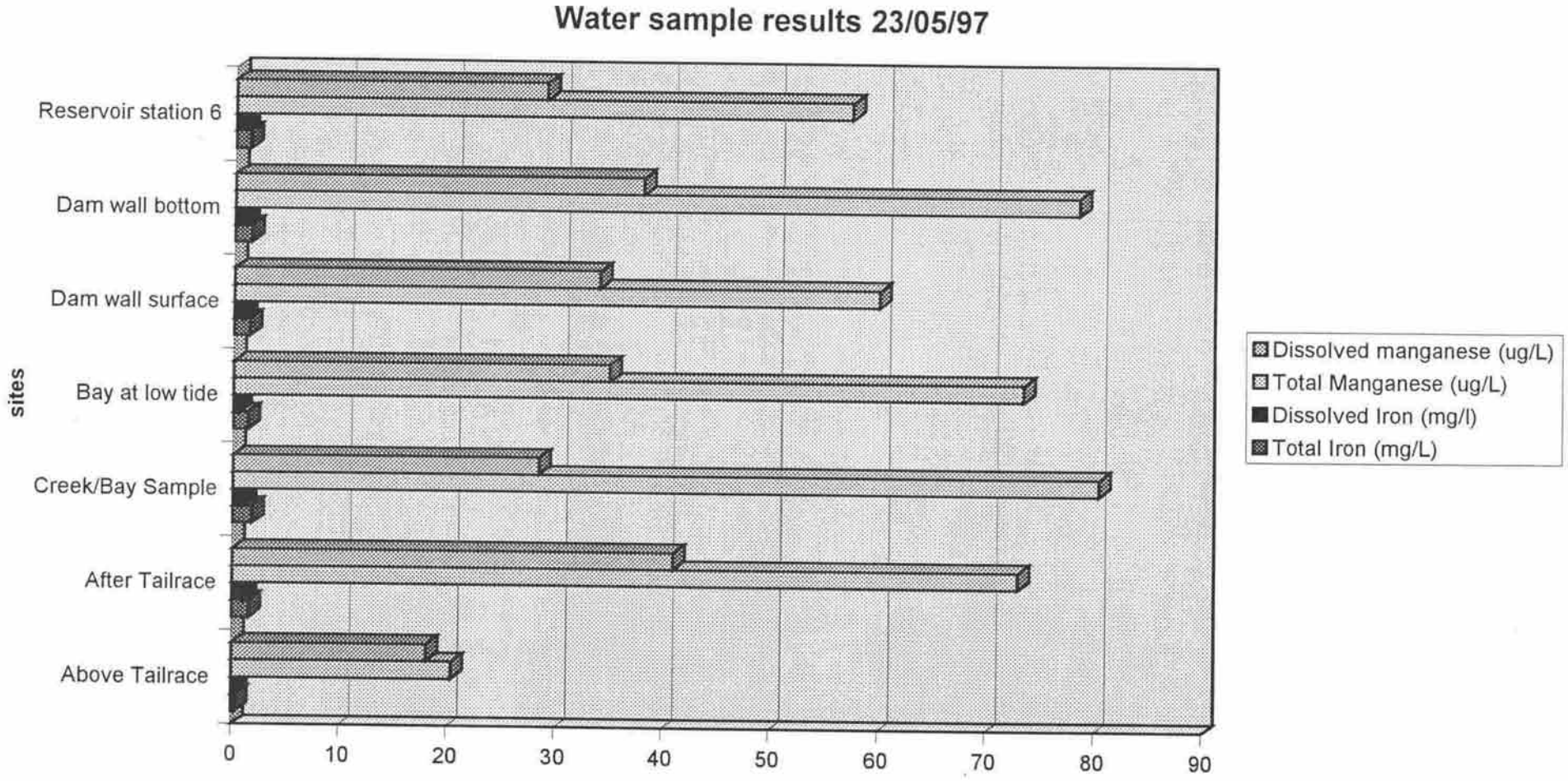
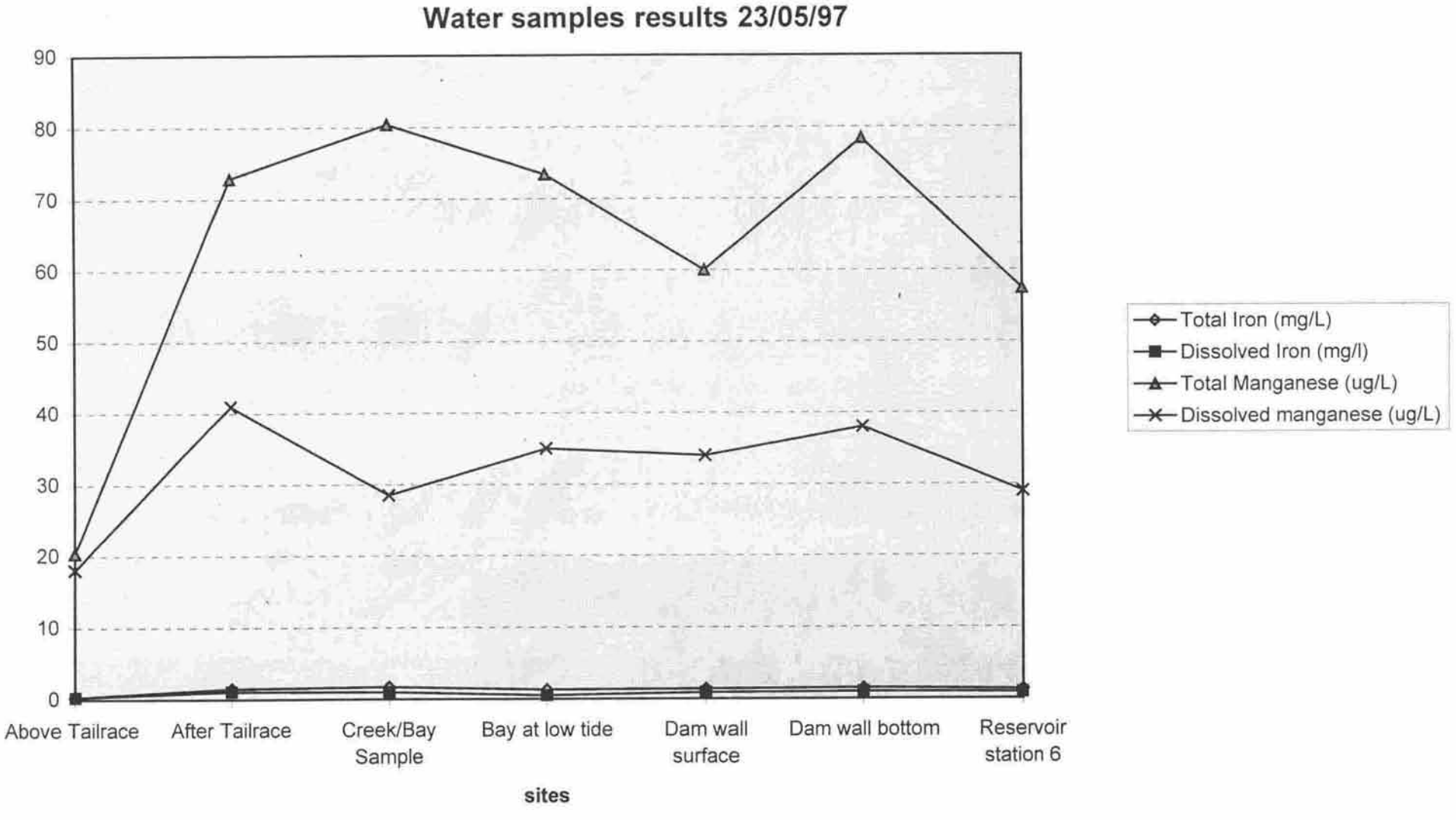
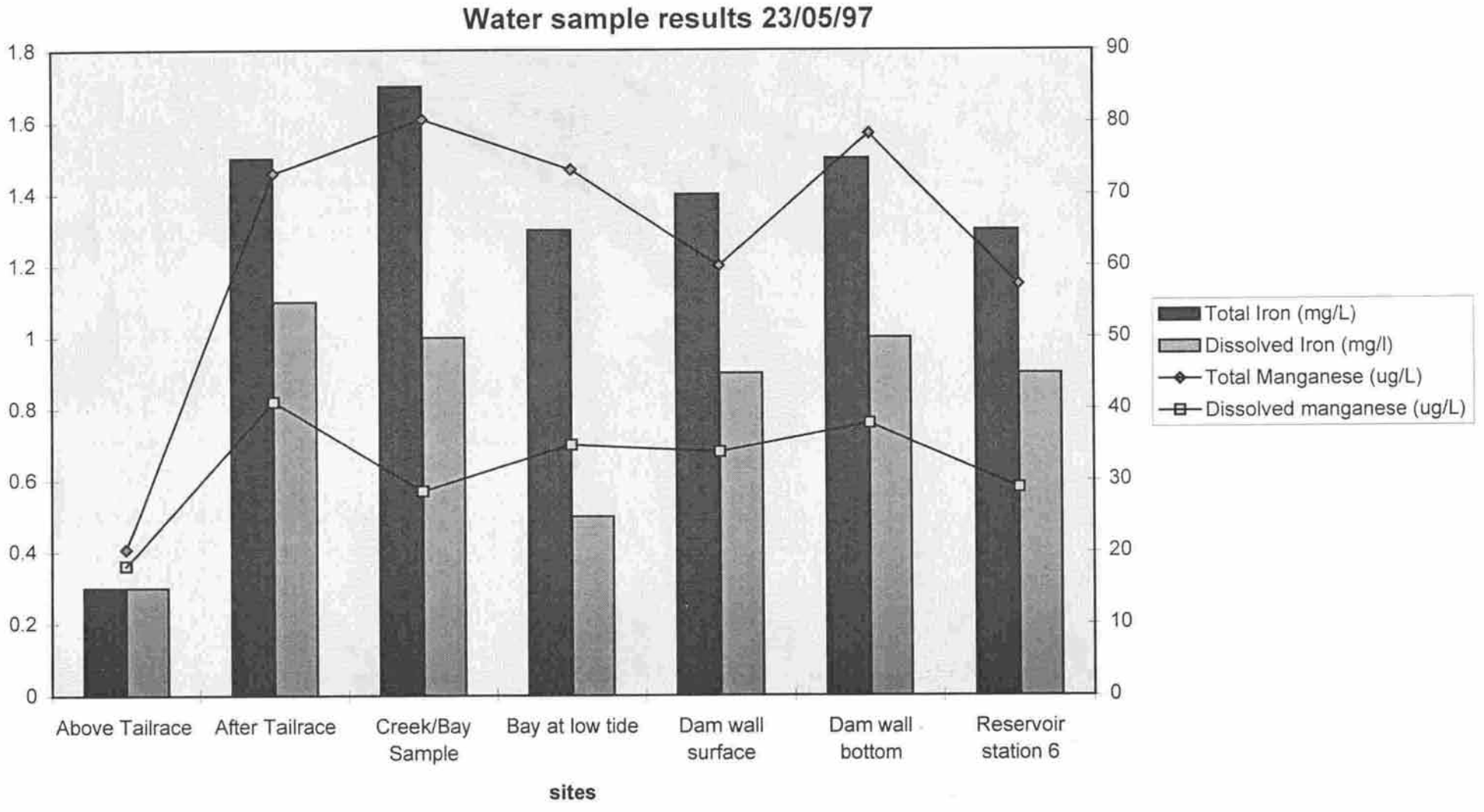
10
20
30
40
50
60
70
Reservoir water
Below Tailrace Ck.
Fagaloa Bay
Above Tailrace Ck.
sites


Water sample results 23/05/97
Reservoir station 6
Dam wall bottom
Dam wall surface
Bay at low tide
Creek/Bay Sample
After Tailrace
Above Tailrace
sites
0
10
20
30
40
50
60
70
80
90
Dissolved manganese (ug/L)
Total Manganese (ug/L)
Dissolved Iron (mg/l)
Total Iron (mg/L)


Water samples results 23/05/97
90
80
70
60
50
40
30
20
10
0
Above Tailrace
After Tailrace
Creek/Bay Sample
Bay at low tide
Dam wall surface
Dam wall bottom
Reservoir station 6
sites
Total Iron (mg/L)
Dissolved Iron (mg/l)
Total Manganese (ug/L)
Dissolved manganese (ug/L)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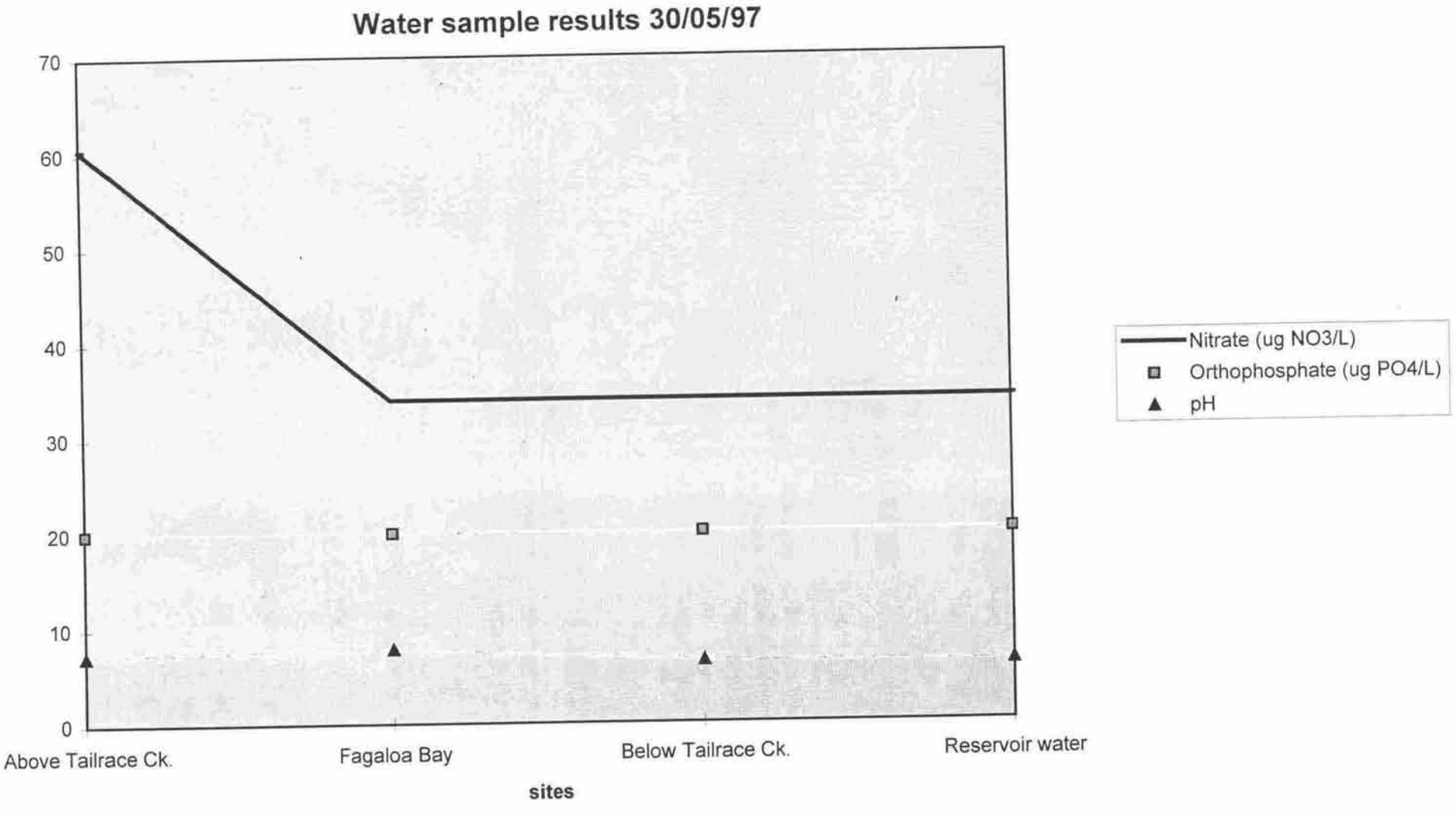
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
90
80
70
60
50
40
30
20
10
0
Total Iron (mg/L)
Dissolved Iron (mg/l)
Total Manganese (ug/L)
Dissolved manganese (ug/L)
Above Tailrace
After Tailrace
Creek/Bay Sample
Bay at low tide
Dam wall surface
Dam wall bottom
Reservoir station 6
sites


Water sample results 30/05/97
70
60
50
40
30
20
10
0
Above Tailrace Ck.
Fagaloa Bay
Below Tailrace Ck.
Reservoir water
sites
Nitrate (ug NO3/L)
Orthophosphate (ug PO4/L)
pH