IMPERIAL COLLEGE

fiji freshwater resources EXPEDITION summer '98

Report

With support and approval from the Royal Geographical Society
http://www.doc.ic.ac.uk/~pasm

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PROJECT INTRODUCTION AND OVERVIEW

AIMS

The Fiji Freshwater Resources Expedition was intended to demonstrate a simple, appropriate and holistic approach to water resource management at a village level on the Fijian Island of Vanua Balavu. The project aims to demonstrate a practical survey methodology whereby the salient features of a village's freshwater supply can be efficiently assessed and documented. It is hoped that such a survey might be deployed by government agencies and other in the planning of future 'Small Island' water resource development. The structure of the survey broadly follows the philosophy laid out in a 'Rapid Rural Appraisal' approach to development. That is to say that the survey should be well targeted, gather data strictly relevant to the purpose of the survey and be within the technical reach of the host nation

This project has set out to demonstrate that a data gathering exercise in the vein of Rapid Rural Appraisal can, when carried out in a systematic and competent way, provide relevant and practical information regarding water resource management on an island community such as Vanua Balavu. By deploying good interview and observation techniques combined with a sound desktop study, it is possible to discern the framework of the water resource situation on the island. At this point a practical, locally acceptable and effective series of solutions can be suggested. We have done this.

For each community we studied we can suggest an appropriate course of action to, in some significant way, mitigate the worst of the water resource problems. (Discuss each village and recommendations). Moreover it is possible to make more general statements about the hydrogeological regions of the island and their potential for water resource development in the context of reticulated borehole supply (i.e. only develop bore hole in the central regions of the island).

The duration of the study was 5 weeks on the target island, with an additional week on the main land.

A PREVIEW OF VANUA BALAVU

The humble island of Vanua Balavu is located in the northern part of the Lau Group. Lau is the most remote province of all the islands in the Fijian archipelago. It is only a one-hour flight but a sea journey may take many days. From the air the island resembles a question mark oddly stretched out. Its centre is beautifully green and rimmed with golden sand. The island surrounded by clear blue ocean and a ring of reef which only allows one narrow passage at Lomaloma (meaning 'the bay within the bay') on the island's east coast. Lomaloma is the largest village on Vanua Balavu and engulfs its smaller sister village of Sawana.

Vanua Balavu itself is 280-km northeast of Suva, the Fijian capital. The island's distant location is particularly ironic considering its important political nature. The Ratu Lau (or King of Lau) always comes from the village of Sawana. Ratu Lau is a hereditary title passed on through the descendants of Ma'afu the Tongan warrior sent to conquer Lau. As the story goes, Ma'afu was a spectacularly brave warrior who subjugated the whole Lau province resulting in his crowning as the first Ratu Lau. He is credited, inter-alia, with fighting off the French by stealing the cannons from their boats while they enjoyed his deceptive hospitality.

Ma'afu made the village of Sawana his home. His descendants still live in the village and keep his proud Tongan ancestry alive. The people of the Sawana hold close ties with Tonga – many still speak Tongan, some have married Tongans to keep their heritage and the village's Wesleyan Minister was 'imported' from Tonga. Today, Ratu Mara is the current Ratu Lau. He is a former British Colonial Governor General, Prime Minister and present President of Fiji. Lomaloma, Sawana's sister village, is mainly made up of people of Fijian descent. Ma'afu had defeated Lomaloma, subjecting its people to slavery, and made his new 'capital' Sawana.

From left to right:
Phil Miller - Samuela Loki - Craig Hunt - Poppy Buxton - Anand Sundaraj - Anna Lewis

Picture taken on the beach at Sawana in front of the island of Yanu Yanu.

LOGISTICS

TEAM MEMBERS

TEAM LEADER

PHIL MILLER

A third year undergraduate reading a Computer Science (Artificial Intelligence) at Imperial College.

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A third year undergraduate reading Physics (with year in Europe) at Imperial College.

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A fourth year from Monash University in Melbourne, Australia reading Genetics and Immunology.

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A second year Biochemist (with year in industry) at Imperial College.

FIJI GOVERNMENT (MINERAL RESOURCES DEPARTMENT- MRD) REPRESENTATIVE

SAMUELA LOKI

A member of the Fijian Government's Mineral Resources Department

ABOUT THIS DOCUMENT

This document was co-authored by the team as above and used sources as described in the bibliography, it was edited by Phil Miller. All members of the team participated fully in the data gathering operation. There are several special interest sections to which members of the team deserve credit.

- The Reticulated Study and meter data analysis, was mainly conducted by Phil Miller.
- The Family Study, which was mostly carried out by Anand Sundaraj.
- The Appendix titled Community Level Water Supply and Outline of the Main Geological Groups (technical overview) was prepared by Craig Hunt
- The Fiji Groundwater Appendix was prepared by the MRD.

Craig Hunt also prepared the methodology used in this study – although as with any expedition this was changed and refined whilst in the target area.

PROJECT INCEPTION

In June 1997 Phil and Poppy became interested in studying the water resources of the Fiji Islands. Phil had previously lived in Fiji and thought that an investigation of the region was worthwhile. A team was assembled (as above) of students qualified in diverse subjects capable of undertaking this project. And it was with this team that we approached Imperial College Exploration Board and other organisations (such as the Royal Geographical Society).

The Imperial College Exploration Board is an opportunity for motivated students to travel abroad and conduct research. It provides financial and logistical backing for projects and also training where necessary. In order to obtain this backing a detailed proposal must be submitted and relevant experience must be demonstrated.

After securing finding from Imperial College (both from the Exploration Board and its Constituent Colleges) the remaining monies were raised from Industry, Academia and other interested organisations.

FINANCE, ADMINISTRATION AND MEDICAL

Administration was provided in part by Imperial College.
The Imperial College Health Centre kindly provided medical training and kit.

OVERVIEW OF OTHER INVOLVED ORGANISATIONS

The Royal Geographical Society (with The Institute of British Geographers) (RGS-IBG) (www.rgs.org) has a long tradition of encouraging and supporting expeditions and field research overseas.
The RGS-IBG's internationally acclaimed Expedition Advisory Centre (EAC) provides training and advice to anyone embarking on an expedition. It is the leading such centre in the world. Each year it assists more than 300 teams, the majority of which are university-based. The EAC runs courses and publishes a range of training manuals on many aspects of fieldwork and logistics.
The RGS-IBG is also the country's main organisation for screening and funding small research expeditions through its expedition grant programme.
Through the RGS-IBG we obtained a grant from the Goldsmith's Company.

The South Pacific Applied Geoscience Commission (SOPAC) (www.sopac.org.fj) is an independent, inter-governmental, regional organisation established by a few South Pacific nations in 1972. Its Secretariat is located in Suva, Fiji Islands, and has about 54 professional and support staff.

Government of the Republic of Fiji Islands co-operation was from the Mineral Resources Department (MRD) (www.mrd.gov.fj) and the Public Works Department (PWD).

- MRD are the scientific arm of the Fiji Government, they survey and specify the use of natural resources – such as water.
- PWD are civil engineers – responsible for road, pipelines etc…

PROJECT TARGET AREA

FIJI

GENERAL

- The Fiji group is comprised of more than 330 islands, ranging from jagged mountaintops jutting up from the ocean, to coral atolls that rise only a few meters above sea level. Few of the islands are inhabited, the rest being true 'desert' islands. The islands lie in the tropics of the Southern Hemisphere. Fiji's two largest islands, Viti Levu and Vanua Levu, make up more than 85% of the nation's land. The third largest island of the group is Taveuni, a rugged ridge of mountains rising from the sea, having their steep slopes carpeted with rain forests, giving way to coconut plantations on the north coast.
- Four smaller groups of islands make up the rest of the country. The Mamanuca's are off the West Coast of Viti Levu, while to the northwest is the Yasawa chain. The Lomaiviti islands are in the Koro Sea between Vanua Levu and Viti Levu, while to the east and southeast is the Lau group.
- The island of Rotuma stands alone, about three hundred miles north of Nadi inhabited mainly by Polynesians.
- The capital of Fiji is Suva, which lies on the south-eastern side of Viti Levu, with the International Airport located at Nadi on the western side of Viti Levu.

CLIMATE

Fiji's climate is maritime tropical. Daytime temperatures range from 24 to 32 degrees centigrade in the cooler season from May to November, warmer weather with temperatures a few degrees higher from December April. The warmer weather also brings more rainfall, which usually the form of passing tropical showers.

POPULATION

The population of Fiji is currently around 780,000 (in a ratio of about 50% native Fijian to 44% of Indian origin). The balance is Chinese, Pacific Islanders and ex-patriot Europeans.

ISLAND SELECTION PROCESS

The process of island selection was made more difficult be the remote location of Fiji and our particular topic of small islands. In consultation with SOPAC several options were made available to us over the months leading up to our departure and for several reasons we selected the island of Vanua Balavu. This was the most suitable island for our rapid appraisal – it has a well field dug by a previous British expedition (who we were able to get into contact with) and some of the villages are connected to a metered reticulated supply, enabling a comparison to be made between supplied and unsupplied villages. Also an airfield and a direct dial telephone system.

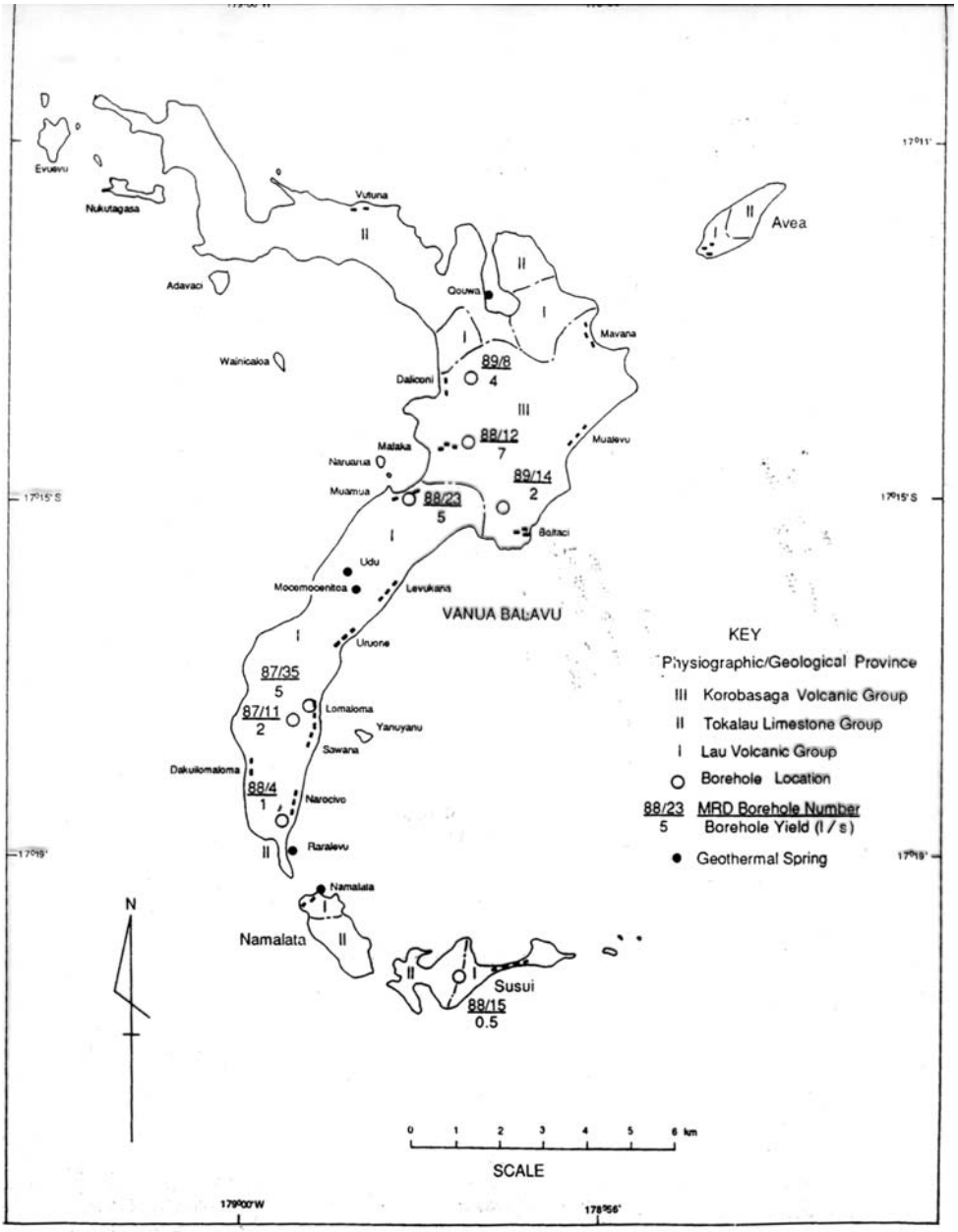


Figure 2 Vanua Balavu, Namalata, Susui and Avea showing geology and location of boreholes and geothermal springs.

VANUA BALAVU - SPECIFIC

WHERE
About 300 km to the north east of Suva in the Lau group of islands

INFRASTRUCTURE AND COMMUNICATIONS
- There is a harbour located at Lomaloma (although at the time of inspection the pier was damaged) and an airstrip at Malaka (see island map). The island is linked to the mainland by boat (irregular service) and plane (regular service).
- There is a system of compacted dirt roads that mostly follow the coastline and link up the airstrip to most of the villages. There are very few privately owned vehicles, however there are some minibuses, which provide public transport.
- Power is provided locally to some villages – mostly oil based generators (some houses have solar power) – these generators rely on government provided oil to run, the government plans to enforce billing soon. For the most part power is not 24 hours a day, only being on around breakfast and evening meal times.
- The island was recently connected to the direct-dial exchange and does for the most part no longer rely on radiotelephones. The telephones are solar powered and therefore do no rely on unstable local power supplies. Post goes on the planes.

INDUSTRY
- Copra – a coconut derivative is the major source of income. The copra is harvested on the island and sent for processing in Suva (their own oil refinery – in Sawana – has been closed).
- Tourism – there is a growing element of tourism on the island. It is well linked due to the existence of the airstrip. There is one resort – Yanu Yanu (owed by President Mara) with others planned.

AGRICULTURE (SMALL SCALE)
- Coconuts
- Bananas
- Taro
- Yams
- Kasava
- Some farming (on a mostly domestic level) – goats, pigs, chickens and cows.

From Daliconi – a old crater edge can be made out surrounding the bay

From taken from a plane on final approach to Vanua Balavu – clearly showing the typical coral atoll layout of the Fijian islands

HYDROGEOLOGY OF VANUA BALAVU

OUTLINE OF THE MAIN GEOLOGICAL GROUPS (TECHNICAL OVERVIEW)

- The island of Vanua Balavu is geologically dominated by 2 major volcanic episodes in the recent geological past. The Southern and Central regions of the island are, as expressed by their arcuate nature, the remnants of a local volcanic centre some 5km East of the village of Lomaloma. The dominant phases of volcanism are the characteristically basaltic/andersitic late Miocene Lau Volcanic Group, occurring in the Southern "spine" of the island and the broadly more basic early Pliocene volcanics of the Korobasaga Volcanic group occurring in the central highland region. The Tokalau limestone group, exposed in the north and southern tip of the island, representing remnant fringing reef development between these 2 periods of extrusive activity.
- These geological divisions of the island lead to the 4 broad physiographic / hydrogeological groupings:
  1. The central highland region, with the Lau group to the south and the limestone to the north, is characterised by deep steep sided predominantly dry drainage valleys, which are erosionally active during the rainy season, and typical of morphology dominated by high energy flash flooding. This region has the largest elevation range on the island. It rises from sea level to the peaks of Namanunu and Sosoilomati at some 220m. Whilst this volcanic group has a geochemical evolution which differentiates it from the southern Lau group (it contains episodes of volcanics with a more iron and magnesium rich mineral assemblage) of greatest hydrogeological concern is the substantial volume of epiclastic sandstone and breccias associated with this group. With a strong presence in the south of the central highland region and underlying some 80% of it's total area to quite some depth, these porous bodies of locally derived weathered volcanics act as potential aquifers (with both substantial potential transmissivity and storage) in a way that the unweathered basaltic/andersitic deposits could not. The presence of this potential aquifer combined with the large relative surface area for recharge, deep seated fracture networks with clear surface expressions, and in island terms, a reasonable distance from the marine environment, offers the greatest potential for water resource development on Vanua Balavu. Indeed the 2 presently active wells, which supply almost the entire reticulated supply for the island, are located in this region. Examination of these 2 well points finds them located on surface exposure of the epiclastic deposits at lower reaches of substantial drainage valleys. Here potential recharge to the underlying aquifer and the chances of intersecting a hydraulically conductive fault zones are maximised.
  2. The Lau Volcanic Group forms the southern spine of the island. Extending in a continuous strip from the southern boundary of the Korobasaga volcanic Group until exposure is replaced by the southern fringing limestone (Naga and Namalata) and occurring as strips of exposed breccia overlain by the Tokalau Limestone Group directly north of the Korobasaga Volcanic group. Once again drainage morphology dominates this region with steep incised valleys cut from a central drainage divide to the sea. A number of the valleys are dry only becoming active in the rainy season. Geologically this group is marked by a more acidic geochemistry with a combination of basaltic and andersitic volcanics. In regards to the hydrogeological environment however, this region is in marked contrast the volcanics of the central region. Of primary significance is the substantial reduction in the prevalence of epiclastic deposits. This most probably signifies less quiescent periods between eruptive episodes in which weathered deposits could build up. This leaves a great deal less volume of potential aquifer in this group, which is reflected, in the relatively poorer well development (see Well Points). Combined with a high coastal area to catchment size and overall lower terrain (approx. mean of 60m, resulting in rain being caught further north) this group offers considerably less well point development potential than the Korobasaga Volcanic Group to the north. It is important to note that this region's well developments have suffered from significant marine incursion. This is most probably as the result of the inevitable proximately to the marine environment, the presence of faults, which cross the sea land the location, and operation of the well points themselves.
  3. The Tokalau Limestone Group occurs in the north of the island overlapping onto the small region of older Lau group breccias to southeast. It also has an occurrence in the south of the island forming the dominant area of the island of Namalata and some 40% of Susui. It is the remnant of fringing reefs developed in shallow seas surrounding volcanic islands. The group is composed of reef frame building corals and other biogeneics as well as more massive precipitation beds. The

topography of this group is less defined by ridges and peaks and there is substantially less development of the sharp incised valley, possibly reflecting a more resistant rock mass and a lower run off potential for the limestone. That is to say that the drainage morphology is less controlled by the development of rivers and possibly dominated by the occurrence of dissolution fluid pathways through the rock mass. Indeed the Limestone regions of Vanua Balavu have extremely poor hydrogeological development potential, relying almost exclusively on harvesting rainwater before it percolates away through the rock mass. Some thin clay and silt layers develop as soils and alluvial deposits in the deeper valleys, however these offer little transmissivity and less storage for serious well point development.

4. Contemporary clastic development, or essentially the development of modern beaches, which intermittently fringe the island, may offer some augmentation to the borehole supplies in the more recessed sections of the central region. However, although at points reaching volumetrically significant volumes this fringing unconsolidated deposit is at all times directly connected to the sea. Where development of this physiographic group has been carried out in the form of hand-dug wells and even potential bore hole sites serious salinity problems have been all but inevitable. There is also a substantial potential for the contamination of this water via pit latrines dug into the same fringing group. This deposit should not be seriously considered for the siting of wells.

SURVEY APPROACH OVERVIEW

AIMS

- To calculate a per capita water consumption value for Sawana village
- Comparison of Sawana community with surrounding communities

And with the assistance of the Mineral Resources Department (MRD) and the Public Works Department (PWD) of the Fiji Government:

- Documentation of present bore hole water reticulated supply and proposal for future development of the reticulated supply
- Geo-chemical sampling of surface and bore hole water supplies throughout the island

The only equipment carried by every member the team was a notebook and pen – with the exception of when we were sampling water quality.

Royal School of Mines – notebooks were our main recording equipment.

A pump test being carried out by MRD and ourselves at the Daliconi site.

The access road to Daliconi was little more than a dirt track and made maintenance and even operation at times near impossible.

RETICULATED STUDY

During the late 1980's a series of exploratory bore holes were drilled in a combined Fiji and British Government project. In recent years three of the bore holes have been explored as a mains water source by the PWD. Part of this expedition's remit, in co-operation with MRD was to fully document the present system and report these findings. (See reticulated map)

On Vanua Balavu there is a newly installed reticulated supply, which was 3 years old at the time of the study. About 50% of the island's population are covered by the reticulated supply.

METHODOLOGY

- Contact relevant PWD representatives, local government administrators, and community leaders
- Visit all relevant operational and non-operational bore hole sites
- Obtain detailed maps of mains system and documented details of water supply infrastructure (storage reservoirs, pumps houses etc.)

It was also envisaged that, in consultation with an MRD representative on our expedition, an outline strategic plan for the future development of the bore hole system be jointly proposed. The situation was complicated by socio-political considerations, particularly in regards to issues surrounding water ownership and distribution. Relevant interviews were conducted to clarify this situation. Any future development of the bore hole mains supply network must take such local concerns regarding land/water/infrastructure into consideration.

OBSERVATIONS

(see also Appendix - Fiji Groundwater)

FRESHWATER LENS

- When considering the occurrence of ground water, particularly on small low surface to shoreline ratio islands, it is more realistic to picture fresh water as forming a lens below the island mass. The upward curves of the lens being due to a density gradient (picnocline) with the incurring salt water. The form and dimensions of this lens are maintained in equilibrium between the often-low levels of groundwater recharge and the continuous presence of the marine environment.
- Within such a balance the potential for marine water to penetrate and pollute freshwater supplies is ever present. For this reason it is imperative that bore holes located on small islands do not exceed the recommended pumping rates for fresh water supply.
- Such a "mining" of water, where well output exceeds recharge, can rapidly lead to marine incursion and long term damage to the aquifer. Where hydraulically conductive fractures transect the freshwater lens and penetrate into the marine environment the potential for marine water incursion into the drinking supply can be substantially larger. An important consideration when relying on fractures as the transmissive element in hydrogeological location of bore holes.

OVERVIEW

- There are currently 3 tapped sites (Daliconi, Malaka and Lomaloma), with 2 working pumps (Daliconi and Malaka) and one of these is constantly running this water is piped either to connected villages or to mains reservoirs (there is no spare pressure to do both at present). The effect of this is that there is no redundancy and no spare capacity. This means that there is no systemic redundancy for recharging of the freshwater (a major cause of saline incursion) or maintenance – both of which are important to consider – especially since the effect of marine incursion can be long lasting.
- Originally the Daliconi and Malaka sites were not connected to the Lomaloma site – as specified by MRD.
- We found that the Lomaloma site and the Malaka and Daliconi sites were linked by pipe and together supplied the whole island. This was not known about by the MRD (who should have been informed). This was done by the PWD without proper consultation about the knock-on effects to the rest of the system.

This 20,000-litre tank, near to Malaka, was generally filled at night – but had no stop value and was prone to overflow. It represents the islands main reserve tank.

The island of Yanu Yanu also contains a 5,000-litre reserve tank which like the main reserve had no stop valve and was prone to overflow.

- At the time of investigation the Lomaloma site was closed due to pump failure. Although closed, Lomaloma has been proved to be silty and saline, this is a sure sign of marine incursion. It has also had to be dismantled and cleaned 3 times for silt in the last 6 months (which is how long the current PWD worker has been posted on the island –historical data before this time is not available). This should be properly tested for saline intrusion before recommencing as a production site. This site was not available for chemical testing at the time as the pump was broken (and it needs to be pumped for a continuous period of time before testing is reliable).

COMMENTS

- In the morning the pressure is particularly low – unless all the pumps are operating. There is also a problem with pressure at the end of the system (toward Namalata – see village study), with no water for most of the day – only in the non-peak evening and night times.
- The general impression we received from the villagers was that they perceived the reticulated supply to be infinite and their birthright – whereas in Fijian law anything more than 3 feet below the ground belongs to the government and they may use (and taxed) this as they please. They had no concept that the supply might be ruined or used to such an extent that it no longer existed.
- The government hopes that by enforcing payment for the system they will be able to coerce the population to use the supply better.
- The main reservoir (a 20,000-l tank at Malaka) is on pressure filling system and only works when both pumps operate or when one pump is exclusively diverted to it (cutting off the rest of the island – this is usually done at night).
- The pump rates of the main system were carefully monitored and estimated usage can be worked out for each connected village. With this in mind and knowing that the pressure reservoirs do not fill each night we conclude that there must be large-scale leakage. Some of this leakage is certainly domestic but we concluded after much study and data analysis that this can only account for about 10% of the whole leakage.

DOMESTIC LEAKAGE

There is substantial loss at the domestic level through both tap and pipe failures, both through negligent use (most of which could be fixed with a 2p washer). Also there is irresponsible use of private reservoirs, which are left to overfill. It is likely that charges for water will help to prevent the latter if properly collected. Also, hopefully, this will encourage maintenance of the reticulated system as a whole. On the issue of payment, there were mixed feelings towards this subject as the locals felt that the government should provide this service free. Many said that they would go back to their old ways of collecting water and stop using the mains all together.

MAIN LEAKAGE

- The leakage is difficult to find, as soil drainage is very good and therefore large losses of water are not obvious – there is a need for specialised equipment to detect this.
- We found evidence that some of the pipes above ground had been damaged due to bush fires. However, most of the pipes are not visible and it is easy to see in the villages that there are greener areas around the pipelines – which suggest leaks on a small scale.
- The majority of the leaks are left unaccounted for – on further investigation it was found that there was a great source of wastage from a private reservoir. There is a private resort island just off the shore from Lomaloma, the island of Yanu Yanu. Over the resort there are 2 5,000-litre storage tanks. These are filled each night. This will not take long and then instead of having a cut off (such as a simple ball valve, common to toilets), the tanks overflow. The knock on effect of this is that there will not be enough pressure to fill the rest of the system when the tanks are being filled. Though it should be stated that when the other reservoirs are on at night they also a prone to flooding – this is an avoidable waste of water.
- There is evidence that the Lomaloma site was pumped beyond the recommended 8 hours a day – sometimes for as much as 24 hours a day. This may well have led to the permeate damage of this site.

- The supply of diesel fuel is erratic and is often lent to the villages to supplement their own electricity generators. At the time of our departure the island only had enough diesel for another 2 days of pumping and none for the villages.

RECOMMENDATIONS

- There is spare capacity at night when consumption is low. At the present there is no automatic system for pressure regulation. This spare capacity at present is used to fill the Yanu Yanu tanks.
- Daliconi's recommended pumping rate (rpr) is 6.4 litres per second.
- Malaka's rpr is 4.6 litres per second.
- Given the rpr information it should be possible to completely fill 2 20,000-litre tanks from empty at night. This should be enough to supplement Lomaloma and Namalata's at peak times. This should also boost pressure uniformly throughout the south part of the system.
- Evidence from the Muamua reservoir suggests that a small (5,000-litre) tank would be sufficient for Namalata over a period of days. This might also be the easiest place to connect to Dakuilomaloma and with the improved pressure there should be enough water for both villages.
- Another suggestion is to fit valves to shut down the supply to tanks when they are full to prevent avoidable wastage.
- To increase system capacity another borehole should be opened up – this should not be a reopening of the present Lomaloma borehole – there are several sites for this Mualevu (89/25), Lomaloma (1995) and Muamua. Only Muamua has been successfully pump tested at 1.7 litres per second – the other 2 were salt positive on a previous testing – this problem may have gone now and we suggest that they are pump tested for their suitability of supply. Alternatively locate another entirely new borehole site, perhaps an investigation for a new production site should be in the northern central highland area. There may be untapped potential here not exploited by current production sites.
- There is a need to check for tidal effects, to see if salinity changes through the tide cycle – indicating communication with the sea and perhaps change the pumping rates accordingly. Also it may well be an idea to allow the pumps to adjust the pumping rates according to system pressure, although this would require the other shortcomings in the system to be sorted out first.
- On a cautionary note: over-pumping has caused saline incursion at Lomaloma. Any new site should be pumped to check for silt and saline intrusion – as this may not be evident at the time of the first pump test.
- Lomaloma should be sealed – at the very least to allow recharge of the freshwater over a period of years.
- There are special need sites that do require immediate attention: these are Susui, Avea (via Mavana – which has at the moment no reticulated supply) and Dakuilomaloma (this is the most urgent site).
- A final point on this subject is that there is no proper road surface to the Daliconi pump site – this makes the pump unmaintainable when there is sever weather. Any new production site should be properly linked with a permanent road surface and the road to Daliconi should be upgraded.

PER CAPITA WATER CONSUMPTION VALUE FOR SAWANA VILLAGE

The central focus of the Fiji Freshwater Resources Expedition was to demonstrate and evaluate a methodology for determining the average water consumption for a 'typical' village household on the island of Vanua Balavu. This study was clearly limited in that there is a range of socio-economic conditions both between individual households and village settlements that will affect this value. In addition the study was restricted to 24 households during a 4-week period in the dry season. It is suggested, however, that the water consumption figure generated will be of assistance in future water resource planning as well as establishing a base line from which longer term and possibly more detailed studies could proceed.

In addition we obtained information for the potential change in water consumption during the summer season, the approximate percentage water loss in the bore hole reticulated system through leaks at a village level (from Sawana main through to individual households). Also we investigated the present scheme for metered water.

METHODOLOGY

- Daily individual household bore hole meter reading (attached to each mains supplied house)
- Observation of individual households
- Interview
- Accurate mapping of properties and water points (primary and user) in sample region of Sawana combined with census data

To determine a working water volume per household (per capita) value by the study of selected households in Sawana Village. The derived value will be categorised under:

- Bore hole water use (cooking/washing/cleaning/tea)
- Rainwater tank use (drinking/occasional cooking)
- Other sources were not applicable

A Sawana village meeting – where we discussed the aims of the project

These are pictures taken of the old reservoir at Sawana – which is now disused and at the time of the study also empty due to lack of rain. It was infested with mosquitoes and stagnant.

MAIN SAWANA STUDY

SURVEY STATISTICS

Population: 250
Households: 50 / 24 interviewed - 50 individuals interviewed (4 man-days)
Reticulated: 100% / metered
Rainwater tanks
- Personal: 25
- Community: 1

Sources: Tank / Reticulated / Reservoir / Jiovu

Sawana village was selected as the central community of the project. It was the project's intention to intensively study this village in order to establish an analytical framework or baseline survey from which to develop our understanding of water resource management of the island. This village was considered particularly useful because it had a metered reticulated supply - providing us the opportunity for a detailed understanding of water usage.

To this end 24 households were targeted for observation, interview and water meter monitoring. Project members also took the opportunity to discuss issues relating to the water supply in the village with residents outside of the 24 households.

From the large number of interviews, discussions (formal and informal) and several village meetings, we were able to record the following.

- There is a clear self-imposed differentiation of water use according to its source.
    1. The reticulated supply is almost only used for washing (personal, food preparation and small-scale agriculture). Occasionally it was used for cooking but rarely was preference expressed for the use of this water as a drinking supply. The vast majority of those interviews expressed the opinion that this water was salty, silty after extensive rain and there was a strong belief that illness was related to the drinking of un-boiled tap water. A number of interviewees suggested that this water be drunk.
    2. Approximately half of the houses studied had their own rainwater harvest tank supply - generally reliant on the roof-space area of their own property. This water was almost exclusively used for drinking and cooking. As a resource this was in high demand during the dry season and in a number of instances padlocks were used control personal supplies. This is not to say that a household water tank would necessarily be used exclusively by that family alone and during our period of study in Sawana the project encountered a complex social interaction regarding the use of personal supplies of water. The only truly communal supply was the village tank, which was often referred to as the Ministers tank because of its location - people from Sawana, Lomaloma and other surrounding villages used this as well in times of drought. Tanks are of a basic concrete construction with rudimentary filters, which result in the introduction of potential pollutants - although no complaints of illness resulted from this supply.
    3. There was an unprotected reservoir supply in the hills behind Sawana is now all but disused (since the introduction of the reticulated supply) and we found this to be stagnant.
    4. Evidence suggested that the jiovu had not been used for several years. On average an adult will drink between 2-4 litres of water and tea a day, with working me needing some 6 litres. Children consumed as little as 1/2 - 1 litre per day. This figure does not include kava (see Kava study), which can account for 4 - 6 litres per adult per day. In the summer this figure is estimated to rise by 50 - 100%.
- In order to establish whether the preference to rainwater as the primary drinking supply was a psychological difference, we performed a kind of *"Pepsi Challenge"* to test which source was of the preferred quality. We gave people two glasses of water: one from the tap (i.e. the reticulated water), and one from the rainwater tank. We found that the vast majority of the 50 participants of this test were in fact able to taste the difference - showing a clear preference to rain water, in many cases spitting out the reticulated supply. It is also of interest to not that Imperial Expedition members were unable to taste the difference. A number of people pointed out that although they did not like the supply it was considerably less salty than it had been in the past. (see geochemical sampling study).

- People were generally unaware of the volumes of water that they consumed -for the most part underestimating this value in relation to the metered readings. There was also very little awareness of the amount of wastage, as the study continued this changed (see Metered Reticulated Supply).
- Through the process of interviewing and through the medical personal in Sawana, it was established that there was very little illness occurrence of the illness associated with an impure water supply - i.e. scabies, cholera and dysentery, although there were occasional reports of diarrhoea.
- On occasions the water from coconuts were used as a substitute for fresh water.

The pier at Sawana is broken

One of the main industries in Sawana is fishing.

METERED RETICULATED SUPPLY

TEST CASE IN SAWANA

- 24 Households were targeted – each household being interviewed and their meter read at the same time each day (this was carried out for 24 consecutive days).
- 2 units (1,000 litres per unit) per day per household were consumed
- Consumption, although strongly centring on a mean of between 2 – 4 thousand litres per day, does range from 200 litres to 10,000 litres. Most households stay within in this range where there is a properly managed supply – see house 210 (210 was where we stayed and had 12 people for most of the metered days), however, a significant number were greater than this due to leakage. This increased the Sawana average.
- A per capita value is difficult to calculate whereas the average for a household is not.
- The total village of Sawana consisting of 50 households uses approximately 100 units per day, including leaks. Approximately 70 units of this are metered for, leaving 30 units for leaks. Leaks mainly occur at night when the pressure is at its highest – as it is not being released by working taps (about 1 litre per second – see utilisation of night water recommendation in Reticulated Study). Most of the wastage is not due to pipe leakage but due to taps being left on or being broken (a simple washer in 9/10 cases)

Comparison Of Obtained Value With Surrounding Communities

Once established the above value combined with other relevant information gathered in Sawana will be used as an analytical framework to study the water provision facilities and conditions in surrounding village communities. As such Sawana acts as an initial handle by which the project is then able to view and, at an initial impressions level, assess the access and attitudes to water of selected surrounding communities

Methodology

- Observation of individual households
- Interview
- Accurate mapping of properties and water points in sample region of Sawana combined with census data
- Where appropriate of communal water points instead of meter readings

Villages were very welcoming when we went to visit and arranged events to introduce us to their communities. Here Poppy is enjoying a village meal in Susui.

SUSUI

SURVEY STATISTICS

Population: 86
Households: 20 / 20 individuals interviewed (2 man-days)
Reticulated: NA
Rainwater /tanks/jiovu
- Personal: 8
- Community: 2

Sources: Tank / Spring

INTERVIEW SUMMARY

- Spring water is only sufficient in the rainy season.
- From observation and interviews we estimate that during the dry season the average household consumes 50 to 60L per day for bathing, washing dishes and cooking from the tanks or tap (depending on what is available). Each person drinks 2.5 to 3L per day. Clothes are washed at the jiovu and spring pools
- General sense that the water supply was insufficient
- Did not feel that the reticulated supply would be a solution, but further storage tanks for when existing supplies are plentiful.

The tiny island of Susui is located to the south of Vanua Balavu. There is one main village (Susui) with a population of around 60 people and a small copra farming settlement, called Wainiceva, where only three people live. Susui had seen more prosperous days in the 1980's when certain rare species of *beche de mer* (sea cucumbers) abounded in the area. These were particularly favoured delicacies in Asia. However these had been almost hunted to extinction. The main source of income on the island is copra. Most families still depend on fishing for food but this is limited as an income source since there are only three motorised vessels in Susui.

SOURCES OF WATER

1. Spring catchment area

The main source of water in Susui comes from a spring water catchment dam located about 1.5km from the village. There is a naturally occurring spring at this point and a catchment area was built to harvest more rain water and to protect the source from debris and animals. The catchment is a rectangular shape and measures 3m by 5m. (See fig. below.) Because the catchment area is elevated above the village, a pipe was built from it to the village so that it could be constantly supplied. After the rains come in July the village has a constant supply of water until around February or March by which time the spring has dried up. The water is then rationed until it rains again.

We visited Susui in July, Usually the beginning of the rainy season, by this time the rains should have started but had not. The water situation was critical. The level of water in the catchment was very low, perhaps only 30cm, and the water was murky and dirty. At the time of our stay, water was being supplied to the village only every four days when the torani koro (elected mayor) turned on the supply for 3 hours. There were around ten taps in the village all of which would be turned on when water was being supplied and water would be collected in buckets and other vessels.

2. Rainwater tanks

Susui possessed two large rainwater tanks with an approximate radius of 2.25m and a height of 2m. One is located in the north of the village, next to the church, and is supplied by water that flows from the roof of the church. The second tank was located almost in the centre of the village, south of the church, and was supplied by the roofs of the surrounding houses. Both tanks were built in 1995 with money donated from the neighbouring island of Natomba. Both tanks are for the public use of anyone in the village. At the time of our visit the water level in both tanks stood at around 10cm. This was particularly dangerous because the village depended on these tanks when the taps were shut off for drinking, bathing and cooking. The tanks had been refilled in March by a delivery of water from Lomaloma.

A boy is drawing water.

A woman takes water from a storage tank in Avea, this is an offshore island with a couple of its own tanks (20,000-litre) – but these were almost empty at the time of the study.

In addition to the two large tanks, the school (in the village's south) had four small tanks - however one was in a state of disrepair. Around six houses have their own private tanks. These were kept locked - to prevent theft - and were used mainly as a source of drinking water.

3. Jiovu (hand-dug well)
This is located about 1.5km to the north of the village. The jiovu is used exclusively to wash clothes. It is 1.5m deep and has a radius of 1m. The water level fluctuates all year round. At the time of our visit the level was approximately 40cm. The water is not of high quality. This is due to the fact that the women contaminate the jiovu by throwing their used water away very close to the well.

4. Natural spring pools
On the west side of the island are three naturally occurring springs very close to the beach. This water appears very clear but is a little salty. It is used for washing clothes and bathing. It is located 20 minutes walk from the village and so is not regularly used. The younger women tend to use these springs for clothes washing while the older women use the more closely located jiovu.

THE USE OF WATER
We spent one day observing the amount of water taken from the two large tanks.

Approximately 400L was taken from the church tank during the course of the day.

From the second tank approximately 200L was removed however this tank was locked shortly after lunch. This was because we made the discovery that there was only a small amount of water left in it and we suggested that the use of one tank be restricted. It was alarming that the villagers themselves had not checked the water level and were completely unaware that both were nearly empty. During the long dry periods when the spring catchment dries up and is rationed, these two tanks are essential because they are the only source for drinking, cooking and bathing. From our observations that day we would assume that 400L of water is gathered from each tank daily. When the spring catchment water is plentiful and the tap supply is turned on, tap water is used in preference to tank water. During these times the tanks are not used. In other words they serve as the emergency source. During the wet season, large enough volumes of water flows from the spring to supply the village throughout the year were storage facilities available.

WATER AND HEALTH
From our interviews with the villagers and the district nurse there were no water related health problems. The villagers and their children appeared healthy. We did not see any instances of scabies.

RECOMMENDATIONS
The village, during our visit, is critically short of water. During the dry seasons it is not self-sufficient but relies from water being shipped in from Lomaloma when the tanks are exhausted. Water is shipped in twice during the dry season. This is an expensive and unreliable exercise. As such there is a clear requirement to increase the volume of potable water accessible to the community. The projects initial impressions would suggest that much larger facilities for the safe storage of rain water are required, including filtering systems to prolong the storage potential of the water. These could be filled from rainwater, which still falls in intermittent patches during the wet season, and were facilities provided from the long-term storage of wet season water, both spring and rain. The later suggestion would require some degree of treatment of the water as well as filtering (possibly chloratisation of the water) but would be perfectly suited to non drinking consumption such as washing and possibly cooking, whilst freeing up scarce recently gathered rainfall for drinking purposes.

It is also clear that the spring needs greater protecting from animal and pollutant incursion. A protective wall, covering and possibly gravity flow system to the storage tanks are recommended.
Clearly the cost of these developments is somewhat prohibitive, however the cost of importing water 200 miles over open ocean is by no means cheap. In the mid term the supply of substantially improved water supplies to the island of Susui would provide economically significant returns as well enabling the community to have an adequate supply of water, and control over it's own water affairs.

NAMALATA

SURVEY STATISTICS

Population: 69
Households: 3 / 6 individuals interviewed (2 man-days)
Reticulated: almost 100% 18 taps
Rainwater /reticulated/tanks/jiovu
- Personal: 8
- Community: 2

Sources: Tank /reticulated/jiovu Spring
Drinking water 4l/day average

INTERVIEW SUMMARY

- The borehole water is, as in Sawana, used predominantly for washing and to a lesser extent cooking. It was considered to muddy and/or salty to consume as drinking water.
- Being at the end of the reticulated supply this village often suffers from intermittent supply is highly intermittent sometimes stopping for up to four days. According to the villagers Namalata is the lowest priority village as far as water supply goes. It is served by a pipe, which has been laid down the east coast of the island which supplies all the other villages on the way. The water pressure is usually low.

SOURCES OF WATER

1. Reticulated

We counted 18 taps. All but one are metered, most have brass taps with a concrete base and are unprotected. Usually a variety of large and small vessels surround each tap, which are filled with water when the supply is turned on. On average there is the capacity to store at least 100L at each tap site. The taps are utilised by one to two families.

2. Tank water

In Namalata there is no shortage of rainwater tanks. Most houses have their own tanks. There are two large concrete tanks - one rectangular and the other a large cylindrical tank. Neither are used as the former is empty (it has been empty for two months) and the latter cracked. There are at least 6 covered tin tanks fed of the roofs of houses. Three more are in varying stages of completion. One house has three concrete rainwater tanks built into the structure of the building. There is an active program in the village - under the direction of the village minister - to build a tank for each family. This is a fantastic initiative, owning your own source of water gives the villagers more control over their resources and much less dependent on the reticulated system which is highly unpredictable. This program gives the villagers not only a sense of ownership of their water source but also a feeling on independence.

Unfortunately it is unlikely that Namalata will ever have enough water to be independent of the reticulated system. The rainwater tanks provide enough water to drink and cook with, however it is the water collected from the taps (when they are turned on), which is used for bathing and washing.

3. Jiovu (hand-dug well)

In the village near the beach there is a large hand-dug well. The water quality is particularly poor. The source is dirty and salty - due to its proximity to the sea - furthermore animals drink from and pollute this source. The jiovu in the past had provided a source of water for bathing and washing but is no longer used by the village.

DAKUILOMALOMA

SURVEY STATISTICS

Population: 65
Households: 8 / 20 individuals interviewed (2 man-days)
Reticulated: NA
Small dam reservoir (tap connection to village)
No tank supply
Sources: Reservoir
Drinking water 2-4l/day average
Non-reticulated water consumption - 150-200l/day/household when possible (not much less on occasions)

INTERVIEW SUMMARY

- People are aware of the need for more water but are waiting for it to be supplied as and when the authorities suggest. Despite the abundant presence of water literally 2km away in Sawana there was no suggestion that it should be piped to them, despite the pitiful supply of water available. Water had been promised for years to come, but in no real sense.
- The water supply is simply insufficient to properly wash children let alone adults. Scabies is common.
- Many people lament the decline of the village over recent years, many putting the exodus to other villages and the main land down to the lack of amenities. Without a school, proper clinic, or reticulated water supply Dakuilomaloma it is thought has little to offer. (The development of such facilities would regenerate this community and they would require a substantially improved water supply).
- Many believe that the US embassy had promised to help and had not done so.
- The tap water does, on occasions, give the village population stomach disorders. The water is reported to be dirty after rain.

Dakuilomaloma is a small settlement positioned on the West Coast on the same latitude as the village of Lomaloma. Dakuilomaloma means literally 'behind' hence the village is called Dakuilomaloma - behind Lomaloma. Dakuilomaloma appears to be a dying settlement. The population has dropped to 65. The local high school (in Lomaloma) does not continue past fourth form so many of the families in Dakuilomaloma had left for Suva so that their children may continue with their education.

As with many other villages the main source of income has been copra. Most of the men farm Kasava and other root vegetables in the nearby bush. An intricate system of canals irrigates their crops. Recently money has been injected into the community with the building of a new communication tower on the ridge that separates Dakuilomaloma from the west of the island. Many of the village's men have found employment in the service of Fiji Telecom helping to build the new tower. Unfortunately their employment will cease with the tower's completion - expected to be the end of 1998.Many of the villagers fish to feed their families however there are no longer any motorised boats in the village.

SOURCES OF WATER

Of all the villages that were visited Dakuilomaloma is in a particularly dire situation. There are no rainwater tanks in the village. In 1992 the American embassy in Suva sent surveyors to make plans for the installation of two large concrete water tanks. In 1996 an envoy of the ambassador was sent to assure the village that the American government would pay for the tanks. To date there has been no construction.

The tap system was the only source of water in Dakuilomaloma – there were no rainwater tanks in the village. As a result the tap water was used for drinking, bathing, cooking and washing. During the rainy season we were told that the water was often silty and it was not unusual for some of the children to suffer diarrhoea from drinking un-boiled water. The quality of the water would improve once the rain stopped. However, towards the dry season as the spring dried up and became stagnant the water quality would again deteriorate. At the time of our study the water situation had become fairly grave in Dakuilomaloma. Due to the lack of rain the Torani Koro (the 'mayor' of Dakuilomaloma) had decided to ration the water - turning on the tap system for two hours in the morning and two hours in the evening, at least this is what we were told. On observation, however, we found that Dakuilomaloma only had around one hour's water supply in the morning and even less in the afternoon. One particular afternoon we found that the supply was only turned on for nine minutes! As there was no alternate source of water in the village this was a fairly alarming situation.

Envoys from the US Embassy in Suva had twice been sent to Dakuilomaloma (first in 1992, then in 1996) promising to build (at their expense) two large water tanks for the village. One feeding from the roof of the Church and the other from a number of bure roofs. As a result the villagers had not taken active steps to ensure alternate sources of water believing that the tanks would soon be built as promised.

Water was the Dakuilomaloma family's most essential concern. By all accounts, after the rains had come there was plenty of water, but there was no system of safe water storage, which resulted in near drought conditions during the drier months May through July. Although E (from family study) and his family were physically healthy and clean - due to E's rigid policy of bathing in the morning - we noticed that scabies affected a quite a few children in the village.

Only 65 people were left in the village. Many had moved to the Suva to find jobs and to further educate their children. E himself was planning on sending all his children to live with family in the capital in order that they may complete high school. The lack of water, from my understanding, was a major reason why Dakuilomaloma's population was in slow decline. Its inhabitants had moved to larger villages like Lomaloma or to other islands where water was available in plentiful supply, their children could school and where there was more work. There was no money to be made in Dakuilomaloma, although Fiji Telecom were building a new communications tower on the ridge which provided employment for the men of the village - the pay was low and the jobs of a temporary nature only. The other villagers farmed and fished to subsist.

The Torani Koro and Tui Dakuilomaloma (Chief of Dakuilomaloma) seemed to have an alarmingly apathetic attitude to the state of the water supply in Dakuilomaloma. Apparently an offer to pipe water either over the ridge from Lomaloma or down the coast from Muamua had been rejected some years earlier. It appeared that a higher power had influenced the Tui to decline the offer of water. The political intricacies of the situation were not explained to us - the villagers knowing that it was not their place to comment to foreigners on the status of the situation.

The only source of water in Dakuilomaloma is from a spring in the hills. The spring has been dammed and a pipe to the village delivers the water. There are nine taps in the village. All are unprotected except one, which is housed in a small shed. The other eight taps are scattered around the village, they are all simple brass taps with a square concrete base. The water quality is usually reasonable except when it is raining heavily and the water becomes silty, when water needs to be boiled otherwise the children suffer diarrhoea

WATER AND HEALTH

The lack of water in Dakuilomaloma is having a dire effect on the health of the children. Many suffer from scabies, a result of the lack of sufficient water for proper bathing. Particularly troubling is that the health officials from the hospital in Lomaloma who visit the village every month seem to be unaware of the problem.

OUR RECOMMENDATIONS

It would be ideal for the village if it could join the reticulated system and water is delivered from the Vanua Balavu's bore holes. A pipe could be fed over the hills that separate Dakuilomaloma from the east side of the island or alternatively down the west coast from Muamua. However, members of the village told us that the village elders had rejected plans to pipe in borehole water into Dakuilomaloma ten years ago. Politics rather than good sense seem to govern the situation. The village of Dakuilomaloma has the lowest priority as far as public works go. The chief agreed with us that the village needs a better more reliable water supply but we felt, from his answers, that someone had told him not to request borehole water higher ranked than he.

Ratu Mara has apparently initiated plans for a road to be built on the West Coast from Muamua to Dakuilomaloma. If this were to go ahead it would be a simple task to lay a water pipe down with the road. This road may be just another empty promise to the people of Dakuilomaloma who seem to be promised many things but rarely get them.

If one or two rainwater tanks were built in Dakuilomaloma the situation of the villagers would be greatly improved. They have no secure source of drinking water, let alone a source for washing and bathing. The church in the north of the village with its corrugated roof would be an ideal place to gather rain. Money is the main obstacle to any such development-taking place. Although promised funding from the American embassy no action has taken place.

Children in the Avea Primary School were encouraged to brush their teeth – but due to the lack of fresh water this was being done in salt water. The school's water tank was leaking at the time of study.

This is the only natural spring in Avea and is a good distance from the village – it is mainly used to clean clothes – detergent can be easily seem in the picture, and animals could also use it to drink from.

AVEA

SURVEY STATISTICS

Population: 65
Households: 40 / 20 individuals interviewed (2 man-days)
Reticulated: NA
Tank supply

- 5 personal
- 5 communal

Sources: Spring and tanks
Drinking water 2-4l/day average
Non reticulated water use - 60-100 l/day /household (access to spring at 1km limits use) Consumption on a par with Dakuilomaloma.

INTERVIEW SUMMARY

- The people of Avea have a water problem. The supply from the spring is reliable through the dry seasons to date however it is unprotected and a common source of stomach upset if not boiled (time consuming and labour intensive). This water is used for washing and cooking in the main. The problem has been the supply of drinking water in the rainwater harvesting tanks. The tanks are filled from a tanker, which ships in water from the main land, as the rains have been insufficient to fill them. This is a serious threat to water security n the island. During our visit the levels of tank water were low, causing the ingestion of muddy polluted water from the bottom of the tanks. This is another source of stomach disorders.
- One substantial problem is that the tanks leak. Simple repairs would allow greater utilisation of what supplies are available. This is made difficult by the geographical isolation of Avea (island off VB) and confusion over who exactly is responsible for such repairs. Avea is an excellent example of why a clear relationship between the government and local communities needs to be established in order to facilitate such simple but crucial maintenance.
- People have mixed feelings regarding the potential installation of a reticulated supply. Many have heard that it is not good water at Lomaloma and suggested that it might not be welcome. Also that such a supply would take a long time to come to their island.
- There is a strong sense that the village community needs to be careful with it's water supply
- No scabies was observed despite the low water consumption figures.
- Washing in the sea was not as common as might be expected.

The island of Avea is north of the village of Malaka on the northern most side of Vanua Balavu. It has no direct connection to the main land, either power or from the reticulated supply.

SOURCES OF WATER

There are 3 public tanks, with a fourth tank at the local primary school (including one under construction). The tank water is from the main land. There is one salt-water hand dug well in the village. There are also 3 spring sources but one of these is unused, they are around the north side of the island. Like Dakuilomaloma, this village was in short supply of water. However, it does seem that rationing came in sooner and one public tank was still full (one was empty and the other was almost finished). The well in the centre of the village was used for clothes washing and bathing. Detergent pollutes the well. We were also told that it is becoming more common to bath in the sea and clean pots, pan and clothes - but this is not good for clothes washing as the water does not lather. The springs are used for cleaning clothes in, one of the springs was in the open air and the other covered. The open spring is not protected from animals but the covered is. When the tanks are dry, the villagers use the covered spring to drink from.

In times when there is drought and the tanks are empty the government has provided tanked water shipped from Suva (1997 & 1998). There are increased cases of sickness when a tank is almost dry. This is because the tanks cannot be cleaned and the silt removed. There is also sickness just after a tank is refilled by rain (as this disturbs the silt).

COMMENTS

Water is at a premium in Avea. The main school tank leaks and there is no one available to fix. It does not appear to fall under the remit of PWD (their job is to maintain the reticulated supply). This should be fixed as it is just wasting the tanked water. The leak duration was about 5 months.

Health problems are reported when tanks low. The hand dug well appears to be just seawater and is not very clean, although people still use it occasionally to drink from.

Water had been rationed since February; this is usually started in April (another example of El Nino). The springs have not dried up in living memory. Also there does appear to have been another expedition, which marked out a borehole position at the back of the village. This site is not really suitable for a drinking supply because due to the proximity to the sea and latrines.

RECOMMENDATIONS

Priority to fix and maintain existing tanks.

The spring water needs to be protected with a covered reservoir, with a new site needed for spring use so as not to pollute the source (spring protection).

There are possible sites for boreholes on the north side of the island. Investigation should be made near to the spring. However, it is probably more economic and stable to get a supply from the Vanua Balavu mainland as increased use of the spring use may cause it to dry.

URONE

SURVEY STATISTICS

Population:
Households: 24 / 18 individuals interviewed (2 man-days)
Reticulated: 15
No tank supply
Sources: Spring/open reservoir and reticulation
Drinking water 2-4 l/day average

INTERVIEW SUMMARY

- Urone is a village that has a decent supply of reticulated water for washing and cooking, however the community do not like to drink the borehole water as it is suggested that the water is bad. Expressing the common opinion that it is salty and muddy.
- There is a total lack of rain water tanks and people either drink from taps that are supplied from an exposed reservoir or walk the 1 hour round trip to Lomaloma to get water (a task the children are often seen doing after school). The drinking of the reservoir water leads to stomach upsets the water being particularly bad directly after the wet season when the water is silty. The reservoir will also dry up on occasions.
- A community gathering of elders/chiefs suggests that they would like the same water tank facilities as are present in Lomaloma but are unable to afford it.

Geochemical Sampling Of Surface and Bore Hole Water Supplies throughout the Island

Funding for the expedition has afforded us the opportunity to closely co-operate with the Fiji Government by including a MRD representative on our expedition; this has served two useful purposes:

- To assist MRD continue in their ongoing monitoring of Vanua Balavu's water supply with their geochemical sampling (completed)
- Provided the expedition with accurate, up-to-date and wide ranging geochemical analysis to be included in our final report

This has incorporated the sampling of borehole, spring and surface water supplies.

Relevant Information Gathered to be included in the final report

- Map of Sawana and water points
- Village maps (whole island PWD supplied - low resolution)
- Village tank/water point information (Roko-Tui Vanua Balavu)
- Interview data
- Water tank observation data for Sawana and selected surrounding communities
- Bore hole meter data + leaks for Sawana selected households
- Geological map 1:25000
- Aerial photography 1:50000 + appropriate enlargements 1:10000

Local PWD worker needs to have kits to maintain the MRD water monitoring – this solution would provide the MRD with longer-term sampling of the main without needing to continue travelling to the island. Also consideration should be give to biological testing of open reservoir systems.

Medical Considerations and Local Hazards

As part of our expedition preparation it was necessary to consult with the Imperial College Health Centre about local health hazards. These include Hepatitis A and Typhoid but not Malaria, once on the island we also found that Elephantitus could also be a problem but according to the local doctor there was not much chance of infection. The only other contagion in Fiji is Dengue Fever (common in the tropics), this is a disease carried by mosquito and causes a blood infection that can prove to be fatal.

We were kindly provided with a comprehensive medical kit by the Imperial College Health Centre, which included everything to help us cope if isolated from professional medical care. They also provided us with basis emergency care techniques, enough to last until professional help arrived.

Mosquitoes were the only major local hazard – and did cause a big response at first in all of the team. They were not particularly responsive to deterrent.

Even during the winter season in the Fiji Islands the sun is still fierce and caused many problems, especially because of local customs about not wearing hats in villages.

Local wild life was in general limited to pigs and the occasional cow. However in the more remote regions dogs were more of a problem, leading to one or two instances of team members being attacked.

Other Local Hazards

- Scabies
- Parasites
- Diarrhoea

Family Study

The basis for this section of the report came from an initial idea I had to try and quantify the extent of 'Westernisation', which had taken place on Vanua Balavu. I soon realised that this was an unrealistic and naïve goal because the island is actually extremely influenced by so-called western ideas and values. It was foolish to think that Vanua Balavu as far as it is, geographically, from our reality, would be an idyllic tropical paradise whose inhabitants had little care for material wealth or other such fixations.

Instead I found a place where the people, though warm and friendly, are troubled by their lack of financial security, who are ambitious for their children but worry about the inadequate education system provided on the island, and are anxious about the unseasonably late rains which threaten to starve their crops and exhaust the reserves of their water tanks. At times I felt incredibly saddened for these people – they merely wanted for themselves the comforts and securities, which we take for granted, but were constrained by finances and a lack of resources. But they, themselves, were (in the most part) not unhappy with their situation but accepting of it.

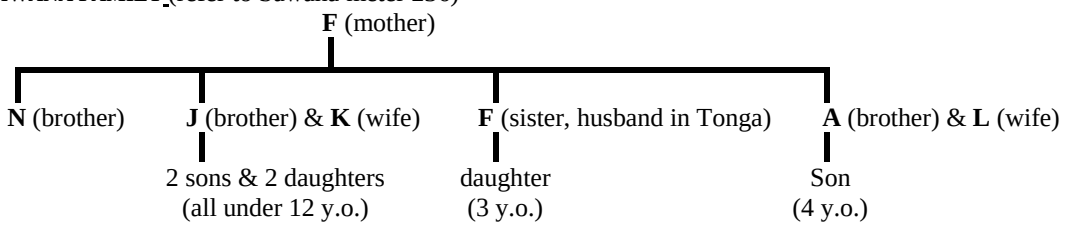
Slowly, as my ideas evolved and my preconceptions were obliterated, this report became a decision to study three separate families – each from a different village. Each village had its own distinct conditions and water supply. Water and its availability was not just the focus of our project, but a major factor in each of their lives. It governed most every aspect of their life. My aim here was to compare and contrast their respective circumstances – economic and social – and in doing so attempt to evaluate the impact of their access to water on their situation.

The first and largest family lived in Sawana and, by the end of our stay, the family I knew best – mainly because I spent most of my time with them. The second family lived in Dakulomaloma (meaning literally 'behind Lomaloma') a village just over the ridge from Sawana on the western coast of the island. The third family lived in on the tiny island on Susui, which was south of Vanua Balavu. I have decided not to use names but to anyone who knows the island and its people, it will be immediately apparent whom I am discussing.

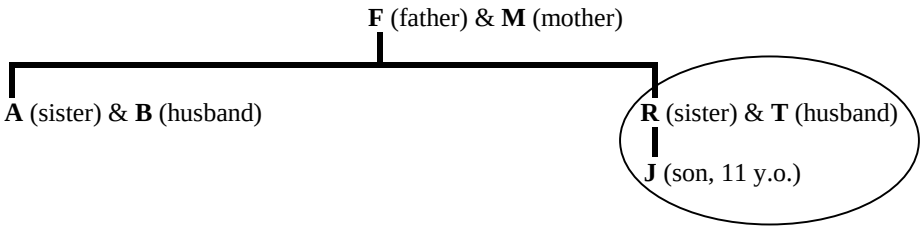
FAMILY RELATIONSHIPS

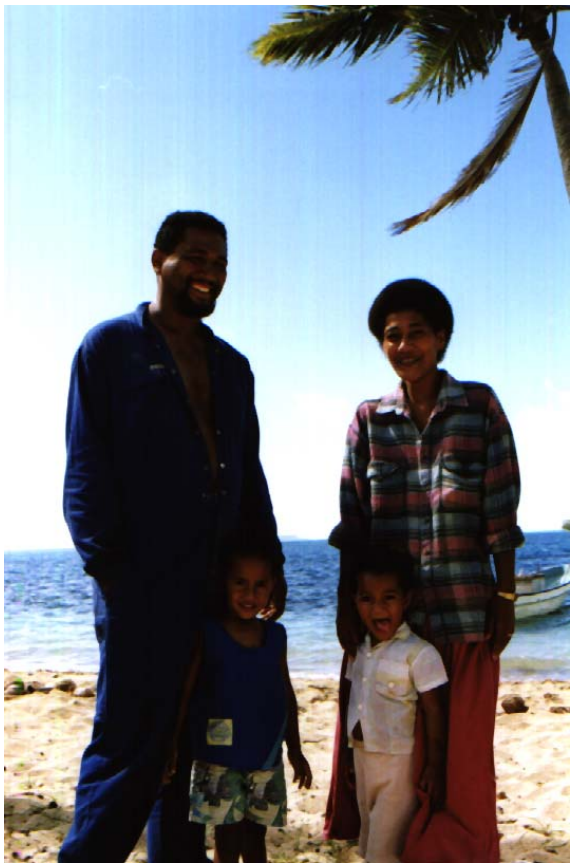
The following diagrams will hopefully illustrate the inter-family relationships:

SAWANA FAMILY (refer to Sawana meter 236)



SUSUI FAMILY





A family group.

SAWANA FAMILY

This large family lived in three adjacent bures (a bure is a Fijian hut).

First bure: At the time of our study five adults and two children lived in this two room wooden house. M (their mother), A (the youngest brother), L (his wife), and their son were the usual occupants. F (the only sister), who ordinarily lived in Tonga with her husband, had been staying with the family in the first bure for the last 9 months with her 3-year-old daughter.

Second bure: Two adults and 4 children lived in this bure constructed from corrugated iron. J (the second brother) was living with K (his wife) and their two sons and two daughters. The eldest boy was just completing primary school (12 years old) and the youngest girl was 4 years old.

Third bure: N (the eldest brother) lived alone in this bure.

Although living in separate homes their life was, in every facet, communal – all water, lavatories and cooking facilities were shared. The toilet was housed in a small, corrugated shed and was shared by all. Their kitchen was a makeshift attachment to the first bure.

WATER SOURCES:

Tap: Sawana was part of the reticulated water system on Vanua Balavu – it was supplied by water from one of the island's three boreholes. The Sawana family had communal access to one shared tap which was located between the first and second bure, which consisted of a pipe with a brass faucet. This tap was their main source of water for washing, cooking and bathing. Water supply was usually constant during the day except for two hours in the late afternoon when the main supply to the village of Sawana was diverted to the southern villages and the island Namalata. A hose could be attached to the tap, which connected to a shower in a small corrugated iron cubicle with a concrete base – this was used mainly for bathing. The tap was metered allowing me to note how much water was being used.

Water tank: Approximately 1m in diameter and 2m high. It was fed from the roof of the first bure. It was located between the first and second bure. The water in this tank was used exclusively for drinking.

ECONOMIC/SOCIAL SITUATION

The Sawana family, though not affluent even by their village's standards, were in a reasonably settled economic situation. L, A's wife, was employed at Ratu Mara's resort which provided a reasonably constant supply of money. The three brothers all farmed small plots in the bush, which provided their staple diet of root vegetables. The family owned a number of chickens and ducks, and J owned two pigs (although one was eaten during our stay). Occasionally when a boat could be borrowed the brothers would fish at night and sell their catch the next day.

N, the oldest brother, had never married. He was involved in a drunken dispute with some men from another village some years earlier. He was set upon and beaten quite badly. In a coma for some time he suffered mild brain damage. I was informed that this was linked with a criminal act for which he was sent to prison in Suva. He had only recently been released and returned to the village. His relationship with the family seemed stable and he had been welcomed back to the fold. There appeared to be no animosity between him and the rest of the village – he was regarded as a simple fool but never treated with any overt disrespect and was always included in the activities of the other men.

F had married a Tongan. She had two daughters but had left the eldest with her husband to travel to Suva to seek special medical treatment for her youngest daughter who was born premature. She had returned to the island to visit her family. She extended her stay in order to spend more time with her mother who she feared would not see again once she returned to Tonga.

J was married to K. J was the most charismatic of the brothers yet rather enigmatic. He and his youngest brother, A, *seemed* to work hard tending their plots in the bush yet I suspected that the two loitered more than they toiled. They also farmed copra to make money. Copra is dried coconut flesh, which is crushed at a refinery to extract coconut oil. There was a copra mill in Sawana but it could not compete with the

competitive prices of more cheaply run, foreign owned mills on other islands. As a result the price of copra per tonne had dropped from $500 (when it was refined on the island) to less than $350 – after taking into account the transportation costs to send the copra to other islands. Farming copra is hard work – the coconuts need to be collected, left to mature, then opened and the flesh cut out. Then the flesh must be dried out before it can be sold – this can be done either in copra driers or by leaving the coconut flesh in the sun to desiccate. For the amount of effort put in the yield is low. Because there was no other way to earn a regular source of income on the island they were forced to farm copra. They earned between $30 and $50 a month each – this amount, L and K told me, varied on how much time they actually spent working as opposed to drinking kava and playing rugby.

It was interesting to note how dependent the Sawana family had become on their tap water source and how much they took it for granted. Particularly because they had only had reticulated supply for a few years – most could remember the old days when water was often scarce. The tap was viewed as an endless source of water supply. It was often left on for hours at a time to soak Kasava or other root vegetables. The tap was also an endless source of games for the children. It was often left drizzling for the ducks and chickens to drink from it.

The tap supply was used daily by each member of the family for bathing. But it was the women who actually controlled its use. The three men went to work in the bush everyday or would amuse themselves otherwise while the four women would remain at home caring for the three children who were not old enough to go to school. The tap would be on all day while the women washed clothes, pots and pans, bathed the children and themselves and did the cooking. It was clear that the bures and the surrounding area were the women's domain during the day while the men were relegated to doing 'manly' tasks.

It may sound odd but in retrospect I'm not really very sure what the men of the family actually did during the day. In focusing on the tap as being their water source I mainly observed the women doing women's business and did not have the opportunity to see what the men actually got up to.

Two or three times I noticed that J would come home during the day and look distinctly out of place surrounded by the female members of his family cooking and gossiping. I got the general impression that the men in the family and in fact most of the men in the village regarded me somewhat suspiciously because I seemed to spend most of my time talking with women and children. After five weeks of my insipid, repetitive questioning and my continual lurking in the background with a notebook, people started to regard me as part of the furnishings – just another palm tree, if you like.

All the members of the family said that they did not enjoy drinking tap water because it often tasted muddy or slightly salty. They preferred drinking water from the rainwater tank. However since we had arrived, many said, the tap water quality had improved. We postulated that the poor quality of the tap water might have been due to the over pumping of the Lomaloma borehole *(see reticulated study)*. Our arrival coincided with the breaking down of the Lomaloma borehole pump so it seemed a reasonable assumption to make that it was the reason for the poor tap water quality.

During the five weeks of our study I noticed the Sawana family's attitude to water slowly change. Initially untroubled by my constant observation of their habits I began to notice slight changes in behaviour. One of team, usually myself, would spend at least one full day per week and often 2 half days observing the Sawana family water usage. In the first week the tap would be left on while not in use but by the last week it was only ever turned on when it was required. The children began to get chastised for by their mothers for wasting water and vegetables weren't left under a running tap for longer than a few minutes. In particular I noticed that every evening, K would turn off the water not at the faucet (which leaked slightly) but at the water meter itself. Their water usage dropped from 2000 litres per day at the start of our measurements - to about 1100 litres per day at the end of the study.

It is undeniable that the reason for the reduction in water consumption was due to our observations. It is quite possible that once we left the level rose again. During the same period, the daily consumption of water at the other meters in Sawana remained constant. Although we monitored other families in the village, the Sawana family was the only one we observed with twice weekly regularity. I think that once the Sawana family realised this they began to make a conscious effort to consume less water. The likelihood of charges being imposed by the Public Works Department for water use (now that the taps were metered)

was probably a strong consideration weighing on their minds. The women of the Sawana family were particularly concerned that water charges would be difficult for them to pay considering the paucity of their income. In some way they suspected that our findings might result in the imposition of extra charges for wastage.

The village of Sawana in comparison to the two other villages in this study consumed astronomical amounts of water. (I suspect that the amount of water used in other villages that were part of the reticulated supply system would be equally large as that of Sawana). But the Sawana family itself was a relatively moderate consumer of water within the village – when considering that the tap supplied 7 adults and 6 children. Another family living in the village, they were considerably more affluent, consisting of 2 adults and 1 child used close to 13,000 litres per day.

SUSUI

Due to the fact that we had to take a boat to get to Susui I was only able to visit twice. The first was just for just one day, we stayed five days the second. The Susui family lived in two adjacent bures and one larger house. My observation of this family was mainly limited to T (the torani koro) and R (his wife) – due to most of our time being utilised to make general findings on the rest of the village.

First Bure: T, R and son (J, 11y.o.)

Second Bure: F and M (R's mother and father)

House: A (R's sister), B (her husband) and children

WATER SOURCES:

Tap: Like Dakuilomaloma, Susui was not part of the Vanua Balavu reticulated system because it was too far away from the main island for an underwater pipe to be feasible (unlike Namalata). Instead water was gathered in a spring water catchment and piped to the village. In the village there were a number of shared taps.

Jiovu and fresh water pools: A hand dug well (10 minutes walk from the village) and three fresh water pools (15 minutes walk from the village), which were by the sea to the south of the island. These sources of water were used for washing clothes.

Water tanks: two large water tanks were located at either end of the village. There were also a number of rainwater tanks owned by individual families. A and B owned a rainwater tank which was fed from their roof. The whole family had access to the tank and it was used mainly for drinking.

The different sources of water were used in different combinations depending on the seasons. Most of the year, when the water was plentiful in the spring water catchment, the taps delivered water constantly to the village. This water was used for bathing, washing and cooking. Rainwater, from A's tank, would be used by the Susui family for drinking.

As in Dakuilomaloma, there was no system to protect water in spring catchment and so during the drier months it ran low. T, as torani koro of the village, was responsible for rationing the water. The taps would be turned on every 3 to 4 days for a few hours only. All the taps in the village would be left on and as much water collected as possible in a variety of different vessels for later use. During these months the Dakuilomaloma family depended mainly on the two communal tanks and A's rain water tank for drinking water, bathing, cooking and washing dishes. The jiovu and springs were used for washing clothes.

ECONOMIC/SOCIAL SITUATION

T was the village's Torani Koro – an elected government position akin to mayor. It was not made clear to us whether this position was a paid one. He farmed copra and tended a bush garden. He also owned a few pigs and a goat. He is an astute spear fisherman and would go swimming at night with a torch to bring back a fish for his family. For extra money he would occasionally hunt *beche-de-mer* (sea cucumbers) and sell them to X, the businessman in Sawana, who had a supply contract with a Taiwanese company who exported the rare delicacy to South-East Asian countries. R, his wife, worked two days a week as the Susui's radio operator. Her sister A was the village's voluntary nurse and operated the dispensary.

Susui sustained itself mainly on fishing and copra. It also had a reputation in the Lau area for constructing quality bure "roof shingles" from palm leaves – a time consuming and intricate process requiring great skill. The Tui Susui (Chief of Susui) at the time of our stay was completing a large order of 200 for the island of [Can't remember name of island – the one with the crazy cult]. The island was owned by an American cult and had offered the Tui the princely sum of $30 for his fortnight's hard labour.

Water is not as limited a resource in Susui as it is in Dakuilomaloma. Numerous sources are available throughout the year and usually do not run dry. 1998 was, however, an unusually dry season [due to the El Nino Southern Oscillation?]. For the first time since their two large communal tanks were built in 1995 the

village began to run out of water in May resulting not only in rationing of the tap supply but the communal tanks being locked. A delivery of water by tanker from Lomaloma lasted only two months.

It was T's responsibility – as Torani Koro of the village – to monitor the water levels and decide when to cut off either supply. Because some of the villagers did not have recourse to a private rainwater tank this responsibility placed considerable strain upon him making his decisions. If the taps were turned off and tanks were locked some would be left with no fresh water source other than the jiovu or the spring pools. Neither source was drinkable since the former was polluted with soap from washing clothes and the latter salty due to its proximity to the sea.

Of particular worry was that it was us who alerted T of the low levels in the communal tanks (only a few inches in each). As a result of our warning the tanks were locked. It is important that in the future volume of water in these tanks is closely monitored in order that an alternate source of water (such as tanking) may be secured before the village runs completely dry.

The PWD conducted a survey of the spring catchment area in 1993 [please check date]. A holding tank was planned just below the spring to protect the water and a filter mechanism built in. The estimated cost of building the tank was $15,000, the village was asked to contribute $2,500 of this total sum. Such a tank seems to be the best solution to the chronic lack of water in the dry season. A large protected tank, which could hold a large enough volume of water to last two months, should be enough to tide the small population of Susui. If the tapped water supply could be maintained longer, the communal tanks would not need to be depended upon quite so heavily as a general water source and could be kept as primarily a drinking water source (which was the reason for building them). The only problem is that Susui is a poor village. It certainly does not have $2,500 and could not hope to raise this money without external sponsorship.

ATTITUDE TO WATER

Each family had a particularly distinct attitude to water. An attitude, which I found, represented that of the wider community in each village. This attitude was dependant, obviously, on the quantity of water they had access to.

KAVA

Despite shortages of drinkable water in Sawana, Dakuilomaloma and Susui there was always plenty of freshwater for kava. This dried root when crushed and mixed in water is a mildly hallucinogenic drug, which calms and relaxes the body. Kava drinking is both an important ceremonial form of introduction and ritual, it is always a part of official meetings, and an important social outlet, which binds the men (and sometimes the women depending on the village's custom) together. Its negative effects are a lot less severe than alcohol – kava is more likely to put you into a dreamlike lazy state than get you in an aggressive mood – although large consumption does appear to have adverse physical effects.

The three brothers of the Sawana family would indulge regularly in kava – probably four times a week, with a particularly long session on Saturdays (immediately after the intra-island rugby game) starting in the mid-afternoon and continuing until well into the night. 10 to 15 men would attend and up to 20 litres of water (always taken from the rainwater tank) could be consumed per hour for eight or nine hours. It was difficult to estimate how much water was used for kava in Dakuilomaloma and Susui. However, from personal experience, I can confirm that it was a very popular past time.

CONCLUSION

Water is a valuable commodity in Vanua Balavu. Its scarcity in Dakuilomaloma had managed to shrink the village's population by half since the 1993 census. In Susui the lack of water has resulted in the extreme measure of tanking water to the island – perhaps this money could have been better spent on building a holding tank for the spring catchment. In stark contrast, families in Sawana use between 2000 and 13,000 litres of water per day. The Dakuilomaloma and Susui families race to the taps with empty buckets when the taps are turned on, while in Sawana the tap is rarely off. Of course, Dakuilomaloma and Sawana's respective water shortage could be remedied but the lack of money prevents any foreseeable solution.

Villagers enjoying a Kava session

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www.mrd.gov.fj

If you require more information about Fiji in general please contact:

Fiji Visitors Bureau
Suva
Fiji Islands

www.fijifvb.gov.fj

If you require more information about expedition planning then contact:

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The Royal Geographical Society (with The Institute of British Geographers)
1 Kensington Gore
London
SW7 2AR

www.rgs.org

ACKNOWLEDGEMENTS

In particular we would like to thank the following for their help, without who help, support and guidance we would not have been able to put together this expedition and produce this report.

Especially:
IMPERIAL COLLEGE EXPLORATION BOARD
For support, guidance, training, and patience.
Imperial College Health Centre
Dr Alan Swann – for his time, a fine medical kit and training.

Royal Geographical Society and The Goldsmiths' Company

The Constituent College Alumni of Imperial College
- City and Guilds College Alumni
- Royal College of Science Alumni
- Royal School of Mine Alumni

Fiji Islands Government
Public Works Department
In Suva
The permanent secretary of public works
On Vanua Balavu
Free use of there resources and much help with the metering
Mineral Resources Department
For man hours and research

British High Commission – Suva, Fiji

South Pacific Applied Geoscience Commission (SOPAC)
For introduction to the target area and help setting this project up – **Many Thanks**

British Geological Survey

National Environmental Research Council (NERC)

Institute of Hydrology

Prof. John Woods, Oceanography, Imperial College

Neil Walker – Revolution Recordings
A radio journal was broadcast on BBC Radio 4 and is available on request.

Alexander Millington, Imperial College – (project logo)
"Thanks for the web space" - pasm
http://www.doc.ic.ac.uk/~pasm

&

Mrs. H. Miller – who supported our efforts and moved on while we were away. – *"We did a good job."*

Photography A. Sundaraj and P. Miller
*Report design and layout P. Miller (*pasm@doc.ic.ac.uk*)*
Imperial College and Royal Geographical Society names used with kind permission.

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The Chartered Institution of Water and Environmental Management

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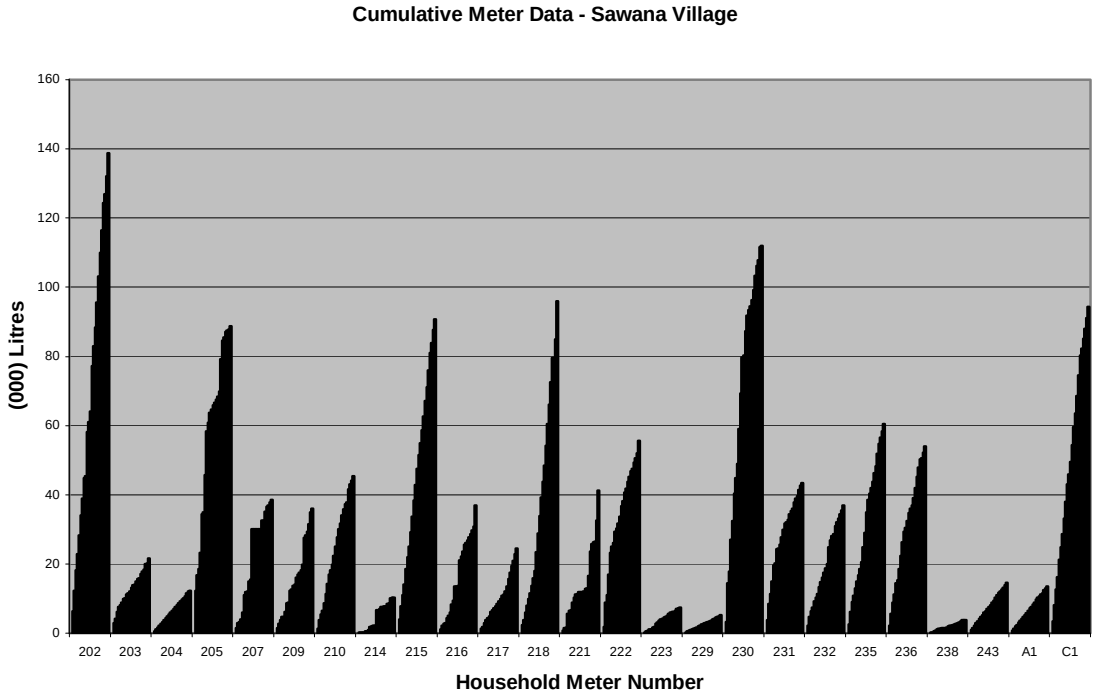
MRD Internal reports on borehole assessment

PWD Lands Department - aerial photography 1:10000 1:25000
Geological maps
Vanua Balavu technical references

Fiji Government Census 1996

Appendix – Sawana Meter Results

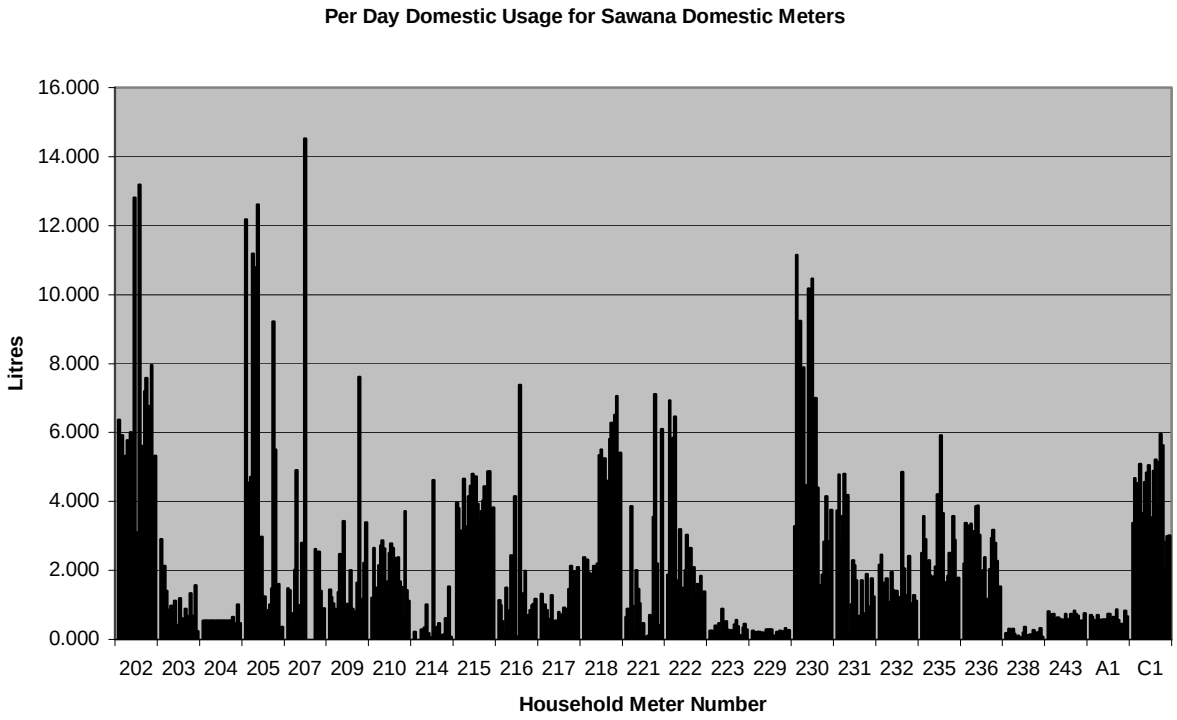


Notes about the cumulative data:
Generally it can be seen that during the course of our stay the use of water became more moderated – the gradient of the graphs can be seen to drop. Since this Sawana relied mostly on the reticulated supply, we can conclude that our presence had an effect on the use of water in the village.

210: this was our own accommodation, where we stayed for the duration with 2 family units of 3 people each. This was quite a high number of people for one household but as can been seen our consumption was very much on the average.

202, 205 & 230: all had simple to fix leaks (205 turned off their supply almost entirely for several days)

204, 214, 223, 229, 238: had extremely low usage – several of these household seemed rarely occupied.

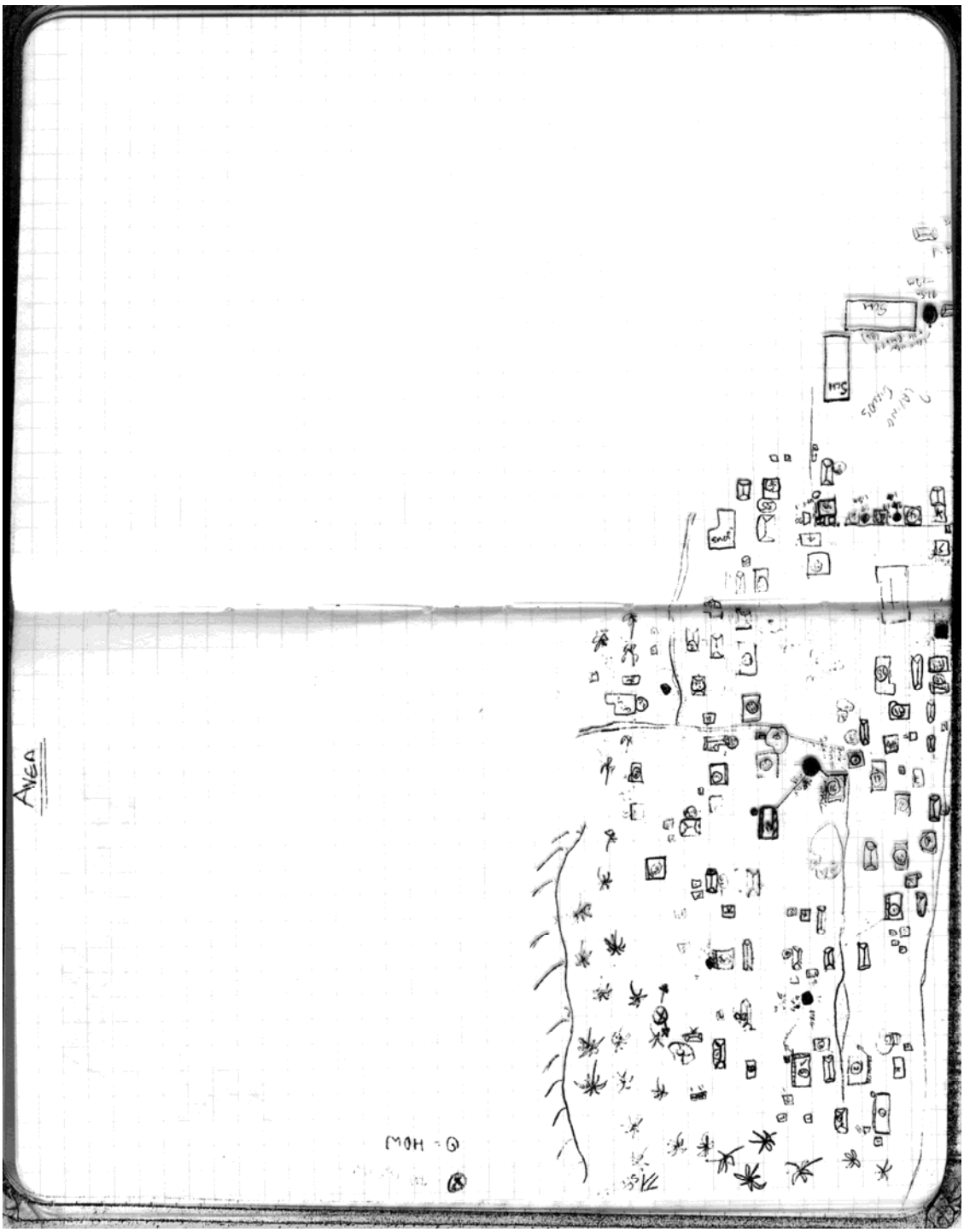


From this graph it is easier to spot days of high usage.

207 can be seen to have left a tap on using over 14,000-litres in one day, from the cumulative data this can be seen to have been a one off event, with water use having been otherwise moderate. While other houses show little sign of using water at all. For example 204, 229 & 238's usage can in the most part be put down to a small leak.

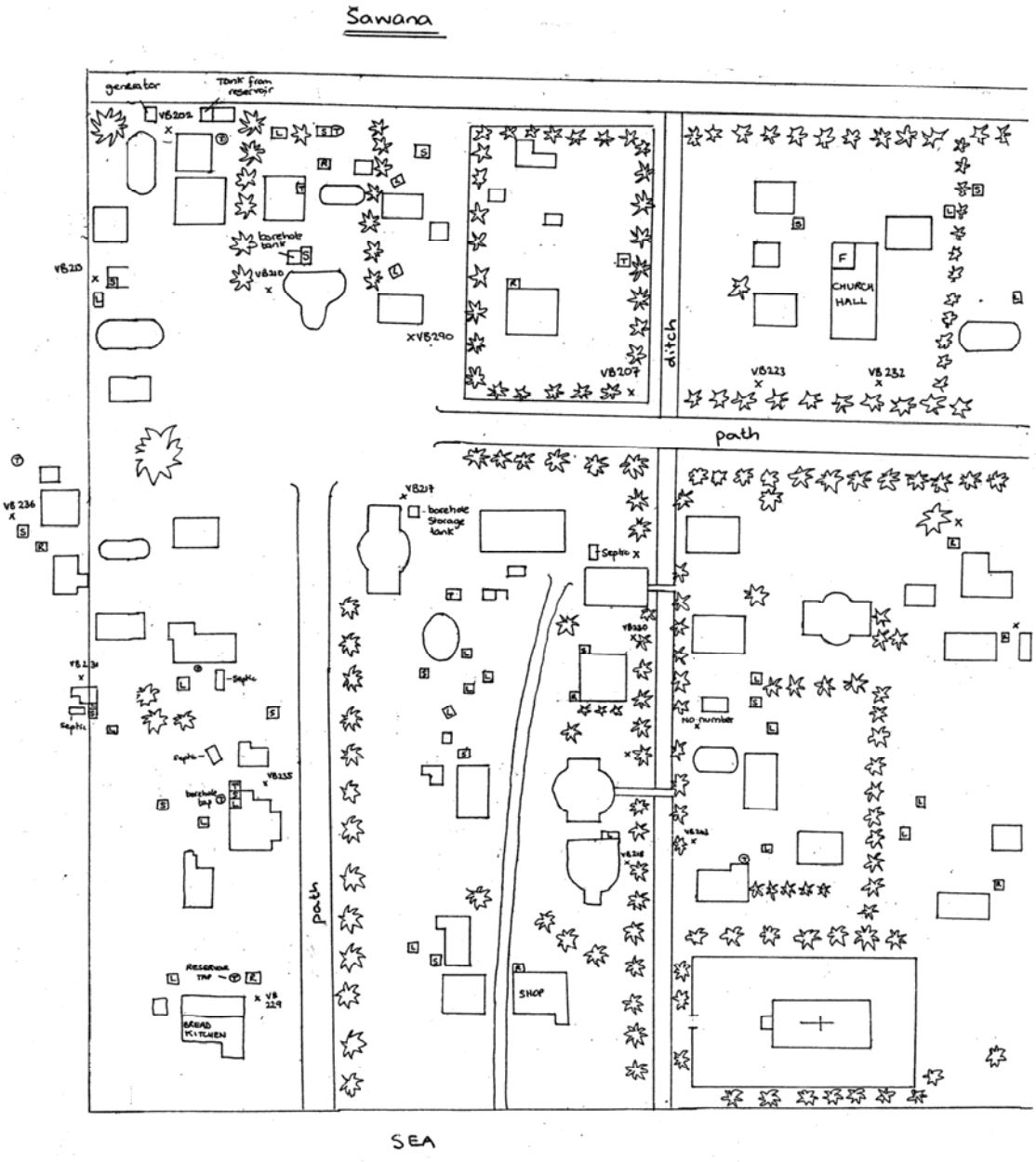
Full data is available from http://www.doc.ic.ac.uk/~pasm

Appendix –Maps



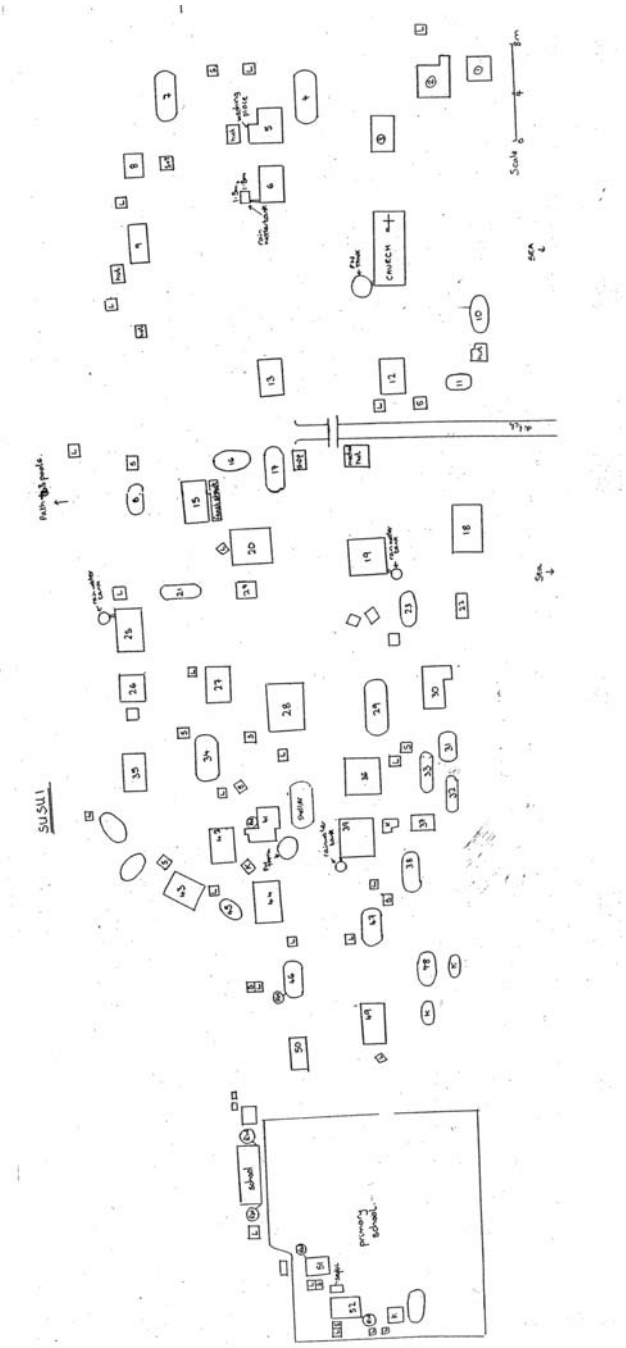
Maps were drawn on site with one team member pacing – for scale and the other drawing – this is the sketch of Avea

Sawana Village – main target area.



Sketches can then transferred to reliable maps of villages in matter of hours.

Susui



APPENDIX – WATER SURVEY RESULTS

MINERAL RESOURCES DEPARTMENT - WATER ANALYSIS

LOCATION		Vanua Balavu, Daliconi			WELL No.	BH 89/08	
					COLLECTOR'S No	SL/98/26	
DATE COLLECTED		13/07/98			**LAB No.**	13021	
DATE ANALYSED		31/07/98 (completed today)			ANALYSIS Rqd.	Complete + E.C.	
GEOLOGY							
SOURCE							
TYPE	Borehole	Borehole	HDW		River	Spring	
	Flowing		Pumped		Surface	Depth	

SITE ANALYSIS/TREATMENT

Sp. Cond.	microS/cm	pH	
Eh	mv	D.O.	m/L
Temp	^0C	HCO_3	m/L
Filtered		Acidified	Acidified

CATIONS		mg/L	e.p.m
Calcium	Ca	60	2.994
Magnesium	Mg	30	2.469
Sodium	Na	36	1.566
Potassium	K	4.3	0.11008
Manganese	Mn	0	0
Iron	Fe	0.1	0.00537
		0.16	
			7.14445

ANIONS		mg/L	e.p.m
Bicarbonate	HCO_3	195.2	3.20128
Carbonate	CO_3	0	0
Sulphate	SO_4	13	0.2704
Chloride	Cl	147	4.1454
			7.61708

TDS	Evap. (180 ^0C)	474	**IONIC BALANCE**	3.2%
	Sum of Ions	486		
TOTAL HARDNESS (Calc.) $CaCO_3$		273	pH	7.47
			Sp. Cond.	713 microS/cm

COMMENTS:

Four sets of each sample received.
Two were acidified without being filtered in the field.
No field measurements ie. E.C. or pH done.
Analysis was done on samples filtered and acidified in the laboratory.
Pretreatment of samples should have been done in the field.

LABORATORY MANAGER

NOTE : DETECTION LIMITS : AAS = 0.02 mg/L & SULPHATE = 0.4 mg/L

With the meter reading we took from Vanua Balavu we were able to get a good idea of the state of the reticulated supply on the island – this is an example taken from the Daliconi pump station. 30 more were taken over a period of 2 weeks.

APPENDIX - FIJI GROUNDWATER

(SOURCE - MRD)

When a hole is dug or drilled in the ground, water saturated rocks will usually be found at depth. This water is groundwater and is the natural store for water found in the pore-spaces and cracks of rocks. Although groundwater can be found almost anywhere, it may not be available for extraction because the pore-spaces or cracks are too small to allow the water to flow in sufficient quantities.

Saturated rocks from which groundwater can be taken are called aquifers of which there are two main types. Firstly in porous aquifers groundwater is contained in pore-spaces in largely unconsolidated rocks, such as alluvial sands and gravels. The water in the second type of aquifer is contained in cracks and fractures in consolidated volcanic and sedimentary rocks which are otherwise impermeable.

GROUNDWATER RECHARGE AND MOVEMENT

On reaching the ground, rainwater either runs into rivers and streams (surface flow) evaporates or is used by plants (evapo-transpiration) or percolates into the ground to the water-table to rise and when it is at a higher elevation than surface water, groundwater flows through the rocks towards rivers, streams and the sea causing the water-table to gradually fall.

During long dry periods groundwater is the only source of flow in streams. When this flow stops and the streams dry, the water table has fallen below the stream-bed. However, groundwater can still occur at depth.

Groundwater discharges from the ground as springs and seepages at high and low levels. Springs high in mountains are discharge points for water perched on impermeable layers of rock whereas low-level springs discharge groundwater from the aquifer into the lower reaches of rivers, near the coast or into the sea below sea-level.

Where fresh groundwater flow meets saline groundwater at the coast there is a zone of mixing, the fresh groundwater passing over the denser saline water to the sea.

EXPLOITATION OF GROUNDWATER

Groundwater is used by the large number of people in Fiji who obtain their water from springs, hand-dug wells and bore-holes. In low lying areas wells are dug by hand and lined with concrete blocks or rings or oil-drums. As the water-level falls during dry periods, wells are deepened to find the water-table. Hand-dug wells are usually sufficient for domestic requirements and water is extracted using a bucket, a hand pump or, where the depth to water-table is less than 7 metres, by a small surface pump.

Where the groundwater lies at greater depths, or larger quantities of water are required, then bore-holes are drilled, either by MRD or private drilling companies. Bore-holes are usually between 20-50m deep, 100-200mm in diameter and are lined with plastic or steel casing and screen. Groundwater is pumped from bore-holes using a variety of pumps and sources of power to drive them. Groundwater can flow naturally from bore-holes in a few geological situations and no pump is required. In Fiji, bore-holes usually yield between 0.5 and 15 litres per second but yields up to 50 l/s have been pumped.

WATER QUALITY AND POLLUTION OF AQUIFERS

Groundwater is a valuable resource stored in a natural reservoir, the aquifer. In general, it is a very pure water source free from contamination. Surface water, such as streams and rivers can easily be polluted by human and industrial waste and can carry large quantities of suspended silt and mud during times of flood. The ground acts as a natural filter to these contaminants so groundwater is relatively pure but care must still be taken not to pollute aquifers.

Hand-dug wells are constructed in areas where groundwater is at a shallow depth so it can be contaminated easily. It is recommended that the wells should be covered when not in use and concrete aprons and drains

round the well tops should be constructed to prevent spilled water and animal waste from seeping directly into the wells.

To minimise potential risk of contamination, pit latrines and animal drinking troughs should be located ate least 30metres away from wells and if possible, down hill to make the underground path to the water-table and well as long as possible. Particular care is required in the disposal of small amounts of chemical waste or fuel/oil products. These should never be allowed to soak into the ground because they can pollute groundwater for many years.

Another source of contamination is from saline water at sites near the coast. Wells drilled, or dug too near the coast may strike saline water, particularly on small islands. A bore-hole sited near the coast may initially be fresh but turn saline due to over-pumping causing up-coning of the saline groundwater.

APPENDIX - COMMUNITY LEVEL WATER SUPPLY

THE SOCIAL SIGNIFICANCE AND APPROACHES TO WATER POINT DEVELOPMENT AT A VILLAGE LEVEL.

INTRODUCTION

The following sub-chapter lays out the social motivations and considerations in the development and location of rural village level water supply. "Village level", being a broad term used in the developing world context to indicate the smallest rural community unit. It is not a hard and fast term and might be viewed as applying to an area around a centre of rural population that is deemed walkable in order to collect daily domestic or irrigation water supply. The point of supply being within that area and hence potentially in the control of the local community. It is distinguishable from a regional water project that will supply a number of disparate communities via water based engineering at some distance (dams, weirs, piped river diversions).

The below text emphasises the need to be aware of the potential social impact of the choice of well site and contends that social as well as hydrogeological information needs to be considered in the process of locating a well point. This presents practical logistic considerations in the field where land ownership, grazing rites, location of latrines, and culturally significant sites will all need to be considered when laying out a survey area and ultimately choosing a location for a well. This may be somewhat academic if a village is in dire need and only one potential site is considered reasonable, however, it is significant where a number of potential sites present themselves. Perhaps the important point here is that the community should feel and indeed be involved in the process of locating a well, not simply to gain the support and long term responsibility of the community to the project (effectively making it their project to support in the future) but also to ensure that well installations are actively and effectively used once the survey and construction teams have completed their work. This may seem somewhat counter-intuitive at first assessment, a well is bound to be used if the need is there. It has however been the experience of many water based projects, some of which are highlighted in this review, that water supply can be rejected or even cause violence and recrimination, after a project is completed, for a wide number of social as opposed to technical reasons. The of the aims of the review below is to demonstrate the wide range of social issues that are potentially involved in the location of a social focal centre such as a well point, that might not be immediately obvious to the outside observer. Knowledge of such factors might assist in the choice of survey area and instrumentation to be applied. For example if a community is unable to provide the man power for a hand dug well due to a local social disagreement, then it is appropriate to concentrate efforts to the location of a borehole and attempt to train certain individuals to maintain it. This decision may have a bearing on the survey area and survey process. Conversely a community that may be able to supply manpower but does not volunteer a person to be trained to maintain a borehole hand pump may ultimately benefit from a hand dug well, again potentially influencing the course and instrumentation of the survey at a village level. Similarly locating a well on hydrogeological criteria alone may ultimately lead to the well being "claimed " by the land owner, dominated by a social group or damaged by those who feel ill served by it. Although such matters do not directly influence the physical response of hydro-geophysical equipment, this sub-chapter attempts to highlight those issues that will be significant for those who might wish to apply such technology at a village level environment. The actual process of establishing communications with a village community and the activities involved in understanding the needs and concerns of the full spectrum of individuals in a village is the task of the NGO social specialists as opposed to the hydro-geologist. However, in practice it may still fall to the survey team to gather information concerning the present supply of water, it's distance, who collects it, where a supply would be most beneficial and local hydrological knowledge. The leaders of the community, official or otherwise, are often the first to present themselves, but it may be necessary to actively seek the opinions of those who do not immediately present themselves. Those who actually collect and deal with the water for example, often the women of the community. Such local information is technically invaluable as it provides some basic hydrological background for the survey (how often do the rivers flow, which river is usually biggest, how long has the well been dry etc.)

This sub-chapter also highlighting the substantial and real need for the provision of local village based water supplies and puts into context one of the motivations to develop the electrokinetic hydrogeophysical technique. The potential value of such a technique in relation to and working in combination with such techniques as EM and Receptivity is highlighted in the subchapter entitled "Appropriate hydrogeophysical

approaches to the location of shallow well points at a village level: A potential role for EK techniques". In that sub-chapter the hydrogeophysical potential of an EK technique is outlined with a specific focus on the characterisation of aquifers and the aim of locating well points appropriate at a village level. In the below text a broader motivation for the *need* for such village level water supply is presented in the form of a literature based review. It is presented in the context that an understanding of the social problem to be solved will help to focus the technical response.

1990 saw the end of the International Drinking Water Supply and Sanitation Decade (IDWSSD). It served to highlight the need for the development of a safe, reliable and readily available (within reasonable walking distance) domestic water supply in communities globally. In retrospect it is possible to see that the aim of providing this level of water resource development to all that need it has not entirely been achieved. A staggering 700 million people in the rural communities of the developing world were supplied to some extent during this period, however this is offset by a similar level in population growth. As Pickford (1989) points out, there were some 2 billion in need at the beginning of this decade. Davidson, Myers & Chakraborty (1992) indicate that this figure remains essentially the same. Perhaps therefor, after the substantial number of people given assistance, one of the greatest values of this decade's work has been to increase the awareness of the need that still exists for reliable safe and proximal water supply. With a decade of awareness and rapid learning under the development communities belt the drive should not be provided by a time frame, so much as the human need for as long as it exists. That need is substantial, Davidson, Myers & Chakraborty (1992) report that 25,000 people die ever day from water borne disease with more than 4 million children a year die from diarrhoea that can be linked directly to poor water sanitation and supply. Kofkes (1988) goes on to site the figure of 80% of all world disease having a direct link to water supply. UNICEF estimates a total of 12.4 million people a year die due to dirty water and poor sanitary conditions. Hofkes (1988) emphasises that it is the rural communities that are in particular need.

McGarry (1983), writing in Glennie (1983) at the beginning of the IDWSSD period, highlights the pressure this sudden decade long concentration of effort placed on national water and sanitation programmes. In some cases so rapidly as to render them unable to cope with the increased responsibilities and influx of funds. He goes on to state that this approach can lead to the transfer of unmodified urban and engineering approaches to rural communities, often with poor results. Kofkes (1988) agrees with this principle reminding development workers that a rural community water supply is not the same as a scaled down urban project. The reliance on a more local "village based" approach is invoked as a way forward in this area and McGarry sites the work of Glenny (1983) in Malawi on a gravity water programme from 1969 - 1979 as example of this approach. This view is strongly echoed by the comments of Van Der Bijl and Hofstra (1986) who's work with TOOL, a Dutch appropriate technology organisation, lead them to believe that smaller scale projects not only targeted the poor of the community better but were more easily managed. They go on to state that small scale village level projects could be taken over by the community with greater ease, integrated better with local activities and generated better cost benefits. Hofkes (1988) agrees, stressing that when supplying a rural community with a water supply the main issue is the use of appropriate technology as opposed to a temporarily more effective technology that is beyond the maintenance of the community. The author goes on to point out that the use of inappropriate technology may well exacerbate an already difficult problem, with reliance developing on a short-term system. This fundamentally refers to the need to supply a water point system that is maintainable by a trained local community representative or group. Ultimately, the aim would be to produce a hydrogeophysical approach that could be operated and interpreted by local technicians.

Glennie (1983) supports the comments of McGarry (1983) indicating that the rapid expansion of interest stimulated by the IDWSSD has the potential to increase the occurrence of non community participatory development schemes. He indicates that governments receiving substantial increases in allocations of money, manpower and materials, which are applied before a fuller understanding of community requirements and structures is known, can lead to a highly inefficient use of resource. It is this efficient use of capital as opposed to simply a great deal of capital that is sited as the solution to this situation. Stern (1985) concurs with these points and goes on to point out the need to convert from responding to water based emergencies to preventing these situations occurring in the first place. He stresses the need to avoid simple reliance on technology and to begin to incorporate long term community sustained maintenance strategies into our development planning. Once of aid is only short term in its approach. Stern sites the general principle of hand pump maintenance as an example. It may be highly effective in the short term however it will eventually need maintenance. If this is not technically possible from the village resources

and no long-term maintenance strategy is in place then the community will simply refer back to its original source. Indeed the situation may be worsened by an increase in population attracted to the development when it was functioning. Thus Stern emphasises the need to have structures community motivation before the installation of a well point of any kind.

A HYPOTHETICAL VILLAGE DEVELOPMENT MODEL

Glennie (1983) introduces his work with a hypothetical village level scenario in order to highlight the theory of his approach to rural water supply. He outlines the problems faced in a typical village concerned with the supply of domestic water.

The author outlines a simple social model with the purpose of emphasising some elementary problems encountered in the development of rural water supply. Glennie starts the hypothetical reconstruction with women spending many hours ever day in the collection and transport of water. This problem of finding sufficient water is exacerbated by the lowering of the water table due to an increase in cultivation and erosion. Eventually the water holes dry up and a serious situation develops. The author highlights the significance of this condition by stressing the link between a clean water supply, hygiene and disease. A limited supply of clean water is indicated as a primary problem. A scarcity of water, particularly if polluted, is suggested to result in a lower standard of hygiene and general health ultimately resulting in a prevalence of disease. Glennie then goes on to expand the scenario to incorporate a poorly informed government agency who, working for political motives, send in field staff who are inexperienced in the social implications of development and who, through a series of social blunders, construct a poorly planned and socially inappropriate spring gravity flow system which supplies only one influential social group within the community. Eventually social upheaval due to conflict and tension generated by the project result in sabotage and neglect of pipe work ultimately resulting in a return to the original polluted source. This sequence of events is supported by White (1978) who also sites the lack of understanding of the social structure of communities as a cause of development failure. The monopolisation and domination of supply by one group within a community is highlighted as a possible cause of an actual as opposed to relative loss of income and social support. White (1978) goes on to site loss of employment under the original scheme, the greater impact on the poor of time lost working on development projects and general cost as potential problems that might be overlooked by an agent of development.

In Glennie's (1983) scenario, he specifically refers to government agencies in his introductory approach, however we can assume that a number of other agencies could fit equally well into this role. Davis, Garvey and Wood (1993) define an agency as" a range of implementing agencies, which include national and international non-government organisations (NGO's), Church organisations, bilateral and multilateral aid agencies, and government departments responsible for water". Essentially an organisation outside of the community structure.

COMMUNITY COMMITTEES

Glennie (1983) devotes the majority of his book to a detailed case study of a 10-year project in Chingale, Malawi. Early on it is stated that a significant factor in the overall approach of this project was the development of village level committees, in a pilot area, that were responsible for making designs about the development of a water supply within their community. Glennie's pilot scheme established such committees within 16 selected villages. The purpose of such social organisations is to allow these villages to approach development agencies and ask for assistance. This is deemed a highly significant step for any development group if the participation of the target community is to be gained. External encouragement to develop water-based committees will be needed to varying extents according to the original social structures within the village in question. Simply because a community is unable to officially ask for assistance in a formal manner does not mean the need is less. Such villages may well require extensive work simply to bring the community to a level of social organisation where it is able to address the problem of it's water supply adequately. Active and often unsolicited encouragement of villages targeted by agencies may be needed to begin the process of committee development.

Glennie sites the formation of such committees as a crucial factor in a projects ultimate success. He states however, that success can not be assured unless the committees are *seen* to have authority. He goes on to

say that in order for the community to have a sense of responsibility, it needs to be answerable to a leadership that is already respected. To gain this and also to ensure that authority is passed on in an acceptable manner, this committee "must come from local leadership". Glennie (1983) emphasises this need to adopt the previous social structure when developing a water committee. The authors study is based on a Malawi case study and outlines a community organisation structure. The committee, being elected by the traditional leaders, was responsible for the day to day planning of the project although the true authority of the project lies with the main project committee as opposed to the village. However, It is hard to see that any groups who are traditionally excluded from the decision making process would be represented by the village hierarchy let alone the "Chief + District Party Chairman". Gleenie (1983) points out that the project to improve water supply to the communities involved came originally from the village leader communities themselves.

DIVERSIFYING COMMITTEE MEMBERSHIP

Although agreeing on the value of a community lead in development issues, Davis, Garvey & Wood (1993) conversely state that "leaders may or may not represent people in the community". They add further that the agenda of the leadership may alienate other more vulnerable groups in the community. There may also be conflict within the community as to who has the right to present themselves as a leader. The major concern expressed is the difficulty in ensuring that the opinions and needs of the whole community have been expressed, including those who would normally have little or no say in such activities. These authors then go on to say that it is therefor important to establish the relationship between traditional leaders, external political representatives and members of the community before establishing a project proposal or committee. Glennie (1983) emphasises the value of a committee within a village, however, by indicating that they are best placed to assess the need of the community. Kofker (1988) goes further pointing out the development of institutions within a community as a benefit in itself. Davis, Garvey & Wood (1993), having expressed reservations as to the value of a leader orientated representation, express a similar point by suggesting that a project may be "community-initiated or agency-initiated". The essential difference being that a community initiated project would be more likely to have the enthusiasm and direct support of the community whereas an agency led program will need to motivate the community to respond to problems as the agency sees them. More usually the case is a flexible approach between the two with the agency defining a region of need and assisting in the establishment of community decision making bodies. This may involve the agency becoming involved in training and education in order that it's own agenda is seen to be valuable by the community. The authors go on to state the importance of recognising that well organised communities will be better placed to put forward request than the less well organised communities who may be in greater need. They thus emphasis the role of actively selecting projects for support and not only waiting for requests. The establishment of a committee in a community that has made no request may actually put it in a position to do so. It should be noted that where Glennie (1983) sites the method of establishing a village committee, Davis, Garvey & Wood (1993) do not.

A STRUCTURED APPROACH TO THE SELECTION OF COMMITTEE MEMBERS

The process of selecting individuals to represent a community on such an issue as water supply requires consideration of a number of factors, which at first may not be obvious. Smith (1989) applies a general management approach to the process of ensuring a representative and viable committee group. The author stresses that problems will arise in "water groups" if they are treated like organisations. That is if they are considered to have strict rules of membership and asked to behave in a similar way to say a subsection of an NGO. This inherently infers a organisational structure which in all likelihood will be entirely alien to them. Smith goes on to say that the failure or success of such committees or water groups can be pinned down to a number of factors.

Firstly it is possible that the members will have outside alliances that are stronger than their sense of duty to the committee. This may mean that decisions are not made for objective reasons but because a member feels they must look out for the interests of other parties. This should be considered when establishing membership of a group and ongoing monitoring where possible. If this is the case, and the true problem lies in the fact that it is almost impossible to tell what other peoples alliances are, then it is a good idea to select people from a wide range of backgrounds in an attempt to balance these biases.

A committee may also not have the social and geographical cohesion required to persist effectively. Smith (1989) points to the need for a group to be able to meet and communicate outside of official gatherings. This to some extent may counteract the important issue of choosing from a wide range of social groups.

Historical conflicts may cause tensions within a committee. If a group has members who have in the past strongly disagreed on almost any issue, it may have some baring on the groups' decision-making capacity. A thorough understanding of the social conditions prevalent in that community is a valuable tool in this process. Perhaps there is a tendency to consider the social aspects of each village within a culture to be alike. This may be true in general terms however, internal histories of relationships, alliances and conflict will have an impact on the overall social structure of a community.

Smith finally suggests that it is crucial that some conflict is allowed in the committees, where it is seen as constructive. He outlines the problem with what he describes as "pathological consensus seeking". This he says may lead to the dangerous state of an organisation or group known as "Groupthink" (first used to describe the near suicidal decision making process that lead to the Cuban missile crisis). This involves no individual input just a general movement in a single direction of thought in an almost numb way. Individualism is necessary to test ideas and keep the debates fresh.

SOCIAL GROUPS WITHIN A COMMUNITY STRUCTURE: PROBLEMS OF REPRESENTATION WITHIN A COMMITTEE.

The issue of selecting a committee opens up a whole area of interest. The potential for internal disagreement on who should represent a community on a committee may reflect the conflicting needs, agendas and status of groups within that community. Indeed the whole process of community input for the project becomes an issue. To rely on a previously established leadership structure may ultimately mean ignoring the most needy of a community, who are intrinsically the ones who need the most help. Potential for internal conflict arises between the groups of different gender, age, social status (Davis, Garvey & Wood, 1993), political origin and financial capacity (Lewis 1991). These authors outline some groups that they consider worth specific attention when planning water based projects. They go on to point out that each community will have it's own special groups that will need consideration. These might include migrant workers who may not be available for consultation or cases where a water hole is shared between two groups.

Fig.1 represents the broad groups that might have separate agendas as presented by Davis, Garvey & Wood (1993). It is suggested that if the opinion of only a limited number of these groups is accounted for the project may ultimately fail. The cause for such a failure could be that the target people of the project receive little or no benefit from the project or indeed become worse of than before. It is also possible that conflict between the groups has broken out over the access to control, rights and benefits to be gained from the project (White 1978)

A Community is made up of many different people.
In a community there are:

- Leaders: traditional, political, religious;
- Professionals: teachers, health workers;
- Business people: traders, commercial farmers, water sellers
- Skilled people: craft workers, blacksmiths, carpenters, well diggers
- A range of people: Women, children, men, young and elderly people
- The disadvantaged: poor people, lower casts, people with disabilities.

(Modified from Davis, Garvey & Wood, 1993)

From the above groups it is suggested that conflicts of interest may arise. Depending on wealth, position of family, resource ownership, gender, education and age, a different perspective on the benefits of a water based aid programme may be derived. Of these groups some will inevitably be in a better position to voice there opinions than others. This is suggested as a fundamental factor when it comes to considering an approach to gathering information within the community.

Lewis (1991) attempts to go a step further in his community classification in his study of a village in the Chitagong hills of Bangladesh. He attempts to apply a modified classification system originally suggested by Wood (1976) based on the ownership of land. By this classification Lewis hopes to get a handle on the groups which are dominant in the community. It works on the premise that the more land you possess the wealthier you are. This in turn infers status and power. We might expect the decision making process to be dominated by those who have the most power. The results are modified by Lewis to take account of such

factors as sharecropping, mortgages and leasing. Four categories are defined by Wood (1976) based on effective landholding. The system did not account for the individuals who own little land but had a skill or piece of equipment that they could hire out. These people were included in decision-making processes in accordance with their relative wealth and status. Essentially, one might expect, assessed on how valuable they are to the farmers. Another group which held status without a large share of land necessarily are those who have links with external incomes. Those in the community who are financially supported by, or have access to, work overseas. This afforded them status and relative wealth, which in turn gave them more say in the community. However, overall the basic land ownership classification proved a valuable guide to the main influences on the community decision making processes was.

POTENTIAL AREAS OF CONFLICT WITHIN THE COMMUNITY.

This heading serves to focus on the socially diverse groups that are potentially present in any village community. From within these subsets a number of potential conflicts of interests are possible in regards to the development and maintenance of a water-based project. These may equally occur within or outside of a representative committee.

GENERATION GAP

One division often represented in leadership is the generation gap, with the elderly often having a greater say within the community. Davis, Garvey & Wood (1993) site a case study to demonstrate the difference of opinion that can develop between young and old within the same community. Essentially the younger people wanted a hand pump and saw this as modern and therefor better, whereas the elder generation related their experiences of hand pump maintenance and preferred a bucket and rope. It was resolved on the basis that the younger people would carry out the maintenance. The example is used to demonstrate the need to gather the opinion of the various groups within a community before progressing beyond planning in order to anticipate and mitigate potential conflicts. Lewis (1991) points out that the generation gap situation has been understood in some developing nations since at least the mid 1960's. The Bangladesh Academy for Rural Development (Gov.body) highlighted the need for specific youth programmes to be run in conjunction with any development project.

THE SOCIALLY DISADVANTAGED

The age of individuals within a group may have little baring on the social advantages experienced, or as the case may be lacked, by groups within the community. Davis, Garvey & Wood (1993) point out that Poverty, disability or a livelihood which has a social stigma attached may affect that groups involvement in decision making and access to water based projects. They indicate an interesting case where the individuals who made the water caring pots where not allowed to use a new water supply as potters were considered of a low social status. In a number of social settings certain social groups have there own water supply. Any development project must be aware of this. The poorest of a community may have little or no say in the decision-making processes. Social status may be denied to this group as the classification proposed by Wood (1976) proposes (see above). Davidson, Myers & Chakraborty (1992) site the example of a caste system as an example of a socially restrictive practice which only allows a strict order of say, status and power within a community and on a larger scale. This is discussed further in the context of gender issues. It is imperative that a field worker makes attempts to contact and ascertain the views of the poorest of a community. This may pose problems socially and these individuals may not be used to proffering opinions. The information gathering structure of any approach to this group must reflect this. This is discussed in under the heading of Gathering Data. Kofkes (1988) points out that if a water source is made more readily available, it is the poor who will benefit in the largest relative sense. The poor will have the most to gain from greater time dedicated to social and economic issues, which was previously taken up by the collection of water.

THOSE MADE REDUNDANT BY A WATER-BASED PROJECT

Perhaps one of the less obvious groups who may become disaffected are those who relied on the previous water set up for there livelihood. Any project altering the water supply structure may result in the displacement of certain individuals. This is an important point not only because these people will have lost

employment but also because the potential for conflict is high. Davis, Garvey & Wood (1993) point out cases where conflict has been avoided by expressly re-employing these people in the new project, a view that is agreed with by Kofkes (1988).

GENDER ISSUES

The issue of gender is now at the forefront of development thinking. The following text goes into some detail as to why from a general perspective. It is important to establish the broad reasoning behind why as the primary collectors and managers of water supply at a village level, women should be consulted in regards to the location of water points.

"Women Play a Central Role in the Provision, Management and Safeguarding of Water. The pivotal role of women as providers and users of water and guardians of the living environment has seldom been reflected in institutional arrangements for the development and management of water resources. Acceptance and implementation of this principle requires positive policies to address women's specific needs and to equip and empower women to participate at all levels in water resources programmes, including decision-making and implementation, in ways defined by them."
Principle No.3 The Dublin Statement on Water and Sustainable Development. International Conference on Water and the Environment (ICWE) Dublin, Ireland, on 26-31 January 1992.

RECOGNITION OF GENDER ISSUES

In only relatively recent water based development projects has recognition has been afforded to the gender issues that arise (Hannan-Anderson, 1985). Perhaps Wakeman (1995) has produced the most prominent recent publication on this issue. This comprehensive study emphasises in it's introduction the strong link between community participation and gender issues. Suggesting that in order to incorporate the needs and views of women into water based projects, the water resource managers at a village level, namely the women, needing to be consulted. The author continues by pointing out that it is actually necessary to gain the input of all the community. That of both men and women and outlines approaches to do this both in an integrated fashion and via separate gender consultations. (This approach is discussed further under the title of gathering information). Davis Garvey & Wood (1993) support this line pointing out that water based development project need to ascertain the views of women as they may not traditionally have a say in the formal decision making process of a community. The authors suggest, however that it is important to recognise that this exclusion does not in any way indicate that the women of the community do not hold an opinion. Indeed the village may actually allow women to have input but only on a private less formal basis as opposed to the open forum of a group meeting. Lewis (1991), supporting a concept forwarded by White (1988), strenuously points out that in the communities he studied, in the Chitagong hills of Bangladesh, the women could easily be seen as passive victims of technology by researchers due to a prevailing social system referred to as Purdah. This essentially did not allow male researchers to have any direct contact with women. It became possible to assume that the women simply accepted the dominance of the man in almost all areas of decision making. This problem not withstanding, the author was able to ascertain from more general observations and overheard conversations that far from being passive, the women of the community were often dominant in a number of fundamental decision making processes. These included water management in the home, animal husbandry, preparation and marketing of produce and matters concerned with fuel and domestic issues. Clearly their input should be gained for any development project in this community. Interestingly the author doesn't point out weather a female researcher would experience similar restrictions in regards to the women of the community.

DEFINING THE DIFFERENCE BETWEEN WOMEN IN DEVELOPMENT AND GENDER ISSUES.

It is worth noting the comments of Davidson, Myers & Chakraborty (1992) who point out that social hierarchies involving women both inside and outside a village community can result in the poorest men and women gaining little benefit from a water development. Mosse (1993) point out those in many ways this helps to define the difference between "Women Issues" in the developing world and "Gender issues". The author points out that it is counter productive and patently incorrect to assume that all women are the same and hence share all the same problems. Mosse goes on to define Gender Issues as those issues which can be perceived as universal to women. These include such concerns as a lack of social and political representation and poor economic recognition for a wide range of informal work. Certain issues mainly

apply to the developing world, such as the reduction in social status of women due to male orientated development projects and the need for women's education in political language. It is important to define these as Gender issues as opposed to Women issues as in some cases women of one social group may well represent the main oppression of women in another social group. In that case the main issue is not gender related but lies in another aspect of a society or culture. Davidson, Myers and Chakraborty (1992) express an example of such a relationship as studied in the caste system in India. This strict class system has a very rigid and defined social code, which among a multitude of other cultural practices means that the women of the higher castes may draw water from a water point before members of a lower caste. If a tank is supplying the water this can mean that the dregs are all that is left for the lower castes. This is an important point. We must not isolate the gender issue from the social status issue. The specific case study that the authors used to stress this point involved an individual called Gulabi who lived in Khaspatti village in the Garwal hills of Northwest India. As a member of the lowest caste her access to clean water was highly restricted. Her distress at walking 8-km for water, on a slope for such poor quality and scarce water was such that it resulted in her later attempted suicide. Apparently, this is not an uncommon tragedy.

WESTERN CULTURAL IMPORTS AND THE MARGINALISATION OF WOMEN: A COLONIAL LEGACY

The comprehensive work of Mosse (1993) outlines the process by which development projects can serve not only to disproportionately benefit men but also may indeed worsen the position of women in a community. The author points out that the Western view of women has in the past, and continues to influences development projects. The concept that women are domestic and men are economically productive has lead to some distorted assumptions about the people the projects are aimed at. Firstly it is considered that by providing the man of the household with benefits will, it is assumed, benefit the entire family. The author suggests this simplifies the project allowing developers to treat each family as a single homogenous unit. Immediately women are excluded from a process that is just as relevant or possibly more relevant to them. Indeed this process of targeting the men of the community may well result in the marginalisation of women. The benefits from the introduction of money, credit, agricultural improvements and technological benefits are often automatically passed onto the men of a community. Perhaps women are given some peripheral benefit such as weaving lessons or elementary health care, however what is not accounted for is that prior to this intervention the women of the group might well have had a substantial say in agricultural approaches, recourse management and decisions effecting the family. By shifting the benefits of a project to men alone the balance of power is shifted away from women. Interestingly Mosse points out that although agricultural training and technology is predominantly aimed at men in Africa, women still and always have produced more than half of Africa's food.

The reason for such a fundamental mistake, the author concludes, on the part of a number of development projects has been simple. Without a full investigation of the target culture, an assumption was made that the Western view of female domestication and subservience was universal. This was particularly prevalent in the first waves of post-colonial development. No suggestion is made by Mosse that pre-intervention cultures in Africa were not patriarchal in the main. Certainly such societies were the rule, however women held sway in certain regions and a balance of power between the sexes had evolved. This influence may not have been formal in a group sense, indeed women may well have been excluded from decision making gatherings, however participation and labour equality would have given a substantial say in the day to day running of a community. The author goes on to contend that intervention of the West has effectively suggested that women are not farmers but only domestically active. This is then backed by placing the key to recourse, in the form of money, credit and technology in the hands of men. Where women, for example, would have been dominant in the process of animal husbandry, providing milk, meat and skin to be traded, now such products are generated and controlled by the male owned development technologies. Women must rely on men to provide cash, cash which development work has encouraged them to perceive as their own and not family owned. This is not to say that men will necessarily behave in a oppressive way because of this, but it does give that opportunity whilst robbing women of their social independence. Western intervention has, in Mosse’s opinion, undoubtedly lead to the net marginalisation of women. Women have become progressively relatively poorer.

So for the first three decades of post- war development we can trace a progressive learning curve. A more detailed look at the issues of gender has lead us to the point where we can now benefit from the lessons learnt from the projects of the past. Mosse (1993) suggests that a balanced gender approach is fundamental for the success of future projects.

HEART OF GENDER ISSUES AT A WATER PROJECT LEVEL

Weather women are actually active in decision making but only behind the scenes or are traditionally cut out from the process entirely, it remains an imperative to get their input on a project. A number of authors, (Curtis 1985; Rogers 1982; Davis, Garvey & Wood 1993) use a number of case studies to demonstrate what is perhaps the heart of the gender issue. Namely that women are usually the main collectors and carriers of water, it is they who will benefit or suffer most from changes in any water program. It is women who have the greatest experience with wells and hence the greatest knowledge. Men on the other hand men are the traditional leaders of the community and as such have the greatest say in the details of the water project. As the agendas between these two groups may well vary the needs of the women may go unheeded. It has been known to result in the women of the community having to work with a water project which is not in their interests or, if the design is based on local knowledge, simply fails as it was based on the flawed knowledge of men. Often the consultation with women may only address the larger issues of water supply, such as hygiene relationships, siting, and considerations for the use of the water point at a community level. Davidson, Myers & Chakraborty (1992) point out the significance of ensuring the ergonomics of a well site are carefully thought through also. The design of a water point is a primary concern to a well user. The height of the pump handle, difficulty of use and height of the outflow are all significant. The authors site an example of this point in the Wollo region of Ethiopia. A project to improve a well point in this area quite reasonably placed a concrete apron around a hand pump. Unfortunately the preferred round-bottomed caring pots of the local people then became unstable. This apparently minor point meant that it took two people to operate the pump. One to pump the handle, which usually takes both hands even of a fully-grown man, and one to steady the pot. A substantial loss of time to the community. Davidson, Myers & Chakraborty (1992) conclude this case study by saying, "these problems were solved after consultation with the people involved in managing the resource - the women of the community."

It is the women of a community who will be responsible for the transportation of water resources from a well point to the domestic home. Curtis (1985) points out that this distance is a fundamental factor in the health and economic well being of women. The author indicates that men of a community may not emphasis this factor when in consultation with development staff, as long as they believe they will receive the needed water. Hence the opinions of women needs to be given prominence when considering the siting of wells. Stress is placed by the author on a water supply being located in a relatively proximal position to a village by outlining the effects heavy load caring can have on women. Pointing out that injury, skeletal deformation, cranial damage, and strangulation are all common occurrences with this work.

Yet the pressure on women is unrelenting. Women may need to provide approximately 40 litres of water per person per day in order to maintain a reasonable level of hygiene. The author suggests that in Africa a typical distance of 6-8 km may need to be travelled to carry some 25 litres of water. These generalised statistics are clear enough to point out that in many circumstances women are faced with an impossible task, particularly during the dry season when the demand for carried water is highest and food is scarcest (Hofkes 1988; Curtis 1985).

Curtis (1985) outlines the health responsibility placed on women suggesting it is quantity as opposed to quality of water that has the greatest impact on health. Clearly then the emphasis is placed on obtaining larger amounts of water. This comment is supported by Mahler (in Davidson, Myers & Chakraborty, 1992) who says "the number of water taps per 1000 persons is a better indication of health than the number of hospital beds. A number of authors point out that general low water availability not only limits hygiene but will be compounded by people resorting to polluted sources, with all the health risks that involves (Rogers 1985; Kofkes 1988). Hofkes goes on to say that large carrying distances will actively encourage a sparse use of water resources for hygiene purposes and stresses the particular prevalence of both eye and skin conditions that this can cause. Curtis (1985) goes on to suggests that the domestic burden of such water provision will often be compounded by the fact that the women are much less likely to receive an education as a child due to their water caring duties. This can have the effect of trapping them in their social circumstance.

MIGRANT WORKERS AND IMPACT ON WOMEN

Siddle & Swindell (1990) indicate that the increasing population of male migrant workers has left a greater agricultural burden on women in a number of African rural cultures. These women must now take on what in some cultures have been traditionally male tasks. The authors qualify this statement by pointing out that this problem is highly variable from nation to nation and even within a single country. Kumar (1985) produced figures indicating that in Nigeria only 9% of women worked in agricultural production, whereas in Cameroon the figure was as high as 56%. Kumar gives a more detailed study of Zambia demonstrating the impact on women of migratory work. The author quotes the figures of 54% of women in male-headed households in Zambia assisting in agricultural labour. In households, which are headed by women, predominantly due to male migration, 85% of women must take on the extra burden. This along with the ever increasing problems associated with environmental degradation, adds to the water burden felt by women.

WOMEN AND WATER RECOURSE KNOWLEDGE

Rogers (1982) points to a hypothetical case that we can assume is based on experience, where the men of a village are digging a well under the supervision of a development worker. They continue to dig until they reach water but are unwilling to dig further as they see no point. No degree of persuasion will change their mind. This clearly will be of no value in the dry season. In this example the frustrated development worker is advised to talk with women who have painful first hand experience of dry wells in future, as opposed to exclusively men. Rodda (1991) who states that women typically have the “knowledge of location, reliability and quality of local water resources shares this view of incorporating women in the process of water development". Interestingly neither author point out how this would persuade the men to continue to keep digging. Perhaps the authors feel the women may be able to apply a pressure to the men which is not available to the development worker. I assume the women would need permission to carry out what is considered the masculine task of well digging.

When the men of a community are prepared to dig a complete well it is still imperative for women to be consulted. A case in point is offered (Davis, Garvey & Wood 1993) where the men of a community were to dig a new well and as such decided to dig it where it would be easiest to do so. This however was not the best place for the women of the community as it was further away and up a hill. This did not figure in the men’s thinking. If the opinion of women were not sort in this case the project would have failed the women of the community and ultimately their dependants. It serves to emphasis the importance of the input of women to any water project.

WELL SITING AND CONCERNS FOR WOMEN'S PRIVACY

Rogers (1985) brings up an important point, which at first one might not think of. The author suggests that it is also important to ask if women about just how close a water point should be. It may be that the centre of the village will not allow women the chance to get away from the continuous social pressure applied by the community. A water point may be the only time women get alone to discuss shared problems and exchange information. This networking between women is no simple gossip shop, though social contact is stressed as important by the author, it also serves to provides a low-pressure environment for the exchange of ideas and developments. A similarly less obvious point, may be found when considering a person’s need for privacy. If a supply is distant from the domestic home bathing may be necessary in a public place. Rodda (1991) points out that this can be both embarrassing and unhygienic as well as exposing women to unwanted advances from men.

SOCIO-ECONOMIC BENEFITS TO COMMUNITY FROM WOMEN GAINING FREE TIME

A number of authors (Curtis 1985; Davis, Garvey & Wood 1993; Hofkes) point out that reducing the work load of women in the community could have socio-economic spin-offs as well as the obvious improvements in the quality of family life. A convenient supply of water will allow time for economic activities such as gardening, cloth dying or crop washing in order to generate extra capital. Curtis (1885) who highlights this point reports a study by the ODA. The study involved improving the access to potable water in a community in Swaziland. It was noted from this development that handicrafts produced by women doubled in production.

POLITICAL ISSUES

As stated previously (Davis, Garvey & Wood, 1993) political problems of leadership may arise in a community. This might involve two communities living in a single village, two communities using the same water hole or even divisions in political alliances within a community.

External politics can a have a dramatic effect on a village community also. Especially as armed opposition groups often rely on rural communities for support. Glennie (1983) points out that he had to start his water based development project in Malawi as a pilot study, as initial attempts to start over a larger area were hampered by anti-government rebels. It was less a violent conflict as a process of spreading rumours that the development in some way represented a government trick. The smaller project allowed a greater control over information and provided a showcase for other communities. Lewis (1991) points out that external politics has generated an under class in villages in the Chitagong hills in Bangladesh. He outlines a social group in the villages who are effectively refugees from India. After a period of conflict between Bangladesh and India a treaty was signed 1965 which allowed the exchange of Indian Muslims and Bangladesh Hindus. The idea was that there would be a direct land swap between the two groups. This essentially didn't happen and the arrivals were left and remain almost completely landless and hence voiceless in the community. Glennie (1991) sites the need to have an understanding of all the external as well as internal social pressures that apply to a water resource development scheme. Glennie (1983) gives an example of this requirement in the form of a political situation that developed surrounding his own project. Essentially a disaffected political group opposed to the incumbent government spread rumours that the water supply development had political motives which in a few isolated cases resulted in the flare up of violence. This initially prompted the proposal of a pilot scheme, which would be less prone to such exploitation. This also offered the possibility of a greater control and communication within the project. It is further suggested that this allowed a showcase, which would have the effect of interesting other initially reluctant communities.

ISSUES OF PROJECT BENEFICIARIES

Lewis (1991) points out that if the larger landowners have the greatest say in the community's participation then it is possible that they may structure it to suit their needs as opposed to those in a less advantageous position. This may actually have the effect of decreasing the status and resource of the poorest of the community. It is thus essential to establish the requirements of the less influential within a community.

At this point it is worth pointing out that few villages are truly in isolation from their neighbouring communities. A number of villages may benefit from a project, which in turn effected the surrounding communities. This is significant as it may have the positive effect of increasing the trade and economic activity between villages, however it is also worth noting that one community may become dominant over others to the point of that village's detriment. Just as preferentially benefiting one social group in a village has the potential for generating conflict, elevating a village amongst a wider community.

COMMUNITY PARTICIPATION:
THE RELATIONSHIP BETWEEN COMMUNITY AND AN AGENCY THAT OPERATES AT A COMMUNITY LEVEL.

THE INTERNAL STRUCTURE OF DEVELOPMENT AGENCIES

Before considering the interaction between the community and interested development Agency it is also important to establish the essential structures of that agency. This will influence the approach of an agency and is central to the ultimate success or failure of a development project. As previously stated Davis, Garvey & Wood (1993) define the major agencies as:

Government agencies: Composed of a number of departments, usually health, water, education and community development. Although well-trained staff often are under paid and under-resourced and hence may suffer low motivation.

Multilateral agencies: Large funding bodies such UN based organisations. Tend to work with government bodies on a national or regional scale as opposed to at a community level. Can be somewhat bureaucratic.

Bi-lateral agencies: A national funding body such as ODA (UK) or CIDA (Canada). Tend to work via contractors on a fairly large scale, often supporting government projects, which can result in low community level involvement. Will often act in an advisory capacity.

Non-government organisations (NGOs): Can be international or national. They may be active in the field themselves or support other NGOs in the field. They tend to have a greater contact at a community level and suffer less bureaucracy. Working more in parallel with government departments as opposed to within them, by the secondment and training of government field staff.

Community groups and religious organisations: Operate in a similar way to the NGOs. They will often have support from external agencies. Their place within the community is ideal for close community contact.

Davis, Garvey & Wood (1993) summarise the personnel of these organisations in the following way:
- Managers in field office, head office, international office;
- Professionals: engineers, technicians, community development, health and financial staff;
- Skilled people: supervisors, masons, mechanics and drivers.

Further to this the authors outlines approaches to the training and structuring of staff within an agency. This includes details of the employment and training of local individuals and highlighting the roles and activities of these groups. One group of particular interest in this study is the extension worker, as they will be drawn from the communities that are directly affected by the activities of the agency. Extension staff has the task of liasing between the community in which they live and the agency. Their task is to help communicate ideas and concepts to the community as a whole. As such they need to have the support of both the community and the agency. As can be seen from the diagram, the extension worker will possibly be a member of a team whose responsibilities may include baseline and socio-economic surveys, assisting in the formation of committees and training of it's members and hygiene education.

An interesting case study used by Davis, Garvey & Wood (1993) outlines one agencies extension staff recruiting tactics. It highlights the input of women into any water based development project. The agency in question required, where possible that the staff member be a long term resident of the community, a good communicator with literary skills, prepared to travel and a woman.

OUTLINE OF THE INTERACTION BETWEEN COMMUNITY AND AGENCY

The relationship between the community and an interested agency is crucial to the success of any project. Davis, Garvey & Wood (1993) highlight the need for an agency to be flexible in its approach to specific community problems. Siting case studies the authors outline a clear need to consult the community members in detail before planning a project. Gaining the agreement of the community as a whole through discussion and interaction with the different groups involved is fundamental to the progress of the program. This may also include the groups outside of the community who are impacted as well. The Agency may have to develop programmes, which are acceptable to a number of groups, in effect a compromise. The authors site an example in which, due to resettlement programmes, two separate communities live in a single village. A process of negotiation instigated by the agency involved eventually allowed an agreement to be reached on how these two groups should be represented for the purposes of community participation.
Davis, Garvey & Wood go on to point out that water holds a central position in the considerations of a community and as such can be a force for both unity and conflict. An Agency concerned with development at this level must be prepared to recognise the potential for conflict within a community, and indeed the potential for progressive positive change. Often at the heart of potential dispute such as a shared water hole, is a traditional or customary agreement. The proposed project may be striking at the centre of a previously accepted balance. A good example of this is the relationship between village people and nomadic peoples. Disputes are not uncommon in this area, especially as the impact of environmental degradation takes hold (Twose, 1991) (see 2.1). A resource may have been shared by a settled group and periodically used by nomadic groups. If the water resource system is upgraded and effectively claimed by the settled group, then the potential for conflict arises when the nomads return. As an agency working in this environment it is

necessary to understand these factors and where possible builds on already standing arrangements. This information may not be directly proffered so an agency must be prepared to actively seek this information, formulating questions that will address the problem. The authors go on to point out examples of specific questions asked in case studies.

Davis, Garvey & Wood (1993) point out that an agency active at a community level must be aware that some communities will cost more to develop than others simply due to their remoteness or generally greater need. It is easy to fall into the trap of addressing the needs of those that are more accessible. Lewis (1991) demonstrates that this bias in project selection can also be experienced at a national level. He points out that a long term general development area in the Chitagong hills of Bangladesh known as the "Comilla model" tends to attract development despite being relatively well of now. This is generally attributed to the greater guarantee of success with projects in this area. The population is relatively well educated and accepts new technologies comparatively easily. This is a desirable position for those in the model area, however, transfer to other areas is necessary.