EU EDF 8 – SOPAC Project Report 79
Reducing Vulnerability of Pacific ACP States

SAMOA TECHNICAL NOTE
HYDROGEOLOGICAL LIAISON MISSION TO SAVAI'I

19th to 24th September 2006

WaSSP/SWA personnel sampling a coastal spring discharging from a small basalt lava tube, NW Savai'i.
(NB. Ruins of Avata Church in background. Both church and village were completely destroyed by massive storm-surge waves caused by Cyclone Ofa in February 1990)

Compiler:

Stephen Booth
SOPAC Secretariat

June 2007

IMPORTANT NOTICE

This document has been produced with the financial assistance of the European Community; however, the views expressed herein must never be taken to reflect the official opinion of the European Community.

For more copies of this report, apply to the SOPAC Secretariat at the address below:

PACIFIC ISLANDS APPLIED GEOSCIENCE COMMISSION
c/o SOPAC Secretariat
Private Mail Bag
GPO, Suva
FIJI ISLANDS
http://www.sopac.org
Phone: +679 338 1377
Fax: +679 337 0040
director@sopac.org

CONTENTS

LIST OF ACRONYMS

ACP	–	African, Caribbean, Pacific
AGC	–	Australian Groundwater Consultants Pty Ltd
BoQ	–	Bill of Quantity
EDF	–	European Development Fund
EU	–	European Union
Hydro R&D	–	Research and Development in Hydroelectricity generation
MNREM	–	Ministry for Natural Resources, Environment and Meteorology
MOF	–	Ministry of Finance
MWH	–	MWH Americas, Inc (environmental consultants)
O&M	–	Operations and Maintenance
PDA	–	Project Design Assistance
PIA	–	(WaSSP) Project Implementation Assistance
PWL	–	Pumping Water Level
RWL	–	Rest Water Level
RWS	–	Rural Water Supply
SOPAC	–	Pacific Islands Applied Geoscience Commission
SWA	–	Samoa Water Authority
TA NAO	–	Technical Assistance – National Authorizing Officer (Samoa-EC)
TDS	–	Total Dissolved Solids
ToR	–	Terms of Reference
WSMU	–	(WaSSP) Water Sector Management Unit
WaSSP	–	(EU-funded) Water Sector Support Programme

EXECUTIVE SUMMARY

Mr Ludo Prins, Programme Advisor for the EU-funded Water Sector Support Programme (WaSSP) in Samoa, contacted SOPAC on the 09th September 2006, with an urgent request for assistance from a groundwater specialist. Assistance was primarily required to resolve long-term concerns about the safe groundwater yields in Falealupo. Currently the Project Design Assistance (PDA) project is finalising the design for the water supply systems throughout Samoa, including Falealupo.

The WaSSP Water Sector Management Unit (WSMU) have already received two expert opinions on how to approach the issue to get the required water resource inputs into the (S4) design that should be finished by mid-November 2006. Some contradictions within the two proposed approaches (refer to email records in Annex A) resulted in uncertainty within the WSMU, resulting in their requiring further advice from a third party. Given the timeframe and staff availability, it was decided that hydrogeological advice could be most immediately facilitated via direct synergy with the SOPAC/EU EDF8 Project, *"Reducing Vulnerability of Pacific ACP States"*.

The Samoa Work Plan, developed through earlier EDF8 multi-stakeholder consultation meetings, has three tasks identified within Key Result Area 2 (Water) as follows:–

WS 2.1.1	Maintain active liaison with and provide technical support to SWA and review of cost effectiveness of alternative sources.
WS 2.1.2	Review of long-term abstraction of groundwater resources northwest Savai'i;
WS 2.4.1	Review groundwater supply potential for Aopo and Asau in northwest Savai'i

Under the auspices of the above tasks, Mr S.K. Booth, Water Specialist within the SOPAC/EU EDF8 Project agreed to undertake a short technical mission to liaise with WaSSP and provide hydrogeological advice as appropriate. The mission was completed between 19th September and 24th September 2006, and essentially involved reconnaissance field investigations in the Falealupo Peninsula with staff from WSMU, Samoa Water Authority (SWA) and the Ministry for Natural Resources, Environment and Meteorology (MNREM), and subsequent presentation of observations and recommendations.

This report records the field observations and data collection made during the mission and presents some outline conclusions and recommendations to assist WaSSP with charting a way forward for the PDA. In the event that WaSSP and SWA succeed in implementing or progressing some or all of the recommendations suggested, additional hydrogeological technical support is envisaged during 2007 from the EDF8 Water Specialist with associated advice and fieldwork supervision during borehole logging and/or test pumping exercises.

1. INTRODUCTION

1.1 Context

The focal sector for Samoa's 9th EDF development cooperation programme is improvement in public health through improved access to safe water supply, basic sanitation, and sustainable water resource management. Improvement and rehabilitation of rural water supply systems is therefore an integral part of the Water Sector Support Programme (WaSSP) in Samoa. Technical assistance services under the on-going Project Design Assistance (PDA) contract is preparing detailed designs and tender dossiers for the proposed works. Three phases of works are planned, including improvements in the Falealupo area in northwestern Savai'i.

1.2 The Falealupo Area

The Falealupa area lies at the far northwestern corner of Savai'i, the most remote location from the country's capital, Apia.

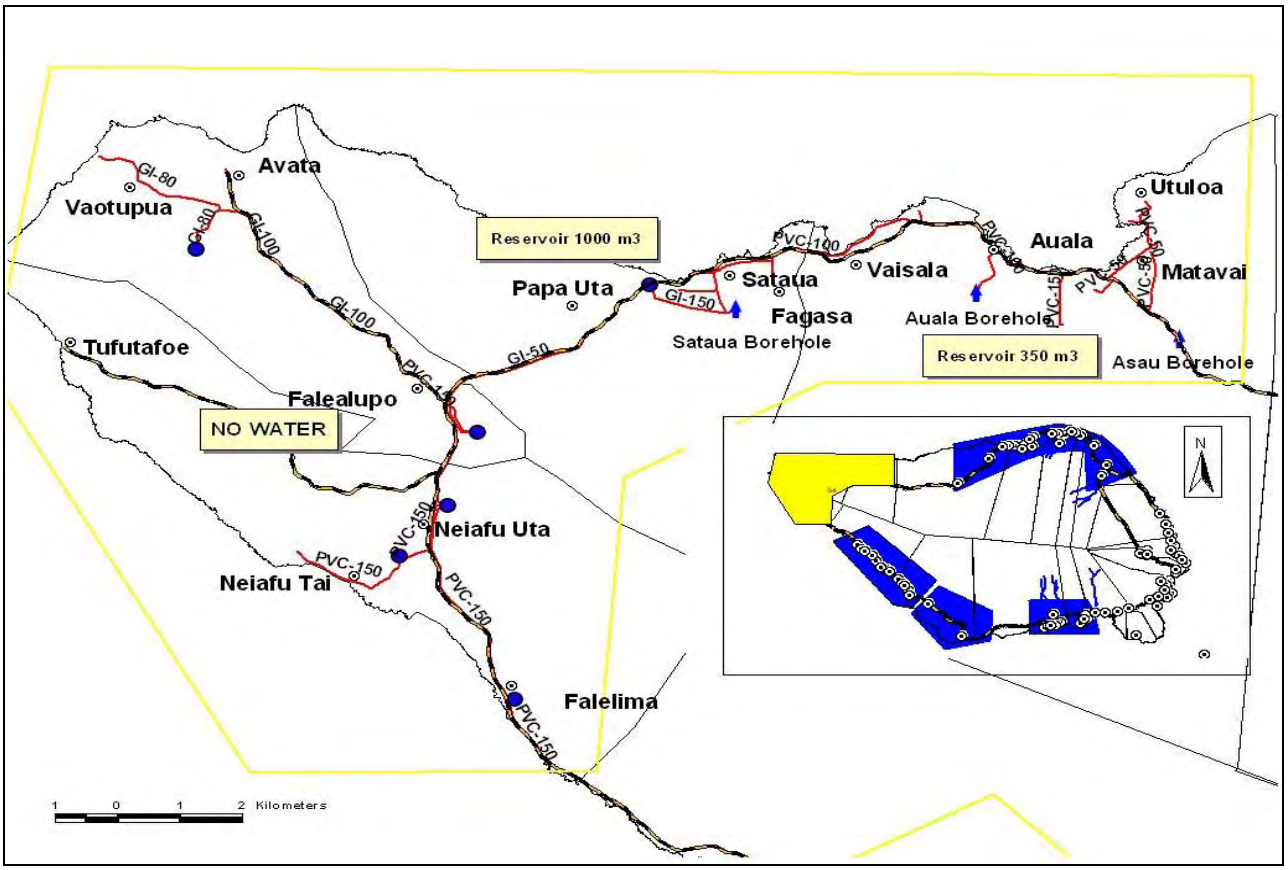

Figure 1. Location Map: Northwest Savai'i, Samoa.

The peninsula comprises a total of 3014 inhabitants in a number of villages (Falealupo, Papa Uta, Avata, Vaotupua, Tufutafoe, Neiafu Uta, Neifu Tai and Falelima). A further 3629 inhabitants live along the neighboring northwest coastline between Sataua and Matavai.

Apart from the Sataua-Auala-Asau water supply systems, which are operated by the Samoa Water Authority (SWA) and reportedly suffer varying degrees of salinity on occasions, there has

been no operational public water supply reticulation serving the other villages in the peninsula since 1993. For the past 13 years therefore, these other villages have relied on domestic-scale rainwater harvesting and SWA water tanker operation for their water supply. Development of the area is therefore quite limited despite high economic potential (e.g. tourism). In line with the Government's development agenda of "Opportunities for All" it remains an area of high priority.

1.3 Access to Safe Water Supply

The earlier EU-funded Rural Water Supply Appraisal Study (2005) recognised the gravity of the situation in the Falealupo area, but without access to hydrogeological studies and information was unable to identify a firm solution for Falealupo's water problems. The Inception Report for the on-going Project Design Assistance (PDA) study (September 2005) noted that a continued strategy to improve rainwater harvesting supplemented by tanker truck was not satisfactory, although no alternative was provided at this stage.

During subsequent field visits in May/June 2006, the PDA team developed outline proposals to provide a solution to safe water access in the area. The proposals complement planned initiatives in nearby villages (Sataua – Auala – Asau) but final design requires further investigation of the hydrogeological regime in this area. The PDA team is expected to submit final designs by mid-December 2006. The scope of works proposed by the PDA team for the further hydrogeological investigations of the Falealupo and the Sataua – Auala – Asau areas is outlined below.

Phase 1 – Initial investigation

a) Investigation: Collection of general hydrogeological data. Collection of specific information: borehole logs – pumping tests – etc. of boreholes 1 and 2 and the Sataua – Asau – Auala boreholes (SWA – Drilling company).
b) Field investigation: supplementary pumping test on Sataua – Auala and Asau boreholes. Determination of boreholes performances and aquifers potential (mainly in Sataua).
c) Geophysical soundings: Geophysical survey, analysis and reporting for the area.
d) Definition of specification for drilling equipment – drilling rig for necessary test holes (Falealupo) and exploitation holes (Falealupo and/or Sataua). In case water source(s) is secured, Falealupo is to be covered under phase 3 of PDA project or EDF 10.

Phase 2 – Test and production boreholes

e) Proposal for implementation (test and production holes) contract by SWA – including detailed Bill of Quantity – listing of suppliers, etc.
f) Other topics to be covered under this service contract: Rehabilitation of the SWA drilling rig – training of local staff/drilling team – drilling of new exploitation boreholes for phase 1 and 2 of the PDA. Replacement of existing borehole pumps based on 18 hours / day pumping rate and reviewed water demand.

Further considerations –

g) Topographic survey, final design and tender dossier preparation to be included in the PDA services – that is at no extra cost to the Contracting Authority.
h) Supervision of works implementation to be covered within the proposed Supervision contract – that is, within the existing inputs, timeframe and budget for Option 2.

Financing support for *Studies and Investigations* was foreseen in the WaSSP Financing Agreement. In particular, it was intended that these studies and investigations support the design work by the PDA team.

1.4 Recent Developments

The PDA consultants submitted a proposal to organise a special mission in November 2006 in order to carry out geological, geophysical and topographical surveys and design, as well as an audit of the SWA drilling equipment for possible refurbishment, along with a related training programme for SWA staff.

In an attempt to draft and finalise the Terms of Reference and cost estimate for the PDA proposal, an expert opinion was sought through the WASSP Project Implementation Assistance (PIA) consultants' team. The resulting PIA expert opinion deviated on a number of important points from the PDA proposal.

The WaSSP therefore sought technical assistance services through a groundwater expert from a third party – the SOPAC/EU EDF8 Project – to review the different proposals, make a site visit to the Falealupo area, and to present recommendations to SWA on ways to move forward. The results of the technical assistance services should allow SWA to:

- successfully complete the design of Falealupo water supply system in the short term (December 2006);
- secure sustainable groundwater levels and water use in the wider Falealupo area in northwest Savai'i for the medium and long term; and
- establish and secure a viable drilling capacity for SWA.

1.5 Objectives of the Mission

The general objective of the mission was to provide technical assistance to SWA and MNREM to define an approach to secure sustainable (ground) water resources use in the northwest Savai'i Peninsula in general and in Falealupo in particular.

Specific objectives of the mission, in order of priority, are listed below.

1. Assist SWA to provide necessary inputs on how to best finalise the design of the envisaged Falealupo water supply system under the PDA project.
2. Assist MNREM to outline, a sustainable (ground)water resources management and monitoring system in the northwest Savai'i Peninsula in general and Falealupo in particular.
3. Assist SWA/MNREM to prepare an outline ToR to investigate the re-establishment of a drilling capacity.

2. PROGRAMME

2.1 Scope of Work

The mission involved undertaking the activities listed below.

- Briefing meetings and discussions with relevant staff from SWA, MNREM and the Water Sector Management Unit (WSMU) of the WASSP.
- Review existing studies, proposals, other documents and correspondence on the (ground)water situation in northwest Savai'i and Falealupo.
- Travel to the Falealupo area to visit the sites of three existing boreholes and meet with water users' representatives.
- Review of which inputs are essential to finalise the design of the envisaged water supply system in Falealupo under the existing PDA contract.
- Review SWA drilling rig condition and capability for rehabilitation (if economically feasible).
- Verbal debriefing meeting on 22/09/06 with relevant staff from SWA, MNREM and the Water Sector Management Unit (WSMU) of the WASSP, presenting initial thoughts on observations, findings, conclusions and recommendations.
- Prepare a short mission report (3-5 pages), excluding attachments, with one or more ToRs and cost estimates for (1) obtaining necessary groundwater resources inputs to finalise Faleolupo design; (2) geophysical (soundings) and hydrogeological (investigations) exploratory study programme; and (3) SWA rig diagnostic for rehabilitation also including spare parts (if economically feasible).

2.2 Programme Chronology

Tuesday, 19 September 2006

18:30 hrs	Depart Suva Nausori on PC511
23:30 hrs	Depart Nadi on FJ253

Samoa

09:00 hrs	Briefing meeting with WaSSP Programme Manager & MOF @ MOF
09:30 hrs	Briefing meeting with SWA, MNREM & WSMU @ SWA
11:00 hrs	Initial inspection of SWA drilling rig (static) at SWA works depot, Apia
14:30 hrs	Depart MOF for Upolu ferry terminal
16:00 hrs	Depart Upolu on vehicle ferry
17:00 hrs	Arrive Salelologa Wharf, Savai'i
19:15 hrs	Arrive Vaisala Hotel, northwest Savai'i

Wednesday, 20 September 2006

06:00 hrs	Depart Vaisala Hotel for field/site investigations around Falealupo Peninsula
07:00 hrs	Quarry/geological exposures/reconnaissance overview
08:00 hrs	various derelict AusAID water supply schemes
09:00 hrs	Kapoua w/s scheme (twin tank failure)
09:30 hrs	Avata village (abandoned) and coastal springs
11:00 hrs	Vaiomaligi wellhead and lava caves
12:30 hrs	Falealupo borehole sites – investigations/discussions
15:30 hrs	Intense rainfall – return to hotel

Thursday, 21 September 2006

06:00 hrs	Depart Vaisala Hotel for continued field/site investigations
06:30 hrs	Derelict timber yard in Asau
07:45 hrs	Asau Borehole headworks
08:15 hrs	Matavai coastal spring/bathing pools
08:40 hrs	Auala Borehole headworks
09:55 hrs	Sataua borehole headworks
10:25 hrs	Sataua coastal spring/bathing pool
10:40 hrs	Sataua water supply storage reservoir
11:30 hrs	Vaisala Hotel – check out
13:00 hrs	Alofaaga blowholes
14:30 hrs	Arrive Salelologa Wharf
16:00 hrs	Ferry (landing craft) departs Salelologa
17:30 hrs	Ferry arrives Mulifanua Wharf
18:30 hrs	Arrive Princess Tui Hotel via MOF, Apia.

Friday 22, September 2006

08:00-10:00hrs	Review of recent proposals and correspondence (e.g. TA NAO, Hydro R&D, MWH)
11:00 hrs	Discussions with MOF & WaSSP
12:00-13:00 hrs	Meeting preparations
14:15 hrs	Present de-briefing meeting @ SWA with SWA, MNREM, WSMU etc
16:15 hrs	Second inspection of SWA drilling rig (mast up) at SWA works depot.
17:30 hrs	Ludo's house
19:00 hrs	Dinner hosted by Ludo & Carmen at Panama Hat Restaurant
22:30 hrs	Return to Princess Tui Hotel

Saturday, 23 September 2006

05:35hrs	Depart Faleolo, Apia on FJ252

Sunday, 24 September 2006

06:35hrs	Arrive Nadi on FJ252
11:30hrs	Arrive Suva

3. FIELD OBSERVATIONS SUMMARY

3.1 Localities Visited

The following details were detailed where recorded:

- Site Name
- GPS Point Number
- Latitude
- Longitude
- Elevation
- Borehole details (depth/diameter/access restrictions etc)
- RWL
- PWL
- Flow Meter readings
- Flow Rate
- Conductivity
- Total Dissolved Solids
- Salinity
- Water Temperature
- Sample recovered (Y/N)
- Laboratory analysis details
- Other General Notes

3.2 Principal Water Resource Observations

3.2.1 Rainwater Harvesting

Due to the absence of a piped water supply since 1993, and no doubt other recent historical practice, most domestic dwellings in the Falealupo Peninsula were commonly seen to be actively undertaking rainwater harvesting via an assortment of roof-gutter-downpipe-storage tank systems. The limited fieldwork time available did not permit a detailed survey of tank types or infrastructure condition surveys, but it was obvious that many separate donors have assisted in domestic-scale tank provision over the years. Comments were noted amongst the team concerning potential system design limitations with respect to only half the available roof area being utilised (needs follow-up).

The ***KEY*** issue here is that rainwater harvesting is already a well accepted, effectively universal practice for the scattered resident population, forming an integral part of their mentality and day-to-day life. Since the philosophy is already well entrenched, continuation and maximising assistance with this practice would appear to be the major and logical first step forward for any rural water supply scheme (such as WaSSP). Helping people to maximise their domestic-scale catchment and storage systems would improve the ability of individual households to retain sufficient storage to get them through most "design drought" periods. Although this is the drier, rain-shadow area of Savai'i, annual rainfall totals are nevertheless relatively high and the water source is of high quality and of course free of charge. This approach would not mean trying to impose anything "new" on people, and most importantly does not carry the often onerous burden of land access, tenure or compensation issues (or even vandalism, destruction or failure) that are commonly associated with installation of piped supply schemes within Pacific communities.

The communities are undoubtedly well aware of the general principles behind rainwater harvesting and it would probably not take too much in the way of awareness and education campaigns, via local NGO's, to further upgrade both domestic and/or community facilities (such as large roof areas available on churches and schools – including eventual tourist hotels). Stored

rainwater should therefore be regarded as one of the primary resources in the Falealupo area, which can effectively be utilised in much of the area as the principal potable source, to be managed in conjunction with other potential sources of lesser reliability or poorer quality.

Clearly, the more rainwater harvesting that can be developed in the area, then the less demand will be placed on more conventional piped (SWA) water supplies, which means all-round savings (for SWA) on pumping costs, distribution infrastructure operation and maintenance, and extremely importantly, less stress placed on the very sensitive aquifer resources. The major disbenefit of this approach for SWA is that they will be losing potential revenue if customers use less piped water!?

3.2.2 Hydrogeological Characteristics

The observations of geological exposures made during the two days of intense fieldwork served to confirm to SWA, MNREM and MSWU personnel the extreme complexity of the hydrogeological conditions and the difficulties associated with groundwater exploration and management techniques in the relatively young volcanic terrain of northwest Savai'i.

Previous consultants' reports have outlined the heterogeneity and inter-layering associated with the variable thickness basalt lava flows and numerous associated scoria-cinder volcanic cones. Secondary permeabilities values, resulting from cooling cracks, joint planes, faults and other structural features, can be extremely high, resulting in effectively zero surface water runoff, so the major proportion of rainfall infiltrates to recharge the groundwater systems. Unfortunately, because the aquifer transmissivities are so high, throughflow and outflow are equally rapid and highly dynamic processes, via such features as discrete lava tubes/tunnels and discharge at numerous coastal spring sites.

The negative aspects of this type of hydrogeological terrain are minimum storage or residence time, rapid transmission of any potential pollutants and a generally deep, low elevation regional water table, lying close to mean sea level. These combined factors can result in deep and very difficult drilling conditions for borehole construction, associated high energy (pumping heads) requirements, and saline upconing if poorly managed pumping practices are concentrated at a limited number of spatially restricted sites.

Anthropogenic contamination, derived from bad sanitation practices, piggeries, cemeteries etc, can be easily transmitted significant distances within the rapid groundwater flow system, with minor scope or time for natural attenuation processes to act. However, most of the interior catchments are steep and rugged with heavily vegetated surfaces and are therefore relatively inaccessible to man's activities.

3.2.3 Previous Borehole Schemes

A number of aid-funded water supply schemes, dependent upon one or more borehole sourceworks, were identified that appear to have been undertaken and installed at different times during the past 20-30 years. This report is not going to discuss these in any detail, but apart from the three current operational sources noted in section 3.2.4 below, the common feature of all previous installations is that they are all now visibly derelict, abandoned or reportedly non-operational. To ensure that any future investment planned in the area by WaSSP and SWA does not fall into the same "bottomless bucket", one simple question that has to be posed is ***WHY*** are these earlier schemes no longer functional?

The reasons are undoubtedly many, but the answers frequently appear clouded by doubt and uncertainty. Hydrogeological conditions clearly impact the situation, though many other factors may have cumulatively contributed to eventual scheme failure. A number are listed below.

- Drilling and borehole construction difficulties *(collapsing formations, large voids, circulation losses etc. Note one borehole was recorded as taking up to 6 months to drill).*
- Lack of test pumping procedures.
- Incorrect pump specifications, pump suction settings or poor pumping regime practice.
- Lack of system storage.
- Unaccounted – leakage.
- High energy costs and intermittent electricity supplies for pumping.
- Lack of regular O&M (= disaster management).
- Lack of regular monitoring and record keeping (lost or no data).
- Lack of institutional memory on what happened when and why.
- Lack of institutional technical capacity in groundwater management issues.
- Over-abstraction and associated salinity and corrosion problems.
- Natural disasters – e.g. Tropical Cyclone Ofa.

No evidence was observed of any water treatment facilities, chlorination or other practices, prior to consumer supply.

Previous reports recognise and warn about the sensitivity and limiting boundaries of the aquifer conditions prevailing in the Falealupo Peninsula, stressing the need for regular and careful monitoring and review of critical basic factors, such as rest water levels, pumping water levels, abstraction rates and volumes, salinity and other water quality parameters. Without such historic monitoring data, developing a confident understanding of how the boreholes and aquifer system are interacting is near impossible. In an environment of minimal data and scarce knowledge, proactive aquifer management practices therefore have little or no foundation.

3.2.4 Existing Borehole Schemes

Asau

Flowmeter indicating approx abstraction rate of 16.4 l/s
Conductivity 1,786 µS/cm
TDS 894 mg/l
Salinity 0.9 %o (psu)
PWL 43.8 m (below top of dip tube) @ 09:35 hrs; 21/09/06
Dip tube obstruction ? at 46.35 m
Pumps 05:00 hrs to 10:00 hrs every day
Pumped straight into supply, therefore distribution system alternatively under pumping pressure then gravity drainage
No treatment
No intermediate storage
Raw water sample recovered from sample tap

Auala

Flowmeter indicating approx. abstraction rate of 14.5 l/s
Conductivity 2,170 µS/cm
TDS 1,005 mg/l
Salinity 1.0 %o (psu)
PWL 62.10 m (below top of dip tube) @ 08:55 hrs; 21/09/06
Dip tube obstruction (silt?) at 67.00 m

Pump switched off at 09:00 hrs
Pumped straight into supply, therefore distribution system alternatively under pumping pressure then gravity drainage
No treatment
No intermediate storage
Sample tap sucking air – water sample recovered from household "downstream"

Sataua

Flowmeter indicating approx abstraction rate of 9.3 l/s
Conductivity 1,302 µS/cm
TDS 655 mg/l
Salinity 0.7 %o (psu)
No dip hole access to obtain PWL
Water sample recovered from leaky valve?

Adjacent borehole approx 11 m away from pumping borehole – RWL 33.88 m (below top of 8" pvc casing) @ 08:55 hrs; 21/09/06. Plumbed b/h base maybe at 36.9 m?

B/h pumps into Sataua Storage Reservoir (21 m x 21 m x 3.5 m) = 1.5 Ml of storage
Constructed 1979?
Reservoir almost full at 10:40hrs; 21/09/06
Gravity feeds from reservoir back into Sataua, Vaisala & Auala villages?
No treatment apparent
Inlet from borehole –
Conductivity 1,298 µS/cm
TDS 656 mg/l
Salinity 0.7 %o (psu)

Notes from debriefing meeting at 14:15hrs, 22/09/06

Some SWA comments are recorded below.

- The SWA Asset Division are responsible for collecting and storing all monitoring data relating to these three operational boreholes. Copies of RWL, PWL, Conductivity and Abstraction (volumes and rates) data were requested.
- The Sataua distribution area is well-metered (should allow good leakage assessment to be undertaken – if not already done so?)
- It was stated that there is an old reservoir upslope of the agricultural station (used to provide interim storage for the Asau-Auala scheme?) – not known why it is not used any more.
- Maintenance of the submersible pumps in all 3 boreholes is undertaken at least 2 times per year, requiring pumps to be lifted and inspected. Are inspection reports/observations available? Are water levels/salinity recorded and total depth plumbed whilst pump is out of hole, any evidence of corrosion on rising main? etc.
- Electricity power supply fluctuations are reportedly common and badly affect the submersible pump motors – the motors often burn out, hence need to lift and replace (frequency?) the pumps.
- It was clear that SWA have significant concerns about high electricity (pumping) costs when discussing the Falealupo area. (Query – is there in fact a water resource problem?)
- It was proposed that perhaps SWA and the local communities should consider a flexible approach, whereby it is recognised that 2nd class water (ref the salinity problems) is

supplied by SWA to satisfy toilet flushing and other high demand usages etc. whereas potable drinking water requirements are supplied via rainwater harvesting.

3.2.5 Falealupo

Two borehole locations are both close to the principal road T-junction in Falealupo-uta. Both boreholes reportedly used to feed a single nearby (quite small) storage reservoir, which then gravity-fed most of the Falealupo Peninsula via a sequence of other small storage tanks. This was an AusAID scheme dating from c.1990-91 and locals (site caretakers) claim it yielded a very satisfactory supply whilst operational, with no discernable salinity problems, but unfortunately the scheme wasn't very long-lived – reasons unclear and conflicting.

No.1 Borehole

Electric submersible pump removed in 1992? and "taken elsewhere" – never returned. Large concrete pump house foundations, but no superstructure remains. Borehole consists of 250 mm Ø steel outer casing with grouted annulus to 150-mm Ø steel inner casing; Borehole dipped cleanly without obstruction to 100 m limit of dipper tape, but no water recorded (unsurprisingly, since original depth claimed to be c200 m+)

No.2 Borehole

Similar large concrete pump house foundations but no superstructure remains. Borehole top not located, but suspected buried at fairly shallow depth at fairly obvious site. Two tricone rock roller-drilling bits and other heavy-duty drilling equipment had been discarded around the site. Pump used to run 3 hours at a time on a cycle of 3 times per day on an autotimer, which apparently malfunctioned. In 1994 the pump was not working (failure to repair autotimer, rather than submersible pump failure suspected. Decided to change the pump (around 1996) but subsequent attempts to clean out the borehole utilising a bailer resulted in snagging, loss of bailer and c.200 m of steel cable down the hole. Subsequent dipping indicated a "dry" hole – but dipper may have been held up by the bailer/cable debris jammed-up at a high level within the hole or piled up at the bottom above RWL. An adjacent 50-mm Ø galvanised iron exploratory pilot or observation borehole was located and dipped cleanly, but dry, to full 100 m extent of available dipper tape. SWA to arrange a gang to try and locate and uncover the top of the production borehole to allow further investigations.

It appears very likely that the two boreholes at Falealupo-uta are the subject of Report No. 1245/2 issued by Australian Groundwater Consultants Pty Ltd (AGC), in July 1987 to the Australian Development Assistance Bureau.

The document relates to a Rural Water Supplies Phase 3 Project, Western Samoa, and essentially provides a Technical Specification and tender documents to cover the following proposed works:–

- Drilling of up to 3 pilot/test holes to 210-220 m depth
- Completing one pilot/test hole as a piezometer if low-yielding material or saline water is encountered.
- Up to two pilot/test holes and constructing 150 to 200 mm diameter production holes to 210-220 m depth.
- Supply and install pump and generator for pumping test. Remove pump at completion of tests.
- Construction of sanitary well heads.

Schematic representations of the production borehole and piezometer completions envisaged are provided. An accurate borehole location is not given, but an enclosed map shows the area of

operations as the Falealupouta region. Appended documents also give details of the NZAID boreholes (1977) at Asau, Auala and Sataua.

If one or both of these AusAID production boreholes can be rehabilitated and returned to service, they are clearly in an excellent, elevated position along the centreline of the Falealupo Peninsula to pump to a local reservoir subsequently gravity-feed back to most of the small villages within S4, including the potential of supplementing (or possibly even replacing) the Asau, Auala and Sataua systems.

4. SWA DRILLING RIG

Initial cursory examination undertaken at the SWA depot at the 11:00 hrs 19/09/06. Rig was static/parked in the mast down position. General appearance is much neglected, rusty, dirty etc. No SWA rig operatives available during this visit. The rotary drilling rig is an Ingersoll Rand, truck-mounted T3W with rock-roller and down-the-hole-hammer capability. The following registration plate numbers were observed which may assist if locating the original manufacturers regarding spare parts or rehabilitation issues:–

- CPN 57313975; and
- Cyclone drills – Serial No. 2662.

The rig has an external Safety Manual dated 1992 and a Cummings V6 engine.

Secondary inspection undertaken at 16:15 hrs, 22/09/06. Driller (of past 2years – no formal overseas training undertaken – he has learnt "on-the-job") is Mr Vaalele and Elect.-Mechanical Engineer, Mr Manuele, both on site. Truck moved outside of garage area and the four hydraulic platform support rams were lowered. All hydraulic support rams exhibiting massive leakage of hydraulic fluid – will directly contaminate works soil area, and undoubtedly cause similar groundwater pollution problems on any virgin drilling site. Failure or partial slippage of one or more of these during drilling operations could prove catastrophic for the borehole, the rig, or the operatives, or any combination of these. The rig mast was then raised and one of the two principal hydraulic mast rams was also clearly leaking. Air compressor leaking oil and significant air pressure losses at numerous points within the compressed air hoses and joints – again potentially fatal if one blows off. The drill stem drivehead is sticking occasionally in the mast, not travelling freely up and down. The drilling control panel is a mess, few legible labels on gauges or hand controls. Water temperature gauge and both air pressure gauges are non-functional. Driller also reported that the engine turbocharger is non-functional. No trials were undertaken to witness any drill stem lifting or rotary drilling operations.

Despite these obvious problems, the driller reported that the rig had recently completed a 38 m deep borehole in 12 hours at the Faleolo (Aggie Greys new hotel) Golf course (no strata details). Also earlier in the year achieved some 90 m of core drilling (no details), but apart from these two sites, the rig has effectively lain redundant since the closure of the EU RWS scheme drilling operations. Driller was in no doubt that in its current condition, the rig would certainly not be capable of drilling to 200 m in hard basalts.

Terms of Reference (see Annex B) for review of the SWA drilling rig were subsequently drafted on 15/12/06, and provided to WaSSP to enable them to issue a *"Call for Proposals"*. A shortlist of potential contractors for invitation to tender was also supplied.

5. CONCLUSIONS AND RECOMMENDATIONS

- A brief reconnaissance, hydrogeological field visit to the Falealupo Peninsula revealed a number of previous small-scale water supply schemes fed by borehole sourceworks. Some of these continue to function, whilst others have failed or been derelict for a number of years (decades). The reasons for the scheme failures are generally shrouded in uncertainty and there appears to be a dearth of historical monitoring data to assist in ascertaining the "true" picture at any particular location.

- The young volcanic terrain of northwest Savai'i results in complex, hydrogeological conditions. Combined with the generally difficult access and land characteristics, it is considered that surface geophysical techniques normally applied to groundwater exploration are likely to result in highly ambiguous analytical results. Given the paucity of good borehole records and monitoring data, there is a minimum of ground truth available for cross-reference. The ground layering models obtained and associated interpretation of surface geophysical techniques would prove extremely problematic, ambiguous and therefore of dubious investment value.

- Rainwater harvesting is evidently a well-accepted, effectively universal practice for the scattered resident population, forming an integral part of their mentality and day-to-day life. Since the philosophy is already well entrenched, continuation and maximising assistance with this practice would appear to be a major and logical primary recommendation for any rural water supply scheme in the Falealupo Peninsula. This approach would not mean trying to impose anything "new" on people, and most importantly does not carry the often onerous burden of land access, tenure or compensation issues that are commonly associated with interruption (or even vandalism, destruction or failure) of piped supply schemes within Pacific communities.

- Stored rainwater should therefore be regarded as one of the primary resources in the Falealupo Peninsula, which can effectively be utilised in much of the area as the principal potable source, to be managed in conjunction with other potential sources of lesser reliability or (possibly mixed with) poorer quality. Clearly, the more rainwater harvesting that can be developed in the area, then the less demand needs to be placed on more conventional piped (SWA) water supplies sourced from the locally extremely "sensitive" aquifer.

- Given the field evidence observed, it is recommended that a combined approach, utilising the conjunctive use of maximising rainwater harvesting practices, supplemented by small groundwater sources, as the probable way forward for a sustainable water resource future in the Falealupo Peninsula.

- If not already undertaken, a leakage assessment study and subsequent repair programme of the Asau-Auala-Sataua distribution system is further recommended to help reduce demand on the primary groundwater resources.

- Given the very tight time constraints remaining to achieve delivery of the design for the S4 water supply schemes, the immediate short-term option appears to be to allow the PDA preliminary design contract process to take its course based upon existing knowledge and sourced as originally planned from the Asau-Auala-Sataua boreholes. **However, this is stated within the following caveats:–**

- Intermediate storage facilities (reservoirs) require to be designed into the Asau-Auala borehole systems; this should enable gravity-fed water supply from strategically placed reservoir(s) and stop these two boreholes having to pump directly into their localised supply mains

- The groundwater management mantra for borehole pumping regimes in sensitive terrains where saline upcoming or intrusion is a serious risk, has to be *"to minimise drawdowns by spreading the load".* Borehole abstraction rates therefore need to be reduced as far as possible, with the pumping period spread to be as near continuous over as much of the 24-hr period as feasible – this should be possible if sufficient intermediate storage is available to buffer the demand supply system. Taking a small amount steadily from each of a number of spatially scattered boreholes will "spread the load" and keep discrete drawdowns to a bare minimum, which is essential in this hydrogeological situation. Over - pumping of individual boreholes with a cyclical on-off pumping regime (as appears to be the current situation, particularly at Asau and Auala) is the least sustainable approach in these difficult hydrogeological circumstances.

- Therefore, to further assist with understanding the limitations of the Asau-Auala-Sataua boreholes, and determine a safe design yield for each site, the Phase 1 test pumping approach, as proposed by Clive Carpenter (MWH – 01/09/06) is to be commended.

- If one or both of the AusAID production boreholes in Falealupo-uta can be rehabilitated and returned to service, they are clearly in an excellent, elevated position along the centreline of the Falealupo Peninsula to pump to a local high-elevation reservoir which can subsequently gravity-feed back to most of the small villages within S4, including the potential of supplementing (or possibly even replacing) the Asau, Auala and Sataua systems.

- Efforts should therefore be made to further investigate the feasibility of rehabilitating the two Falealupo-uta boreholes. Investment in a down-hole CCTV survey is initially recommended to accurately ascertain what and where obstructions exist within each borehole, and whether the risks are likely to be feasible from an engineering (and financial) viewpoint to attempt to recover the boreholes.

- Alternatively, such surveys might confirm beyond doubt that it would be less risky and more cost-beneficial to simply re-drill the sites, and this prospect, and the appropriate costings, should be a serious factor in any future design equation.

- If a visual CCTV survey is commissioned, additional down-hole geophysical probes should be considered for logging the borehole condition and vertical water column, particularly continuous recording of the temperature-conductivity profile and discrete depth sampling, to help define the position of any critical water quality stratification or saline interface boundaries.

- If a specialised borehole logging package is arranged for further investigation of the Falaelupo-uta boreholes, the opportunity should also be taken of similarly accessing and recording the Asau-Auala-Sataua boreholes, which will require pump removal for up to one day at each site. Terms of Reference (see Annex C) for provision of geophysical logging services were subsequently drafted on 20/12/06, and provided to WaSSP to enable them to issue a *"Call for Proposals"*. A shortlist of potential contractors for invitation to tender was also supplied. In the event that WaSSP and SWA succeed in implementing or progressing some or all of the recommendations suggested, additional hydrogeological technical support is envisaged during 2007 from the EDF8 Water Specialist with associated advice and fieldwork supervision during borehole logging and/or test pumping exercises.

- The PDA distribution system from Sataua up to a high-level reservoir close to the Falaealupo-uta crossroads should be designed with sufficient flexibility to allow for possible two-way flow, since successful rehabilitation of one or both of the Falealupo-uta boreholes will allow future feed into and contribution to the total reticulation system supply.

These high-elevation boreholes may prove able to supply a significant component (potentially 100%) of the total peninsula demand. This will have the very beneficial joint results of (1) potentially being able to reduce pumping rates and volumes from the Asau-Auala-Sataua boreholes, perhaps even replacing them completely, and (2) relaxing the risk of saline intrusion and upconing at the coastal margins of this sensitive aquifer.

- It is apparent from simple initial visual inspection that the SWA drilling rig has some very obvious mechanical and hydraulic problems requiring significant investment to enable it to be returned to a fully efficient drilling operation. In its current condition it is highly unlikely to be able to perform at all adequately in the hard basalt terrain of northwest Savai'i without frequent breakdowns, probably terminal! The leakage of hydraulic and compressor fluids and loss of compressed air pressure not only pose a severe groundwater pollution hazard, but also an unacceptable health and safety risk to rig operatives and nearby observers. The author of this report is not a qualified drilling rig mechanical engineer, and it is urgently recommended that such a person is commissioned to undertake a full and detailed condition survey of the rig to determine the relative costs and resources required to enable refurbishment, or alternatively recommend decommissioning/scrapping and utilising external drilling contractors. It is understood that an expert audit such as this is proposed by the PDA consultants, and this is commended and should be endorsed. Terms of Reference (see Annex B) for review of the SWA drilling rig were subsequently drafted on 15/12/06, and provided to WaSSP to enable them to issue a *"Call for Proposals"*. A shortlist of potential contractors for invitation to tender was also supplied.

ANNEXES

A Email Records and Comments

B ToR for Review of SWA Drilling Rig

C ToR for Provision of Geophysical Logging Services

ANNEX A

EMAIL RECORDS & COMMENTS

FROM NIGEL WALMSLEY 11TH AUGUST 2006

Attached is the explanation note on the investigations (as yet incomplete) and presented in the form of obtaining agreement from the EC for a negotiated procedure.
The files are:

1. Explanation note
2. Excel sheet with:

Sheet 1 – Rough costings from Hydro based on two distinct phases (i.e. no pump testing until Phase 2);

Sheet 2 – the start of a a revised costing (for a phase 1) which allows for initial hydrogeological and geophysics and pump testing (of the existing Sataua borehole only).

The Explanation Note discusses a 2–phase approach but latest thinking is that we should try to do pump testing of Sataua as part of the first phase and leave all the stuff about drill rig rehabilitation, new boreholes, etc. could then be separate. This could allow something to proceed more quickly.

As such the scope of works and costings need to be revised accordingly if this is to be the approach.

The essential part which is missing is a **decent scope of works and terms of reference and costings for the surveys, pump tests**. These need to be firmed up and a way forward agreed. My feeling is that we should try to get S4 done as part of the designs work by Eric – if at all possible – even if this means doing a design based on an assumption that the reliable yield is available in the Sataua aquifer and then confirming this assumption later!

Informing Clive on what we are trying to achieve (i.e. providing supply to the Falealupo area from Sataua aquifer) you should ask Clive to feed in to this in terms of helping to finalise a ToR and to establish costs.

Some of the questions that perhaps need addressing are:

* **What is the best way to achieve what we want**
* **What would he recommend as the minimum needed hydrolgeological investigations to assess the aquifer parameters in and around the around Sataua area**
* **What equipment is recommended/needed (electro?? Other??), is it available in Samoa, regionally, what are the relative costs for hire or purchase?**
* **What pump tests are required to confirm reliable yield from the Sataua borehole - how can we best achieve this, etc.**
* **Who should/could supervise any investigations/tests?**

On the rig:

* **Who could do the assessment of the drilling rig**
* **Is expertise available regionally?**
* **Other advice, etc.**

COMMENTS & RECOMMENDATIONS FROM MWH WATER RESOURCE SPECIALIST (CLIVE CARPENTER), 1ST Sept 2006

Dear Peter, Brian and Russell,

Please find below my preliminary assessment of the Falealupo Area hydrogeological assessment requirements for Nigel Walmsley. I leave you to forward onto him in due course.

As you know, there is an almost complete absence of information for this part of Savai'i. The RKL drawings show the area to be mostly underlain by saline groundwater, with no surficial water courses. The area is also in the rain shadow of the island peaks, with a typical rainfall of 2000-2500 mm/yr only (in relative terms).

It seems likely that this saline groundwater is due to a combination of both highly permeable basalts and the promontory shape of the area, the latter resulting in very little groundwater flow from the more central part of the island, thus restricting groundwater throughflow.

That said, a brief review of RKL Appendix H shows that not ll the bores highlighted as saline are in fact that salty. Specifically, SB13-15 have a reported TDS of only 120-130 mg/l, which is pretty low, if correct.

What further concerns me is the brevity of the tests undertaken to date at Sataua and Auala (< 2 days). The test yields for Sataua were excessively large (18 l/s), whilst the unacceptability of the chloride levels is marginal. Please note that in the Maldives and other seriously small island states, groundwater up to 600mg/l Cl (or 2,500 uS/cm) is used for supply.

Realistically, there are 2 options, depending on existing infrastructure, budget and pre-existing demands on the existing supply boreholes - none of which I know.

From the info you have provided, I understand the total pop to be supplied is approx 5,500. Assuming 200lcd, then we need to provide a design yield of approximately 1100 m3/d ie 12.7 l/s.

The most obvious short term option is to re-assess the viability of the Sataua - Auala - Asau boreholes. but I am not familiar with whether the pipelines and reservoirs exist to make this option economically viable.

Clearly saline up-coning is the main concern, but if pumping can be near continuous from as many of the bores as possible, thereby keeping the per bore yield to a minimum (5-7 l/s) for the 3 bores identified above, then we may have a workable solution. Chloride levels of 400mg/l might just have to be acceptable to the local population, or combined with rainwater harvesting if they are fusy, if this enables the water to be more readily used for potable activities.

The alternative is to carry out a detailed investigation of the entire peninsula, requiring observation boreholes to find fresh groundwater in advance of drilling any production bores.

Surface geophysics in my opinion is a non-starter. You have to have very good geological control, and we don't here. We don't know the thickness of the lava units, and even within them there is considerable heterogeneity. In my opinion this is a waste of time.

It would be better to drill say 3 observation bores, appropriately instrumented with multi-level piezometers, and then profiled regularly with temperature-level-conductivity (TLC) dip meters, augmented with permanently installed TLC probe dataloggers. This would give us much more information on the freshwater lens thickness in the area, and its response to tidal, rainfall and abstraction impacts.

As I don't know whether the Sataua - Auala - Asau boreholes option is viable I can't comment on the respective benefit of the two different approaches. But the benefit of the S-A-A borehole apprach is that if nothing else, the bores will be better understood, which is no bad thing, and has benefits to the lcoal populace.

So by way of an action list I recommend the following:

Phase 1 - Test pumping of the Sataua - Auala - Asau boreholes

i) secure all relevant background hydrogeological data for not just the S-A-A bores but the rest of the Falealupo Peninsula, including geological logs, pumping tests, hydrochemistry, abstraction rates, groundwater level observations, rainfall, bore elevations etc.

ii) carry out test pumping of the S-A-A bores as follows:

a) install dip tubes in each well if not already available, with slotted PVC below the water level, to the base of the bore
b) using TLC dip meters, profile the boreholes before pumping and install TLC dataloggers
c) allow 3 days pre-test monitoring;
d) undertake a 2 week constant rate pumping test at 20% above design yield (eg if ony 2 bores available then pump at 8 l/s, else 6 l/s for the 3 bores). Dataloggers can record every minute for TLC, but should be manually dipped at conventional pumping test intervals. Discharge measured using at least 2 methods, and EC of water recorded as well.

TLC dipmeters and LTC dataloggers are available from Solinst (http://www.solinst.com/Prod/Prod.html), and have been successfully deployed in Niue by ourselves last year and are now part of an on-going gw monitoring programme run by the local staff. I believe SOPAC procured them from EnviroEquip in Australia.

iii) Analysis of results to determine whether yield can be sustained indefinitely, without increasing salinity.

The above represents the minimum to enable the yields of these 2-3 bores to be realistically determined.

Ideally, a groundwater observation borehole should be installed within 50m of the abstraction borehole (detail provided below), but this would require rig mobilisation and is likely to fall into Phase II works.

Phase II - Hydrogeological Investigation of the Falealupo Peninsula

It is possible the Phase I work will either not provide the required yields at acceptable salinities, or the associated pipelines are too expensive.

I am not convinced enough work has been undertaken in the Peninsula to demonstrate there is no fresh groundwater available. Coastal bores are reported as saline, but SB13 & 14 are actually reported as fresh albeit with small (3 l/s yields).

In the first instance the following is recommended:

i) locating, levelling, dipping, salinity profiling and sampling all bores, dug wells, coastal springs (abandoned or otherwise) in the Peninsula;

ii) analysis of the above to try to establish hydraulic gradients, freshwater lens occurrence

Thereafter groundwater monitoring is required to establish whether a freshwater lens is sufficiently large to be used for exploitation. Thus:

iii) based on ii) site and drill 3 observation boreholes, to fully penetrate the freshwater lens, and install within the open boreholes 3-4 multi-level piezometers per bore, separated by low permeability backfill. Piezometers to be salinity profiled with a TLC dipmeter every quarter, with LTC dataloggers in one piezometer per hole. Monthly downloads of these piezometers should enable a reasonable understanding of the freshwater lens (if any) in the area to be determined.

iv) based on the analysis of iii) an estimate of the Peninsula water balance can be made, and areas taregtted for production bores as appropriate. It is likely that this would consist of a larger number of low abstraction rate bores, eg 5-10 bores of 1-3 l/s each.

It is clearly obvious from the above that Phase 1 provides a more immediate approach to addressing the water supply issues of the area. The lack of any hydrogeological investigations in the area, coupled with the apparent lack of a rig to undertake such investigations, makes the S-A-A borehole testing preferable.

Such borehole testing requires working pumps and flow meters at the bores, plus the purchase of dedicated salinity dip tapes and dataloggers. Additionally, the abstraction bores should be ideally fitted with dip tubes (nominally 30mm ID), if they can get in the bores.

Such pumping test investigations should be supervised by a qualified hydrogeologist. We could send people out if requested, as could any other consultancy. Alternatively the whole project could be used as training programme for Samoan counterparts, and added to the existing project as an extension.

The pump tests could be run concurrently if not too close to each other. The work would take say 3 days travel, 15 days in the field (although the expat need not be there for that time), plus a few days for analysis for each bore.

SWA or a local contractor would be needed to put in the dip tubes etc. A local consultant or government staff might be able to supervise the tests once they are underway, enabling the expat time to be reduced accordingly.

Clearly the hydrogeological assessment of the area is a much larger job, and it would be hard to scope this up without knowing the success of the first Phase and how much, if any of it needed to be done. Experience in Niue suggests a week survey the peninsula with counterpart staff, a week to drill and install each observation bore, and a week of analysis. Then furtehr time for production bores as required.

I would suggest you got a NZ drill contractor in to assess the rig. I used Northland Well Drilling in Niue, who were very good. Can provide details if required. They could train up local staff also. other option is probably Mineral Resources Department in Fiji, but of course they are no contractors per se and have a job to do in Fiji anyway. Again I can find some contact details if required.

Original Message--F**rom:** Michel Van der Stricht [mailto:office@hydro-rd.be] **Sent:** vrijdag 9 juni 2006 4:44
To: Nigel**Cc:** Eric Goessens; Michel Van der Stricht**Subject:** Re: S4-Falealupo

Dear Nigel,
Thanks for the clarifications. I acknowledge the rather strict EC framework, but I think that to make reasonable decisions, EC/SWA/NAO need to have sound and reliable informations.

One of the first priorities is the issue of the drilling rig and the pumping equipment, not only for the possible additional boreholes in S4 but for the supply of all the sites outlined in my September report.
You need to have an expert to look at the existing rig, to state if it is possible and economical to rehabilitate it. I am not a mecanical expert and I don't know eighter if this machine could drill up to 200 m and more. It might be cheaper and more efficient to by a second hand performant drilling rig or to outsource the works than rehabilitate an old out of date engine. We need a professional advise about these issues, the soonest the best, especially because of these strict procurement rules.

For the hydrogeological and geophysical investigations, there is no hurry. These could be done later this year (but not too late if Eric has to include the results for designing a solution for S4 in phase 3).

I have respond to the other points in the text.

Best regards
Michel
HYDRO R&D
Water Resource & Development
15/303 avenue des arts B1348 Louvain-la-Neuve Belgium
T +32(0)10453870 F +32(0)10453943
office@hydro-rd.be www.hydro-rd.be

Le 8 juin 06 à 06:13, Nigel a écrit :

Dear Michel,

The Falealupo area remains a high priority for the government and it was well received by SWA and others that Eric visited the area to investigate things further – as the existing proposals to simply maintain a *business as usual* approach for the area does not necessarily reflect the gravity of the situation for the peoples of Falealupo.

Internal discussions as to whether to progress this and/or how to proceed are continuing – and take account of both Eric's earlier note and the points in your email below. Even if there is support to move down this track, the issue from the NAOs perspective is less to do with the technical "what" but more about the "how". As you'll appreciate, we're working within the confines of the EC machine and it is not easy to move quickly nor to go outside the procurement rules, etc. Issues of competition, tender procedures, etc. are all part of this.

We're currently looking into all these issues and should be able to get back to you soon. We'll also continue to liaise with Eric as he receives further information/estimates/ideas etc. from yourself.

In the meantime, it would be useful to receive some feedback from yourself on some of the issues raised in your note:

- Although the borehole logs of the 3 boreholes that were drilled in the area could not be retrieved, it appears from discussions with the drilling crew that these were poorly equipped (inadequate screen, no gravel pack) or not drilled deep enough. This is certainly the reason why they collapsed or ran dry.
    - Is there a way SWA could confirm this now??

  I don't think there is any chance to retrieve the borehole logs. But there was one guy (member of the drilling crew when I visited the rig in Savai'i in September) who was involved during the drilling of these boreholes. He could confirm the equipment issues. I'm 100% sure that these are the reasons for collapsing.

- If it is intended to drill additional boreholes in the area, it is advisable to implement some hydrogeological investigations and possibly some geophysical soundings. I remember that there was a geophysical survey of the area some years ago, but with no clear and tangible results. I don't think that the Met has ordered in the meantime any geophysical equipment.
    - We doubt if Met has any equipment and it is therefore assumed that fee rates, etc. of costs you have floated include provision of the necessary equipment

  .Fee rates do not include provision of the necessary equipment; These (RENTAL including transport) are quoted under another heading

- On the other side, as far as I 'm informed, SWA/EC have choosen to refurbish and repair the existing drilling rig. This will probably require some external expertise to make a sound diagnostic and a proper list of spare parts.
    - There is no commitment as such – but is the rig capable of drilling to 200 m??

See remarks above

Finally, on a financial viability note – what would the rough cost in tala be of pumping 250l/c/d to 3000 people from a ~200m depth (based on 0.67 tala per kW)
Any further information from your side including a breakdown of scope of works/activities, costs, etc. would also help at this stage.

I'll make some calculations and will provide you a more detailed estimate early next week

Thanking you
Nigel

Sent: 31 May 2006 01:13**To:** Nigel**Cc:** Eric Goessens; peterwopereis@ipasifika.net; Nadia Meredith; Michel Van der Stricht**Subject:** S4-Falealupo

Dear Nigel,

I had a discussion with Eric about the Falealupo area and I understand you got a feedback of this. To resume the situation, from the investigations I did during my last mission in September, I'm quite sure that the groundwater potential is good in that area (like in all parts of Savai'i). The main issue is that the coast is quite steep and that boreholes need to be 150 to 200 m deep to reach the fresh water lens that is slightly above sea level.

Although the borehole logs of the 3 boreholes that were drilled in the area could not be retrieved, it appears from discussions with the drilling crew that these were poorly equipped (inadequate screen, no gravel pack) or not drilled deep enough. This is certainly the reason why they collapsed or ran dry.

Anyhow, if it is intended to drill additional boreholes in the area, it is advisable to implement some hydrogeological investigations and possibly some geophysical soundings. I remember that there was a geophysical survey of the area some years ago, but with no clear and tangible results. I don't think that the Met has ordered in the meantime any geophysical equipment.

On the other side, as far as I 'm informed, SWA/EC have choosen to refurbish and repair the existing drilling rig. This will probably require some external expertise to make a sound diagnostic and a proper list of spare parts.

I am engaged with the EC Water Facility from 28/6 till end of October. Normally there should be a one month break somewhere between. What I eventually would propose is to come to Samoa for 2 weeks before 28/6. Time would be spent to make hydrogeological investigations for the siting of some boreholes in the Falealupo area, investigate and define the needs and possibilities for geophysical investigations and finalise the requirements/technical specifications for the various boreholes that have to be drilled. If we have a quick response from your side we could also mobilise a mechanical expert for the rehabilitation of the drilling rig during the same mission.

I could then do the geophysical investigations (with our own equipment) somewhere between August and September during the WF break.

Please give me your opinion asap as I have to back in Europe for the 28/6..

Best regards

Michel

-----Original Message-----
From: Sebastian Mariner [mailto:sebastian@osmconsult.com]
Sent: 01 September 2006 12:52
To: Phillip Kerslake
Cc: Taputoa Titimaea; 'HYDRO-R&D'; Shorley Mariner
Subject: PDA Samoa – Savai'i S4 design proposal and SWA drilling equipment upgrade
Importance: High

Talofa Tafea

We refer to the last progress meeting hold in SWA premises on 31/09/06 (weekly progress meeting) and our discussions about the S4 scheme, and requested refurbishment of existing SWA's drilling equipment and other related issues. We append below a summary of comments discussed with SWA, Jean-Claude (HydroRD) relating to the above.

The PDA comes slowly to its end in March 2007 and the phase 3 design is scheduled in mid October - end November 2006 (Eric's last mission in Samoa). In order to be able to draw up a comprehensive design for

the S4 community scheme in Savai during this phase 3 and allow the SWA to commit its drilling equipment to the foreseen necessary works including boreholes depths up to 200m, we would like to propose the following.

To avoid any administrative complication with the EU, HYDRO-RD would be pleased to act as a sub-contractor to SWA by providing the necessary expertise for:

1/ the geological, the geophysical, the topographical surveys (see hydrogeological review report) and design of S4 and
2/ the audit of the SWA drilling equipment: diagnostic, prepare the necessary technical specifications and orders to refurbish the drilling materials.

SWA would ask the funds to the EU under the WSSP programme, budget that we could set up together. The budget would include the fees, the equipment (rental), the freight costs, the transport costs (local & international). These funds would cover our design inputs and incidentals charges from SWA

Contract would be established between the EU and SWA, HRD acting then as a sub-contractor to SWA, and provide: Senior Hydrogeologist (Michel Vander Stricht), senior Geophycisist (HRD expert), Senior mechanical Engineer drilling equipment specialist (HRD expert), all necessary devices and software (resistivity meter and TDEM equipment, Topographer (Renaud) and design Engineer (Eric).

The TDEM geophysical method being particularly adapted to identify the limit between saline and freshwater (a crucial issue for Samoa islands water management), it could be a good opportunity for the SWA to join our team and be trained on this method on the field.

To match with the time constraints, the results of the study should be available the latest in the beginning of December, therefore the field mission has to take place in November.

We are open to any approach with SWA to find a suitable solution to both concerns and will be happy to discuss further this matter with at your own convenience.
Thank you for your attention
Regards
Jean Claude Ceuppens
Hydro-RD
and
Sebastian Mariner
[CPEng., CPA]
OSM Consultants Limited,1st Floor Tavita Chan Tung Building, Pesega, Samoa
T +9685) 31594 F+(685) 26605 M +(685) 777 0515

Stephen to Sahara

1. your Asset Engineer (Lautua?) emails me the monitoring data records as discussed and promised on Friday
2. also I would appreciate the list of people/contacts etc who attended the de-briefing meeting on Friday and
3 a draft copy of the minutes of that meeting from the chairperson (or whoever responsible), and
3. your tabulation of the GPS points we recorded during the field visits (not urgent)

GENERAL

Water Sector Support Programme (WaSSP) and linkages to SOPAC

Samoa is supported by the European Union to address water management through a sector-wide approach bringing together all stakeholders to consider and agree on all aspects of water services and water resources management under one action programme.

The "Water for Life" document sets out a sector plan and framework for action for Samoa to address water sector development needs. It is based on a common vision for the future of the water sector and elaborates specific policies, programme priorities, and budgetary implications to help guide future investment to provide a tool to clarify how and where support is most needed and would have greatest impact.

The EU is providing €19.09 million Euro (SAT $60 million tala) to improve water supply, sanitation and resource management in the period 2005-2010. The Water Sector Support Programme (WaSSP) is consolidating the "Water for Life" initiatives by covering 6 different components as follows:

1) *Institutional framework for effective water governance.*
2) *Institutional capacities to manage, develop and self-sustain water related systems.*
3) *Improvement and rehabilitation of rural water supplies towards access to safe water supply in rural areas.*
4) *Increased effiency and effectiveness of water supply systems.*
5) *Improvement in sanitation and wastewater reducing detrimental public health and environmental impacts of inadequate sanitation facilities.*
6) *Sustainable framework for water resources management.*

Samoa plays a leading role in the Pacific region demonstrating this sector-wide approach and other countries would benefit from the lessons learned in this process. Samoa government representatives have also championed regional collaboration on water and wastewater management through active and high-level participation in the regional consultations on sustainable water management.

Several regional programmes have been developed by partner (regional and international) organisations in the Pacific that could provide further support to Samoa's water sector. Linkages can be established between these programmes and each of the 6 components of the Water Sector Support Programme and through improved communication, duplication of activities can be prevented.

This approach can likewise be applied to the Asian Development Bank supported drainage and sewerage programme. The opportunities have been discussed with representatives of the lead implementing agencies of WaSSP including the Ministry of Finance, the Ministry of Natural Resources, Environment and Meteorology, the Ministry of Health and the Samoa Water Authority.

ANNEX B

SAMOA
Water Sector Support Programme (WaSSP) & Samoa Water Authority (SWA).

CALL FOR PROPOSALS

TERMS OF REFERENCE
FOR
REVIEW OF SWA DRILLING RIG

Background

Samoa Water Authority currently own and operate a single rotary drilling rig to undertake groundwater investigations in Samoa. This rig reportedly represents the only borehole drilling capability within the country, but due to the age, poor maintenance and clearly inefficient operational status of the unit, there are significant concerns regarding not only its mechanical condition and actual drilling capacity, but also the attendant health & safety aspects involved during operation.

The hydrogeological conditions prevailing over Upolu and Savai'i, the two major islands that comprise Samoa, are dominated by difficult and "unforgiving" hard basalt terrains derived from geologically young volcanic activity. Such rock types demand a drilling rig to be 100% operationally efficient if significant breakdowns and programme delays are to be avoided.

Significant EU-funded initiatives, managed by WaSSP, are currently active in Samoa's water sector. Further investment in an active groundwater exploration and development programme is critically dependent upon the ready availability and operation of a reliable drilling unit. Given the observed limitations and condition[(1)] of the drilling unit, a full mechanical and technical survey of the unit requires to be urgently commissioned to enable WaSSP/SWA to progress with confidence.

Proposal

Suitably qualified individuals, contractors or consultants, are invited to submit a technical and financial proposal to complete the following tasks:-

- undertake a full and detailed condition survey of the SWA drilling rig, and associated compressor, pumps, truck and ancillary equipment. Physical, on-site survey to include both static and operational trials in Apia, Samoa. Provide a detailed report highlighting the relative costs, resources and practical timeframes required to enable rehabilitation and refurbishment to 100% mechanical efficiency.

- Provide a cost-benefit comparison of refurbishment of the existing unit versus the following alternatives:-
    - option 1 - decommissioning/scrapping the existing unit and employing external drilling contractors (identify possible regional sources) as required, or
    - option 2 - replacement of the existing unit with purchase and import of a new rig, or

  - option 3 - replacement of the existing unit with purchase and import of a second-hand rig

- Provide a comprehensive and fully costed preventative maintenance plan and servicing schedule for annual drilling operations, detailing a recommended listing of critical spares to be held in-stock by SWA.

- Interview all SWA personnel associated with drilling unit operations and report on existing institutional and technical capacity.

- To ensure human resource operational efficiency matches the mechanical efficiency of the rig, identify, recommend and provide report on indicative timeframe, costings and potential locations for all short- and mid-term technical, mechanical, and hydraulic *Training Needs,* inclusive of occupational health & safety issues, with respect to drilling operatives and supervisory staff.

- Prior to departure from Samoa, provide a summary presentation of all findings and recommendations to WaSSP/SWA personnel.

Timing & Deliverables

Closing date for receipt of proposals at the client's address noted below is:

Tuesday 02nd January 2007.

All Tenders shall be priced on a lump sum basis, inclusive of all fees, travel and subsistence requirements required to complete the commission.

Tenderers must provide a detailed methodology and outline programme of approach, full supporting documentation referencing similar project experience and the cv's of personnel to be utilised.

Tenders and supporting documentation to be delivered as hard copy in sealed envelope (and/or electronic via email ?)

All inspections, surveys and report drafts detailed above must be completed during January 2007. Two weeks will be allowed for receipt of feedback from WaSSP/SWA on draft reports. Following incorporation of any changes, the deadline for delivery of completed final reports (electronic format) shall be no later than:–

Monday 19th February 2007.

Client Contact

Mr Ludo Prins
Programme Adviser
Water Sector Support Programme
Ministry of Finance
Level 3, CBS Building
PO BOX 2692
APIA, SAMOA
Office Tel: +(685) 22975
Fax: +(685) 21312
Mobile: +(685) 7785271
Email: ludo.prins@mof.gov.ws

SKB/15.12.06

(1) Recent observations

Initial cursory examination undertaken at SWA depot at 11:00hrs 19/09/06. Rig was static/parked in the mast down position. General appearance is much neglected, rusty, dirty etc. No SWA rig operatives available during this visit. The rig is an Ingersoll Rand, truck-mounted T3W with rock-roller and down-the-hole-hammer capability. The following registration plate numbers were observed which may assist if locating the original manufacturers regarding spare parts or rehabilitation issues:–

- *CPN 57313975*
- *Cyclone drills - Serial No. 2662*

The rig has an external Safety Manual dated 1992 and a Cummings V6 engine.

Secondary inspection undertaken at 16:15hrs, 22/09/06. Driller (of past 2years – no formal overseas training undertaken – he has learnt "on-the-job") is Mr Vaalele and Elec-Mechanical Engineer Mr Manuele both on site. Truck moved outside of garage area and the four hydraulic platform support rams were lowered. All hydraulic support rams exhibiting massive leakage of hydraulic fluid – will directly contaminate works soil area, and undoubtedly cause similar groundwater pollution problems on any virgin drilling site. Failure or partial slippage of one or more of these during drilling operations could prove catastrophic for either the borehole, the rig, or the operatives, or any combination of these. The rig mast was then raised and one of the two principal hydraulic mast rams was also clearly leaking. Air compressor leaking oil and significant air pressure losses at numerous points within the compressed air hoses and joints – again potentially fatal if one blows off. The drill stem drivehead is sticking occasionally in the mast, not travelling freely up-and-down, The drilling control panel is a mess, few legible labels on gauges or hand controls. Water temperature gauge and both air pressure gauges are non-functional. Driller also reported that the engine turbocharger is non-functional. No trials were undertaken to witness

any drill stem lifting or rotary drilling operations. The leakage of hydraulic and compressor fluids and loss of compressed air pressure not only pose a severe groundwater pollution hazard, but also an unacceptable health and safety risk to rig operatives and nearby observers.

Possible Contractors/Consultants for invitation

Northland Well Drilling, Northland Regional Council, PMB 9021, Whangarei, NZ or Inland road, Lake Ohia, Kaitaia
Tel +(64) 90 406 798
Fax +(64) 90 438 0012
E-mail: nwd@pcconnect.co.nz

McMillan Water Wells, 120 High Street, Southbridge, Canterbury, NZ
Tel +(03) 324 2571
Fax: +(03) 324 2431
E-mail: mcmillan.water@xtra.co.nz

Mineral Resources Department, Suva, Fiji
Mr Waseroma O'Connor, Drilling Supervisor
Tel: +(679) 338 1611
Fax: +(679) 337 0039
E-mail: wise@mrd.gov.fj

ANNEX C

SAMOA
Water Sector Support Programme (WaSSP) & Samoa Water Authority (SWA).

CALL FOR PROPOSALS

TERMS OF REFERENCE FOR PROVISION OF GEOPHYSICAL LOGGING SERVICES

Background

Significant EU-funded initiatives, managed by WaSSP, are currently active in Samoa's water sector. In the Falealupo peninsula of NW Savai'i, further investment in an active groundwater development programme is critically dependent upon obtaining greater confidence in the current down-hole hydrogeological conditions and engineering integrity of a number of existing boreholes. The basalt lava terrain, saline intrusion risks and uncertain technical records indicate that, prior to SWA attempting test-pumping or potential rehabilitation of some of these sites, geophysical down-hole logging investigations are recommended to clearly define initial borehole conditions and identify any potential obstructions.

Proposal

Suitably qualified individuals, contractors or consultants, are invited to submit a technical and financial proposal to complete the following tasks:–

- undertake a full and detailed down-hole asset condition survey, to terminal depth within the following five boreholes[(1)] :–

Locations	Reported Depth (mbgl)	Diameter (mm)	Approx SWL (mbgl)	Comments
Falealupo-uta No.1	220 ?	150	≥ 150 ?	Disused/open
Falealupo-uta No.2	220 ?	150	≥ 150 ?	Disused/open
Sataua	38.45	150	34.3	Operational
Asau	54.11	150	42.9	Operational
Auala	82.62	150	61.5	Operational

- For each location indicated on Figure 1 (***requires insert of suitably detailed location map***), provide a detailed report, highlighting the hydrogeological and engineering conditions observed and recorded. Each report to detail observed or inferred physical conditions, both above and below water column, of all casings, screens and open-hole sections, any breakages, leakage/inflows, zones of instability/cave-ins, fractures/fissures, obstructions/blockages, or any other unusual circumstance encountered. As a minimum, a combination of colour CCTV and caliper logging shall be required, though the contractor is at liberty to propose additional complimentary logging techniques for consideration by the Client. Each report to be accompanied by provision of comprehensive colour video/dvd recordings as appropriate.

- In addition, each report to provide a continuous profile of temperature and conductivity variations within the water column; where salinity/density stratification is apparent, recover discrete depth samples and undertake water quality analyses as directed by the Client.

- For locations where any blockage(s) or stability issues are identified, report on relative options, likely costs, resources and practical timeframes required to enable rehabilitation and refurbishment of the borehole to full operational efficiency.

- Where applicable, provide a cost-benefit comparison of refurbishment of the existing borehole versus the option of decommissioning and abandonment of the existing asset and drilling a new, replacement borehole in the near vicinity.

- Prior to departure from Samoa, provide a summary presentation of all findings and recommendations to WaSSP/SWA personnel.

Timing & Deliverables

Closing date for receipt of proposals at the client's address noted below is:

Tuesday 02nd January 2007.

All Tenders shall be priced on a lump sum basis, inclusive of all fees, travel and subsistence requirements required to complete the commission.

Tenderers must provide a detailed methodology and outline programme of approach, full supporting documentation referencing similar project experience and the cv's of personnel to be utilised.

Tenders and supporting documentation to be delivered as hard copy in sealed envelope (and/or electronic via email ?)

All inspections, surveys and report drafts detailed above must be completed during January 2007. Two weeks will be allowed for receipt of feedback from WaSSP/SWA on draft reports. Following incorporation of any changes, the deadline for delivery of completed final reports (electronic format) shall be no later than:–

Monday 19th February 2007.

Client Contact

Mr Ludo Prins
Programme Adviser
Water Sector Support Programme
Ministry of Finance
Level 3, CBS Building
PO BOX 2692
APIA, SAMOA

Office Tel: +(685) 22975
Fax: +(685) 21312
Mobile: +(685) 7785271
Email: ludo.prins@mof.gov.ws

SKB/20.12.06

(1) Recent observations

A brief reconnaissance, hydrogeological field visit to the Falealupo peninsula in September 2006 revealed a number of previous small-scale water supply schemes fed by borehole sourceworks. Some of these continue to function, whilst others have failed or been derelict for a number of years (decades). The reasons for the scheme failures are generally shrouded in uncertainty and there appears to be a dearth of historical monitoring data to assist in ascertaining the "true" picture at any particular location.

Falealupo
Two borehole locations, both close to the principal road T-junction in Falealupo-uta. Both boreholes reportedly used to feed a single nearby (quite small) storage reservoir, which then gravity-fed most of the Falealupo peninsula via a sequence of other small storage tanks. This was an AusAid scheme dating from c.1990-91 and locals (site caretakers) claim it yielded a very satisfactory supply whilst operational, with no discernable salinity problems, but unfortunately the scheme wasn't very long-lived – reasons unclear and conflicting.

No 1 Borehole
Electric submersible pump removed in 1992? and "taken elsewhere" – never returned. Large concrete pump house foundations, but no superstructure remains. Borehole consists of 250 mm Ø steel outer casing with grouted annulus to 150-mm Ø steel inner casing; Borehole dipped cleanly (September 2006) without obstruction to 100-m limit of dipper tape, but no water recorded (unsurprisingly, since original depth claimed to be c200 m+)

No 2 Borehole
Similar large concrete pump house foundations but no superstructure remains. Borehole top not located in Sept'06, but suspected buried at fairly shallow depth at obvious site *(SWA have reportedly subsequently uncovered and successfully relocated the borehole).* In 1994 the pump was not working (failure to repair autotimer, rather than submersible pump failure suspected?) Decided to change the pump (in 1996?) but subsequent attempts to clean out the borehole utilising a bailer resulted in snagging, loss of bailer and c.200 m of steel cable down the hole. Subsequent dipping indicated a "dry" hole – but dipper may have been held up by the bailer/cable debris jammed-up at a high level within the hole or piled up at the bottom above RWL. An adjacent 50-mm Ø galvanised iron exploratory pilot or observation borehole was located and dipped cleanly, but dry, to full 100m extent of available dipper tape.

If one or both of the AusAid production boreholes in Falealupo-uta can be rehabilitated and returned to service, they are clearly in an excellent, elevated position along the centreline of the Falealupo peninsula to pump to a local high elevation reservoir which can subsequently gravity-feed back to most of the small villages within S4, including the potential of supplementing (or possibly even replacing) the Asau, Auala & Sataua systems. Efforts should therefore be made to further investigate the feasibility of rehabilitating the two Falealupo-uta boreholes. Investment in a down-hole CCTV survey is initially recommended to accurately ascertain what and where obstructions exist within each borehole, and whether the risks are likely to be feasible from an engineering (and financial) viewpoint to attempt to recover the boreholes. Alternatively, such surveys might confirm beyond doubt that it would be less risky and more cost-beneficial to simply re-drill the sites, and this prospect, and the appropriate costings, should be a serious factor in any future design equation.

If a visual CCTV survey is commissioned, additional down-hole geophysical probes should be considered for logging the borehole condition and vertical water column, particularly continuous recording of the temperature-conductivity profile and discrete depth sampling, to help define the position of any critical water quality stratification or saline interface boundaries.

If a specialised borehole logging package is arranged for further investigation of the Falaelupo-uta boreholes, the opportunity should also be taken of similarly accessing and recording the Asau-Auala-Sataua boreholes, which will require pump removal for up to 1day at each site

Asau-Auala-Sataua
These three schemes are currently operational and SWA shall be responsible for arranging temporary removal of the submersible pumps to allow the geophysical logging contractor unimpeded access as required.

Possible Contractors/Consultants for Invitation

AUSLOG Pty Ltd
Unit 9, 29 Collinsvale St
Rocklea, QLD, 4106
Brisbane, Australia
Ph: +61 7 3277 4671
Fax: +61 7 3277 4672
e-mail: auslog@auslog.com.au

FUGRO Ground Geophysics
21 Mellor Street
West Ryde (Sydney)
N.S.W., 2114
Tel: +61-2-8878 9000
Fax: +61-2-8878 9012
General Enquiries: ground@fugroground.com

European Geophysical Services Ltd
22 Hardwicke Stables
Hadnall
Shrewsbury
Shropshire
SY4 4AS
United Kingdom
Tel: +44 01939 210710
Fax: +44 01939 210532
E-mail: eurogeophys@compuserve.com

Robertson Geologging Ltd
Deganwy
Conwy
LL31 9PX
United Kingdom
Tel: +44 01492 582323
Fax: +44 01492 582322
E-mail: sales@geologging.com

McMillan Water Wells,
120 High Street, Southbridge,
Canterbury, NZ
Tel +(03) 324 2571
Fax: +(03) 324 2431
E-mail: mcmillan.water@xtra.co.nz