

Pacific Islands Applied Geo-science Commission

Report Title: PACIFIC HYCOS MISSION TO TONGA

Date: 21 June– 25 June 2010

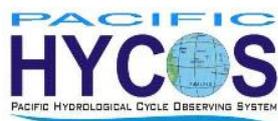


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24 June 2010 HYCOS Project

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Acronyms

APC	African, Caribbean and Pacific countries
CEO	Chief Executive Officer
DB	Database
EU	European Union
EDF	European Development Fund
FP	Focal Point
GIS	Geographic Information System
HYCOS	Hydrological Cycle Observing System
MLSNR	Ministry of Lands, Survey, and Natural Resources
MoH	Ministry of Health
PACTAM	Pacific Technical Assistance Mechanism
SOPAC	Pacific Islands Applied Geoscience Commission
TIDEDA	Time Dependent Database
TOR	Terms of Reference
TWB	Tonga Water Board
WMP	Water Management Plan

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Introduction:

Project implementation of Pacific HYCOS activities in Tonga had been delayed since Oct 2008 due to difficulties within MLSNR to obtain operational budget and support for proposed monitoring activities. It had been proposed that MLSNR undertake the regular joint monitoring activities proposed for Mataki'eua and develop water resource analysis and reporting skills as well as make improvements to the existing database including inclusion of paper records and review identified anomalies as well as backup to Tideda.

In late 2008 it was discussed with MLSNR on how to best progress this and in 2009 a proposal was forwarded for MLSNR to consider the attachment of a hydrogeologist, via PACTAM, to the unit which would be funded by SOPAC and AusAid. Subsequent to this MLSNR enlisted the support of a volunteer Hydrogeologist, Nicola Fry under the Australian Youth Ambassadors for Development AYAD to assist with the units water needs and provide day to day focus on the water resource requirements of Tonga.

This mission was timed to coincide with the availability of John Tagiilima (EDF8 B Envelope) and the recent commencement of Nicola Fry. The mission is to develop synergies of water resource capacity building and support offered under HYCOS and EDF8.

The intention of the mission is to progress the components under B Envelope and HYCOS to develop an achievable and focussed schedule of joint groundwater monitoring activities. Additionally review the current status of activities commenced under HYCOS including Mataki'eua and database consolidation to ensure that some objectives can be achieved with the remaining time of HYCOS.

Peter Sinclair (Project Adviser) travelled to Nukualofa, Tonga from 21 -25 June 2010.

Objective(s):

The main activities proposed:

- Progress activities under Pacific HYCOS in particular the monitoring for Mataki'eua, and the 10 village wells
- Progress activities under B Envelope funding, including proposed water resource drilling, and mobile water quality lab
- Retrieve loggers from monitoring bores and review data, reports of communication failures.
- Review monitoring of Mataki'eua over last year and assist in developing schedule
- Install TB3 rainfall gauge at Mataki'eua
- Review updating of database activities.

General:

Kelepi Malfi the focal point for HYCOS is currently on leave until August. He had planned to undertake further studies in Australia, and there is some doubts that he will return this year to resume his function as Principal Geologist. In his place he Rennie Vaiomounga will take up the role of principal geologist until permanent need for replacement is officially required.

Nicola Fry a hydrogeologist volunteer under AYAD scheme has joined the MLSNR group for 12 months. It was discussed and agreed with Rennie that whilst Nicola is in place that she will be able to assist in leading the team Akapei and others in undertaking groundwater

monitoring, investigation, analysis and reporting requirements. Nicola has a background in GIS and databases and so will assist in developing these skills and improvements in the database.

The joint mission with B Envelope facilitated TWB's involvement in the installation of the rain gauge and the rehabilitation of the damaged bores MB4 and MB5. This relationship is to be promoted through continued joint monitoring activities and the sharing of data.

Mataki'eua well field

An inspection was made of 2 of 23 the newly constructed B Envelope funded pump houses in Mataki'eua. HYCOS provided meters and associated pipe works including gate valves for some 37 installations, which will cover all pumping stations to be rehabilitated. Meters read in m³ and are recorded twice daily, once in the morning and once in the evening. Recommended that they recorded a 6 digit number each time which includes the leading 0's to avoid confusion. Also recommend that they record total pump hours, which will assist both with maintenance and with alternate usage calculations.

A TB3 automatic tipping bucket rain gauge was installed at the workshops for the Mataki'eua well field. The site was chosen based on security, accessibility and alignment with WMO rain gauge installation guidelines. Site details recorded as an Annex

All 4 Diver loggers installed in monitoring bores with MLSNR staff in Oct 2008 were retrieved. All these loggers reported communication errors. MLSNR first identified issues with 2 of the loggers reporting communication errors in Sept 2009, first download. The Diver loggers have been dispatched to the supplier for repair whilst under warranty.

It was agreed that focussed monitoring of Mataki'eua freshwater lens and its abstraction is achievable and of benefit to a number of stakeholders, it will provide valuable information on the possible impacts to the lens. HYCOS will support MLSNR to monitor and report on this. Activities include develop proposed monitoring schedule, review of usage data, and available rainfall data, bacteriological and EC sampling and assessment of main pumping wells, with the production of an annual report.

Village wells

A joint DoH and TWB activity focused on improving the water supply and protection of water sources at 10 village wells was reviewed. The improvements have been identified under the Drinking Water Safety Plan project and TWB and DoH. The improvements are being considered under the B Envelope funding for reducing vulnerability to disaster and will consider electrification (reduced potential for pollution from diesel and reduced operating costs), replacement pumps, improved shed housing, improved or refurbished header tanks, and where required drilling and construction of new production bores. A review of the existing infrastructure was undertaken by B Env John Tagiilima and MLSNR.

The sites were chosen by TWB and DoH based on those that were in most in need. Criteria included age of infrastructure and conditions of wells and reservoirs. Some of the sites identified will be difficult to rehabilitate, in particular the depth of the water in which to introduce a submersible pump is in some cases less than 0.4m. Also the site at proposed Vaini Village is within the Beulah College, with the bore housed within a school building and the reservoir on top of building. Structural integrity of the reservoir was questioned, and it may be alternate options be considered, new bore site or water sourced from different supply.

Observations on the village wells with respect to water quality, water depth and existing well infrastructure provided with assistance of MLSNR is provided as annex. John Tagiilima has additional information on the proposed pump house and header tanker structures and will develop possible areas for B envelope funding.

Bacteriological sampling and analysis was undertaken by Public Health Inspector Isileli Fakailoatonga on a weekly basis, 20 samples total, 10 villages with 2 wells per village) Where DoH are currently taking weekly water samples for bacteriological sampling then

recommended that the salinity of village production wells be recorded by health at the same time in the field. HYCOS to provide EC meter which will allow the salinity to be recorded last the same time DoH will need to alter its existing form to accommodate this data. B envelope to consider TPS WP84 EC meter to be provide to health to undertake salinity readings of village wells

DoH records of village well construction to be provided to John Tagiilima by Isileli.

B Envelope

B envelope has identified actions under its CIP which are specific for geology MLSNR. These include need for mobile laboratory to allow samples collected and field testing to be undertaken. Drilling of resource investigation bores and construction of ongoing monitoring bores to determine future resource potential. Some specific equipment needs.

The specific requirements for a mobile laboratory include a 4WD capable vehicle to accommodate up to 5 people, (dual cab), with custom made body work to allow lockable dust proof storage of field equipment. Equipment to be serviceable by local dealers with spare parts readily available in Tonga. Due to funding situation of vehicle the servicing of the vehicle for the first two years to be included as part of the funding arrangement with the purchase of the vehicle. John to provide example of proposed vehicle and body work for review by MLSNR

The proposed drilling to assess future freshwater water reserve potential and construction of monitoring bores to be provided to B Env by MLSNR with assistance of HYCOS. The work undertaken by White and Falkland 2009 will serve as guide to determining the proposed requirements for the drilling. Where possible local drilling contractor to be used to undertake this work. MLSNR to provide costing \$/metre for use of local rig and assess its capabilities to undertake this work since its recent rehabilitation.

Additionally MLSNR have requested B Env consideration of signage for the Geology unit, a single bay lockable storage shed where mobile laboratory vehicle can be stored and refurbishment of attached small house for storage of field equipment and basic workshop/laboratory for equipment repairs and testing. These additional items to be considered by B Envelope with MLSNR to assist in determining costing

Additional

A meeting with Dr Reynold Ofanoa at the Department of Health identified that there is a need for the digitising of the bacteriological data into a more readily accessible format from current paper records. Edwin Liava'a through Pacific HYCOS will assist DoH in developing template which will allow the data to be entered to spreadsheet and then to be uploaded to NZ MoH database.

Dr Rey identified that they currently have consumables for IDEXX at 20 samples per week until Christmas 2010. B envelope may consider additional support of consumables where DoH can demonstrate the value of the data being collected and for its specific monitoring of the village well improvements proposed.

Agreed that Edwin Liava'a from HYCOS will follow up this mission with a mission focussed on securing the data being collected and training in TIDEDA and assist with developing the GIS which will be further developed with Nicola Fry. DoH needs for recording of bacteriological data will be

Follow up Action:

Action	Who	Date required	Date completed
Diver loggers to be returned to supplier for repair	PS	asap	30/06/2010

whilst under warranty and returned to MLSNR			
Mataki'eua usage data since usage meters installed from Lindsay and Pita Mola at TWB	PS	30/06/2010	02/07/2010
Lindsay to request pump hours to be recorded by operators at Mataki'eua and six digit numbers. Lofi to assist. PS to provide email to Lindsay and Pita	PS/ PM	asap	
Rain gauge site details to be completed by MLSNR, Nicola Fry to coordinate.	PS/NF	09/07/2010	
Site number for Mataki'eua in consultation with Tonga Meteorology Office	EL	3-10Jul 2010	
MLSNR staff to note and record changes to bores in database. Nicola and Edwin to assist.	Amelia, Nicola, Edwin	09/07/2010	
TWB to undertake concreting of base and bore protector casing. Nicola to arrange.	NF	09/07/2010	
Groundwater monitoring program for Mataki'eua	AV/NF/PS	14/07/2010	
Survey team in Tonga to level MB4 and MB5	Rennie and Akapei		
TIDEDA training and Tonga database data cleansing	EL, NF, Amelia	3-10Jul 2010 complete 30Jul	
MoH data entry – template EL and PS	EL	3-10 Jul 2010	

List of Contact(s):

Name	Designation	Department	E-mail
Rennie Vaiomounga	Geologist	MLSNR	rennie@lands.gov.to 7714395
Nicola Fry	AYAD volunteer-Hydrogeologist	MLSNR	nicolafry@gmail.com 8761693
'Apai Moala	Senior Hydrological Assistant	MLSNR	apai@lands.gov.to 7775628
'Akapei Valiea	Senior Hydrological Assistant	MLSNR	vaileaakapai@gmail.com 8823829
'Amelia Sili	Database management	MLSNR	amelia@lands.govto 7709108
Tupou Tui'lautala	IWRM (EU) Facilitator	MLSNR	poutuilautala@rocketmail.com
Saimone Helu	CEO	TWB	twbhelu@kalianet.to

Pita Moala	Project Manager	TWB	ewsup@kalianet.to
Lindsay	Chief Engineer	TWB	
Lofi	Mataki'eua Workshop Engineer	TWB	
Nafe Tufou	Mataki'eua Well field and workshop Supervisor	TWB	7717416
Akihiro Shimoyama	JICA Snr Volunteer Water Demand Management Leak Detection	TWB	Harusuke428@star.ocn.me.jp
Dr Reynold Ofanoa	MOEHS	MoH	rofanoa@health.gov.to 8833179
Isileli Fakailoatonga	Public Health Inspector	MoH	

Annexes:

Annex I: Mission Diary

Annex II: Village wells Details

Annex III: Rain gauge Site installation – details

Annex IV: Field sheets Mataki'eua

Annex V: Photographs

Annex I - Mission Diary

Activity Name – Title / Task Profile Number	ACTION
<p>Monday 21/6/10 AM Travel Tonga from Nausori PM</p> <ul style="list-style-type: none"> • Meet TWB – Pita Mola, Lindsay , John Tagiilima • Update on Mataki’eua water reserve and rehabilitation of 23 pumping wells, (new pumps, housings, and electrification) Arrange support and approval from TWB for installation of rain gauge at Mataki’eua • Arrange transport and technical support for village wells with TWB • Meet with Rennie and MLSNR staff Apai, Amelia, and AYAB volunteer hydrogeologist – Nicola Fry • Arrange for release of rain gauge which was being held at DHL awaiting payment of customs duty \$623.75TOP 	
<p>Tuesday 22/6/10</p> <ul style="list-style-type: none"> • Meet with Timotee water quality officer for TWB who outlined the water quality sampling undertaken at the distribution points along the main line. 12 samples taken monthly for bacteriological. Analysis using MPN. • Monthly sampling of all active pumping wells includes EC. Sampling 3rd or 4th week • Travel to Mataki’eua with TWB, Lindsay and MLSNR staff, • Review of new pump sheds and usage meters, with TWB, sampling of pumping wells undertaken by TWB. PS to request usage data from TWB. Recommendations provided on recording of meter readings, i.e. 6 digits recorded including 0’s for m³ also the recording of pump hours for maintenance purposes in the usage books. • Determine best location for TB3 rain gauge. Identified site on the top of water reservoir as is most secure location and still accessible. Lofi – workshop 2IC, provided support with installation. • Mataki’eua monitoring – water level measurements undertaken for MB1, MB2, MB4 where loggers were installed. All loggers were retrieved and non operational, suspect being left unattended for extended period was cause. Carbonate growths were found on two of the three loggers retrieved. • SMB4 had been badly damaged from plant which had backed into whilst putting in fencing. Assistance from Nafe and Lofi at TWB and SOPAC the use of the TWB excavator allowed retrieval of logger and commence rehabilitation of bore. • Loggers from SMB2 and SM3 were soaked in vinegar to remove growths which had built up. Overnight soaking sufficient. 	<p>Diver loggers to be returned to supplier for repair whilst under warranty- PS</p> <p>PS to request usage data from Lindsay and Pita Mola at TWB</p> <p>Lindsay to ensure that pump hours recorded as well as m³ for pumps (six digit values)</p>
<p>Wednesday 23/6/10 Mataki’eua well field</p> <ul style="list-style-type: none"> • TB3 rain gauge installed and some explanation and training of 	<p>Request of Andrick for resurvey options for damaged bores MB4 and MB5 - PS</p>

<p>the installation, calibration, and use of Wincomlog software for download. Calibration of the rain gauge undertaken. Nicola to collect site details including GPS and relevant site photos at next visit.</p> <ul style="list-style-type: none"> • With assistance from TWB (Lofi and Nafe), and John Tagiilima rehabilitation of the SMB4 undertaken. Damaged part of piezometer pipes cut and joined to undamaged pipes. NOTE: Reference point for future water level measurements now changed. Elevation point and bench mark from Andricks survey work is now no longer valid for this bore. Require resurvey of measuring point for elevation • Concreting of bore casing protector to be undertaken by TWB. <p>Village well survey Isileli Fakailoatonga Dept of Health, Lindsay TWB</p> <ul style="list-style-type: none"> • Reconnaissance of the proposed 10 village wells for rehabilitation. Village wells identified as most needy based on TWB and DoH criteria and DWSP. Rehabilitation to be undertaken by the EDF10 B Envelope project. • Review of the existing sites and consideration for monitoring needs and potential risk and threat of contamination to well and water source. • Summary of village well assessment in Annex. 	<p>Rain gauge site details to be recorded by Nicola at next site visit</p> <p>TWB to undertake concreting of base and bore protector casing. Nicola to arrange</p> <p>MLSNR staff Akapei an Amelia to take note of changes to bores in database. Nicola to supervise that change has been noted</p>
<p>Thursday 24/6/10</p> <p>Meeting MLSNR Rennie Vaiomounga, Nicola Fry , John Tagiilima</p> <ul style="list-style-type: none"> • Discussed arrangements on how to best assist progress of the MLSNR in water resource management whilst Kelepi is on leave. Agreed that where Rennie is filling in for Kelepi that he will be required to focus his efforts on the seismic work and that Nicola to assist Akapei to progress the groundwater aspects. HYCOS would assist NF and AV in developing up a work schedule for next 6 months. Amelia and 'Apai to be available for assistance with field work and database respectively. Rennie to enlist support from MLSNR management for groundwater and vehicle accessibility. Rennie to discuss arrangement at next team meeting. • Rennie on advice from Andrick to request from Tonga survey team the levelling of the MB4 and MB5 (Assistance from Akapei to progress) • Nicola to arrange with Akapei and TWB the concrete slab of MB4 and MB5, and forward photos to Peter • Peter to return retrieved Diver loggers to Aqualab whilst under warranty for repair. Previous failures of these loggers were Sept 2009. Nicola to provide data • Monthly download of rain gauge at Matakī'eua at beginning of the month. Site sheet and csv file to be forwarded to HYCOS immediately after upload. • Edwin to provide training in Tideda 3-10 July including 	<p>MLSNR to develop groundwater sampling program. PS to assist.</p> <p>Rennie to advise all at next team meeting of proposed work schedule and staff focus</p> <p>Rennie with assistance from Akapei contact Survey team in Tonga to level MB4 and MB5</p> <p>Nicola with Akapei to arrange for concreting of MB4 and MB5 base with TWB</p> <p>Details of logger failure to be provided by Nicola to PS</p> <p>Ongoing monthly downloads of rain gauge NF and AV EL reinstall Tideda</p>

<p>upload of rain data and appropriate site numbering. (Discuss site numbering with Tonga Met office – Edwin). Amelia's machine has been Edwin to bring copy of database and Tideda software for installation if required</p> <ul style="list-style-type: none"> • Nicola and Akapei to provide monthly summary data from Tideda to Tonga Met office and to TWB staff as email of summary and CSV file of data. • Data backup compromised with hard drive previously provided damaged. HYCOS to provide new hard drive for backup • HYCOS to assist MLSNR with developing monitoring schedule of Matakī'eua and work program for MLSNR. Discussed need for sampling from pumping wells for E coli-joint activity with TWB. Utilise IDEXX and MoH to undertake analysis 23 pumping wells in first month, additional wells 2nd month. Where required analysis undertaken by MLSNR staff and HYCOS using health facilities in August • PS to follow up usage data with Lindsay and Pita Mola at TWB • Nicola and MLSNR to foster relationship with TWB especially Matakī'eua sampling and monitoring and sharing of data. 	<p>and Tonga database, training Tideda and program for data checking</p> <p>HYCOS to provide hard drive</p> <p>GW monitoring schedule – PS/NF</p> <p>Usage data for Matakī'eua PS/TWB</p>
<p>B Envelope</p> <ul style="list-style-type: none"> • John identified that the impact on Matakī'eua from abstraction was a concern (T Falkland per's comm. advises John that that the current abstraction is already impacting on the freshwater lens and no additional abstraction from Matakī'eua should be undertaken). John supportive of the monitoring of the lens in Matakī'eua to assess this impact. • Identified that transport to undertake the groundwater monitoring activities was a major impediment for MLSNR. Discussed the need for a mobile laboratory which would allow monitoring and analysis to be undertaken. PS indicated that basic field sampling was more critical than established laboratory at MLSNR, which could be undertaken by other agencies with mandate and skills for this work. • Mobile lab would require specialised compartments for holding of equipment and allowing work to be undertaken safely, be 4WD, and a vehicle that parts could be readily obtained in Tonga. • Discussion on need for lockable storage garage of vehicle on the MLSNR site - John to consider single bay garage with concrete slab under B Env funding • The small house on MLSNR land (JICA) to be considered for refurbishing for workshop/laboratory use under B Env funding • Water resource drilling of groundwater investigation holes and monitoring bores. Discussed that the funding identified under B Env should be used to investigate gwgroundwater 	<p>John to cost out mobile lab requirements and provide to MLSNR for review</p> <p>Lockable storage/garage requirements costed JT</p> <p>Peter to email Rennie regarding the potential duplication of existing services available in government where MLSNR established a laboratory for bacto</p>

<p>potential of additional areas which may be suitable for use as water supply/water reserve for future water needs in Tongatapu. MLSNR and HYCOS to develop proposal with budget estimates for B Env to consider.</p> <p>Meeting with Dept of Health – Dr Reynold O’fanoa</p> <ul style="list-style-type: none"> • John requested DoH to provide assistance with the village committee consultations re electrification, building design, emergency power needs • Construction details of wells to be forwarded to John to assist with design. • DOH to also include the salinity of pumped water from village wells when sampling for E Coli using IDEXX. PS to check if EC meter provided under HYCOS if not options to purchase under B Env. HYCOS to provide Hanna EC meter in short term • Dr Rey indicated that they currently have been funded by WHO for IDEXX reagents until the end of the year based on 20 samples a week (2 wells per village, 10 villages). B Env to consider 200 – 400 reagents for additional monitoring needs Village wells and Matakī’eua. • Dr Rey agreement for no cost analysis of the Matakī’eua sampling, proposed for August PS to arrange for Monday sampling and analysis MLSNR, TWB, Health • Dr Rey identified that bacto data is not digital. Request from Dr Rey that Edwin assists with generating template which can be used by current trainee to enter this data from paper records. 	<p>sampling.</p> <p>PS to provide Hanna EC meter and calibration solution in short term, B Env to consider purchase of EC TPS meter</p> <p>Edwin and PS to arrange template suitable for entry of bacto data from paper records to digital format.</p>
<p>Friday 25/6/10</p> <p>MLSNR – follow up on requests</p> <ul style="list-style-type: none"> • Queries on rain gauge download and site sheet. PS to follow up • Purchase necessary tools for groundwater monitoring and village wells survey. Additional tools required but unavailable in Tonga at time- PS to purchase in Fiji. <p>Travel to Fiji</p>	<p>Follow up on rain gauge site sheet details PS</p> <p>Tools to be provided to MLSNR under HYCOS. PS</p>

Annex II – Village Wells Field Inspection

Village wells – Identified rehabilitation needs – DWSP

Villagers	Pop 06	Upgrade Borehole		Chlorine treatment		Reservoir	Reservoir Stand		Pump		Reticulation		Solar	Training
		<i>Head</i>	<i>Shed</i>	<i>Upgrade</i>	<i>Install</i>	<i>Replace</i>	<i>Structure</i>	<i>Ladder</i>	<i>Upgrade</i>	<i>Replace</i>	<i>Upgrade</i>	<i>Replace</i>		
Fatai Village	323	√	√		√	√				√	√	√		√
Fahefa Village	361	√	√		√					√				√
Kalaa Village	128	√	√		√					√				√
Ha'alalo Village	526				√									√
Ha'ateiho Village	2322				√									√
Vaini/Pakilau Village	3091				√				√				√	√
Holonga Village	543	√	√		√			√						
Fatuma Village	414	√	√		√			√		√				
Kolonga Village	1199	√	√		√			√						√
Talafo'ou	381	√	√	√	√			√						√

Construction details for Village (Department of Health)

Village	Type of pump	Size of column pipe	Well depth	Water depth
Fatai	Helical pump	2"	22 ft (6.706m)	----
Fahefa	Helical pump	2.5"	52 ft (15.85m)	7 ft (2.13m)
Kala'au	Pump head	2.5"	50 ft (15.24m)	---
Ha'alalo	Helical pump	2"	85 ft (25.91m)	12 ft (3.66m)
Ha'ateiho	Helical pump	2"	38 ft (11.58m)	6ft (1.83m)
Vaini	Helical pump	2"	60 ft (18.29m)	---
Holonga	Helical pump	2"	48 ft (14.63m)	---
Fatumu	Helical pump	2"	110ft (33.53m)	---
Kolonga	Centrifugal pump		20 ft (6.10m)	---
Talafo'ou	Helical pump	2"	45 ft (13.72m)	---

Survey MLSNR

Village	Date and time	DTWT (m)	EC at water table $\mu\text{S}/\text{cm}$	Total depth (m)	EC at base of well $\mu\text{S}/\text{cm}$	Depth of water (m)	Comments
Fatai	29/6/10 15:40	4.20	788 (25.0°C)	4.80	855 (24.9°C)	0.60	
Fahefa	29/6/10 15:10	----	808 (27.4°C)	----	-----	----	Sampled at tap only
Kala'au	29/6/10 15:20	15.44	810 (24.9°C)	16.15	877 (24.7°C)	0.71	
Ha'alalo well A	29/6/10 14:45	21.81	580 (24.9°C)	22.21	635 (24.9°C)	0.40	
Ha'alalo well B	29/6/10 14:45	----	----	---	---	----	Could/did not access
Ha'ateiho well A	----	----	----	----	----	----	Did not visit
Ha'ateiho well B (without pump)	29/6/10 14:25	6.93	706 (24.9°C)	8.06	782 (24.9°C)	1.13	This was the bore with no pump attached

Ha'ateiho well B (with pump)	29/6/10 14:25	----	885 (25.9°C)	----	----	----	Inaccessible, sampled at tap only. Pump was operating.
Vaini	29/6/10 11:25	13.80	~600 (±400)	14.45	1120	0.65	Well was pumping. Forgot to record temperature.
Holonga Well A	29/6/10 11:50	12.42	922 (24.7°C)	12.80	950 (24.7°C)	0.38	We turned pump off before measuring
Holonga Well B	29/6/10 12:00	---	1120 (26.6°C)	---	---	---	Inaccessible, sampled at tap
Fatumu	29/6/10 12:25	29.38	720 (25.0°C)	30.41	935 (24.9°C)	1.03	Pump was not operating
Kolonga Well A	29/6/10 13:30	3.42	734 (24.9°C)	3.96	840 (24.5°C)	0.54	Pump was not operating
Kolonga well B	29/6/10 13:40	---	---	---	---	---	Inaccessible, pump was not operating, and therefore we could not sample at tap.
Talafo'ou	29/6/10 13:00	17.76	860 (25.1°C)	18.25	1028 (25.1°C)	0.49	

Initial investigation 23/6/10

Village	Latitude	Longitude	Estd DTWT	Comments
Fatai	S21°08.158'	W175°16.678'	8-10m	Dug well with manhole. No sampling tap. No meter on pump or from header tank. Header tank leaking. Pump previously solar, currently diesel. No obvious threat of contamination (although some potential for hydrocarbon contamination from current diesel operation)
Fahefa	S21°08.832	W175°19.824'		Drilled bore 6" casing, no access to well, 2" sampling tap. Meter on outlet of tank from header stand operating (019834m ³) 12:20 23/6/10, Fibreglass header tank No obvious threats of contamination. Diesel pump currently, proposal for electrification
Kala'au	S21°08.275'	W175°20.248'		Dug well 2x3m. Very old Southern Cross handpump. Access via manhole Well located in middle of village with threat of contamination from septic tanks. Closets tank is approx 5m (Church hall, limited use) Three septic tanks attached to houses 25m, 30m, and 30m. Red soils 1m thick underlain by limestone. Well believed to be 12-15m deep. Diesel operated helical pump pumps approx 200m to new header tank with meter?
Ha'alalo well A	S21°11.004'	W175°16.777'		Drilled well , no meter believed to pump 10hrs/day. Diesel pump Manhole accessible and 2" gate valve for sampling No obvious threat of contamination
Ha'alalo well B	S21°11.006'	W175°16.793'		Dug well, no meter believed to pump 10hrs/day. Diesel pump Manhole accessible, no sampling tap

				No meter on tank No obvious threats of contamination.
Ha'ateiho well A	Didn't visit			No obvious threat of contamination. Metered and sampling tap, pumps up to 16hrs/day. Currently diesel pump (helical) Drilled bore
Ha'ateiho well B (with pump attached)	S21°10.967'	W175°14.221'		Some potential threat of fuel contamination. Shed in poor condition. Unable to access well. Believed to pump 10-15KL/day, pumps up to 16hrs /day, not metered. Currently diesel pump (helical) Drilled bore
Ha'ateiho well B (no pump attached)	S21°10.967'	W175°14.216'		Currently has no pump attached to it, no shelter, just concrete hole in ground with pipes. Bore accessible, once pipe removed.
Vaini	S 21 ⁰ 12.043'	W 175 ⁰ 09.959'		Dug well. Well located in Beulah College, SDA church. Well located under building. Reservoir on top appears structurally compromised. Access to bore is limited with locked door, no meter observed. Electrical helical pump operating on float (regular switch on and off)
Holonga Well A	S 21 ⁰ 11.803'	W 175 ⁰ 08.519'		Dug well accessible via manhole. Pump house in disrepair. Pumps approx 400m to header tank. Helical pump, diesel operation but approx 5m from electrical powerlines. Well located close to house, no obvious threat of contamination
Holonga Well B	S 21 ⁰ 11.826'	W 175 ⁰ 08.541'		Drilled bore. No meter , bore inaccessible, requires sampling piezometer, no obvious threat of contamination, electrical helical pump operation

Fatumu	S 21 ⁰ 12.792'	W 175 ⁰ 06.628'		Dug well accessible via manhole, no meters on well or reservoirs. Well located on playing field. Closest septic >50m. No obvious threat of contamination from septics, rather the public accessibility. Header tank fibreglass and leaking at seam, tank full. Currently diesel operation operating approx 5hrs per tank assume 10hrs operation/day.
Kolonga Well A	S 21 ⁰ 08.454'	W 175 ⁰ 04.444'	3.53m	Dug well. Diesel operation no nearby electricity Header tank fibreglass with Elster meter on tank outlet and main line to village (both usage from well A and well B through meter). Accessible manhole
Kolonga well B	S 21 ⁰ 08.547'	W 175 ⁰ 04.518'	NA	Drilled bore, no accessible point for DTWT, sampling tap available. Diesel operation no nearby electricity. Header tank fibreglass.
Talafo'ou	S 21 ⁰ 08.318'	W 175 ⁰ 06.757'	17.82m	Hand dug well (old southern cross +ve displacement pump), accessible via manhole (Steel casing from old Sthn X could be used for monitoring piezometer in well). Diesel operation new Lister pump tank approx 1km from pump. No obvious contamination threat. No nearby electricity

Annex III – Rain Gauge Site Installation

Rain gauge site installation details – Mataki'eua

The tipping bucket TB3 was installed at Mataki'eua well field to provide site specific rainfall information for the purpose of water resource investigations and management including water budgeting and recharge studies.

It was agreed with TWB staff that the most appropriate location was within the TWB compound at Mataki'eua, based on accessibility and security issues. The actual site chosen was on top of the approx 2m high cement water storage tanks in the centre of the compound where they provided greatest security and accessibility to the instrument, and met the general WMO guidelines for establishing a rain gauge site.

In general the site is located in a high area, top of ridge feature, with no significant obstructions from trees or buildings. The site is approximately

The site was installed with the assistance of TWB staff at Mataki'eua, Lofi and MLSNR staff 'Apia, Amelia, and AYAD volunteer Nicola Fry.

It was agreed that the station will be maintained by MLSNR staff and that the site will be inspected and the data downloaded at the 1st of each month, (where possible). The data will be archived to Tideda at MLSNR and the scanned site sheets and rainfall data will also be archived at SOPAC regional database archive. A copy of the TIDEDA output 9am to 9am daily records will be provided to both TWB and Tonga Meteorology office on a monthly basis by the MLSNR staff.

Site documentation was completed by MLSNR staff 1 July 2010



General site photographs of new rain gauge on water storages - Mataki'eua



Calibration of new rain gauge at Mataki'eua.

Annex IV – Field Sheets – Mataki’ea Well field

ANNEX 3 Field Data Sheets – Salinity Monitoring Field Sheet

Ministry of Lands, Survey, Natural Resources and Environment

Salinity Monitoring Bore Field Data Sheet

Borehole No: SMB2
 Date: 22/6/10
 Arrived: 2:27
 Observers: NF, AV, PS, AS
 Departed: 3:10 sh

Time
 Time

Location:
S21009.233' W175°14.499'
 Elevation of datum 27.1 m (ASL) (GPS)

*used survey mark
 as datum
 for measurements.*

Remarks:
This ~~well~~ bore has the barrodive attached.
downloaded barrodive results.

1/2 m up

Pipe No.	Water level (m)	Total Depth (m)	EC at midpoint of screen (unit)	T °C	Height of measuring point above datum (m)	EC at WL
1	13.785	38.36	57.2MS	25.5		567µS/cm 24.6°C
2	13.57	25.92	9125µS	25.1		494µS 24.9
3	13.62	25.10	5852µS	25.1		376µS 24.6
4	13.57	18.65	1015µS	24.9		1789µS 24.5
5	13.57	18.39	902µS/cm	24.9		554µS 24.5
6	13.56	15.22	525µS/cm	24.6		576µS/cm 24.7°C
7						

Note: No construction details for piezometers available. Assume 0.5m sump and 1 metre screen. Midpoint of screen estimated to be total depth minus 1 metre.

Comments: (Maintenance of site, proximity to pumping, pumping or not) -
we downloaded barrodive & restarted it for
30 minute intervals to begin @ 3:30 pm 22/6/10

Data entered.....	Date.....	Officer.....
Data verified.....	Date.....	Officer.....
File name and path of entered data.....		

ANNEX 3 Field Data Sheets – Salinity Monitoring Field Sheet

Ministry of Lands, Survey, Natural Resources and Environment

Salinity Monitoring Bore Field Data Sheet

Borehole No: SMB4
Date: 23/6/10

Time

Arrived: 12:00 noon

Time

Observers: N.F., A.S., AM

Departed: 12:42

Location: 21°09.066' 175°14.899'

Elevation of datumm (ASL) → survey datum on side of steel casing

Remarks: borehole just in soil, no concrete base yet.

to top of
sg = 1.010m

Pipe No.	Water level (m)	Total Depth (m)	EC at midpoint of screen (unit)	T °C	Height of measuring point above datum (m)
6	13.30	16.65	647µS (1.65)	24.7	
5	13.37	19.54	835µS	24.7	
4	13.37	23.81	1475µS	24.7	
3	13.34	29.57	10.2M	24.7	
2	13.45	31.39	35.6M	24.7	
1	13.58	35.15	124.39.2	24.7	

EC at water level 620µS
25.1°C
831µS, 24.7°C
1473, 24.7°C
906µS, 24.7°C
945µS, 24.7°C
132µS, 24.7°C
+ 0.00

Note: No construction details for piezometers available. Assume 0.5m sump and 1 metre screen. Midpoint of screen estimated to be total depth minus 1 metre.

Comments: (Maintenance of site, proximity to pumping, pumping or not)

Data entered.....	Date.....	Officer.....
Data verified.....	Date.....	Officer.....
File name and path of entered data.....		

ANNEX 3 Field Data Sheets – Salinity Monitoring Field Sheet

Ministry of Lands, Survey, Natural Resources and Environment

Salinity Monitoring Bore Field Data Sheet

Borehole No: SMB1
Date: 22/6/10
Arrived: 12:20
Observers: NE, AM, AV, PS
Departed: 12:47

Time
Time

Location: S 21°09' 534" W 175° 14' 084"
Elevation of datum: 23.6 → GPS m (ASL)

Remarks:

Pipe No.	Water level (m)	Total Depth (m)	EC at midpoint of screen (unit)	T °C	Height of measuring point above datum (m)
1	10.125	24.2	40.4 MS	25	
2	10.05	21.72	213 MS		
3	9.98	16.70	1100	25	
4	no water	at total depth (9.42m)			
5	9.96	9.42	703 μS	24.7	
6					
7					

EC at WL
32.1 MS/cm² 25°C
10.4 MS/cm² 24.7
10.12 MS 24.6°C
633 μS 24.7°C

Note: No construction details for piezometers available. Assume 0.5m sump and 1 metre screen. Midpoint of screen estimated to be total depth minus 1 metre.

Comments: (Maintenance of site, proximity to pumping, pumping or not)

Data entered..... Date..... Officer.....
Data verified..... Date..... Officer.....
File name and path of entered data.....

SOPAC Trip Report 458 – Sinclair & Liava'a

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$z = 81.7 \text{ cm}$
 $y_1 = 49 \text{ mm}$
 $y_2 = 60 \text{ mm}$
 $y_3 = 52 \text{ mm}$

$y_4 = 39 \text{ mm}$
 $y_5 = 36 \text{ mm}$

logger cable from black mark to base of new cut = 15.48m
then add length of logger cable to that

ANNEX 3 Field Data Sheets – Salinity Monitoring Field Sheet

Ministry of Lands, Survey, Natural Resources and Environment

Salinity Monitoring Bore Field Data Sheet

Borehole No: SMB5
Date: 24/6/10

Arrived: 2:40pm
Observers: N.F., A.M., A.S.
Departed: 3:10pm

Time

Time

Location:

S21° 08' 859

W175° 15' 446

Elevation of datumm (ASL) data = steel camp
= 800mm above ground

Remarks:

Pipe No.	Water level (m)	Total Depth (m)	EC at midpoint of screen (unit)	T °C	Height of measuring point above datum (m)
1	9.02	32.27	53.2ms	24.7	
2	8.82	32.27	32.5ms	24.6	
3	8.66	23.50	56.5ms	24.7	
4	8.64	18.67	127.0ms	24.6	
5	8.66	13.73	106.8ms	24.6	
6	8.66	11.15	65.1ms	24.7	
7					

EC at WL

34.1ms 24.7°C
24.8ms 24.7
41.9ms 24.7
122.8ms 24.7
78.0ms 24.7
68.1ms 24.7

Note: No construction details for piezometers available. Assume 0.5m sump and 1 metre screen. Midpoint of screen estimated to be total depth minus 1 metre.

Comments: (Maintenance of site, proximity to pumping, pumping or not)

bore had fallen tree on top of it, had to get
backhoe to remove tree. concrete slab also
damaged - may need to resurvey.
logger removed - could not download data,
cable replaced down pipe #3.

Data entered.....	Date.....	Officer.....
Data verified.....	Date.....	Officer.....
File name and path of entered data.....		

Annex 4: Photographs



Installation of rain gauge and calibration at Mataki'eua



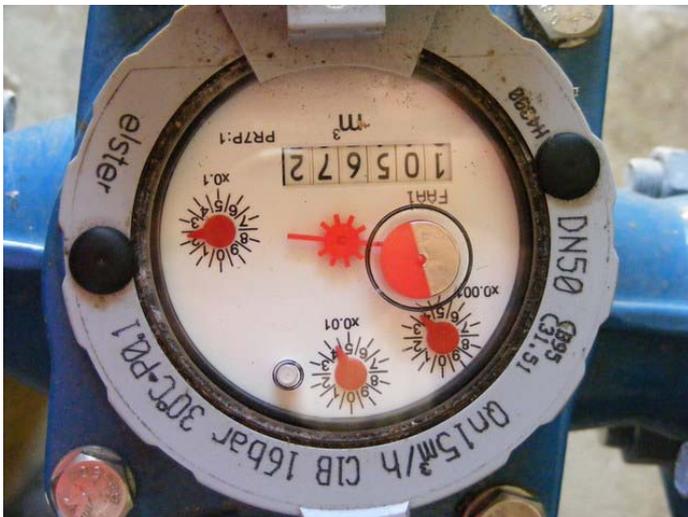
Damaged MB 4 – Mataki'eua



Rehabilitation of MB4



Water level measurement of monitoring bores



New pump houses and meters for the rehabilitation and electrification of 23 production bores in Mataki'eua

Handwritten record book showing meter readings for 23 production bores. The pages contain tables with columns for 'OPERATOR', 'METER', and 'READING (FM)'. The text is in a local language, likely Tongan, and includes various notes and data points for each bore.

Recording of daily meter reading at 23 production bores – Mataki'eua



Typical village well set up +ve displacement helical pump and Lister diesel motor

Site Documentation – Mataki’eua Rain Gauge

Completed by Akapei Vailea, Apai Moala, Nicola Fry, on 1 July, 2010.

Geology Section, Ministry of Lands, Survey and Natural Resources, Tonga.

TB3 Rain gauge was installed on top of water tank at Mataki’eau Tonga Water Board Office, on 23 June, 2010, to obtain rainfall records for use in water resource management.

Installation team: Peter Sinclair, John Tagilima, Apai Moala, Akapei Vailea, Amelia Sili, Nicola Fry, and Tonga Water Board staff

Location

S21°09.386’, W175°14.318 (WGS84)

Elevation: 37m (measured on GPS with error of $\sim\pm 20$ m)

Site name: Mataki’eua

Site number: 11001

Rain gauge details:

- TB3 Rain gauge
- 0.5 mm tipping bucket
- ML1 logger
- Calibrated at site, 23 June 2010

a) Measurements

- Height of base plate of rain gauge from tank surface: 0.22m
- Height of tank surface from ground: 1.99m
- Distance from gauge to edge of tank (north): 0.75m
- Distance from gauge to edge of tank (east): 0.92m
- Distance from gauge to edge of tank (west and south): >10m

b) Type of sheltering

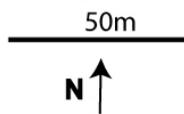
- Sheltering in the area consists of trees and office buildings about 20 – 30m from site.

c) Microscale/toposcale surroundings of instrument

- i) Large (20m high) Banyan tree ~ 30 m from site, 1 storey buildings ~ 20 m from site, 2 storey building ~ 30 m from site, ~ 2 m high fence surrounding tank ~ 3 m from site,. Closest tree ~ 10 m from site (small Papaya tree).

- ii) Minimal other urbanisation within the area. Nearby vegetation is mostly coconut trees and low shrub.
- iii) Sealed road ~30m from site, and office area has sealed road ~10m from site. Gauge is installed on concrete water tank. Gauge installed on approximately highest elevation within the region, on top of a small hill, where water storage tanks are located (for the Mataki'eua bore field).
- iv) Other significant structures in the area: Digicel phone towers ~2-3km from site, Kings Palace ~1km from site, fuel storage tank ~20m from site. Site is ~2km from the lagoon.

Photos of site



- Rain gauge site
- T Water Tank, concrete sealed
- B Small building
- BT Banyan tree
- O Large building (office)
- FT Fuel tank

Figure 1: Aerial view of gauge site (photo from Google Earth)



Figure 2: Gauge from above, without cover



Figure 3: Gauge, looking E, without cover



Figure 4: Gauge from above



Figure 5: Gauge, looking E



Figure 6: Looking S, from ground surface below water tank



Figure 7: Gauge, looking ESE, from ground surface below water tank



Figure 8: Panoramic view from gauge, showing nature of surrounds