SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING (SPSLCM) PROJECT III SURVEY VISITS TO TONGA & FIJI ISLANDS

18th February to 8th March 2002

Andrick Lal
Assistant Surveyor
South Pacific Sea Level & Climate Monitoring Project Phase III

SOPAC Trip Report 308

July 2002

Undertaken under Task RT2001.13 – South Pacific Sea Level & Climate Monitoring Project Phase III

ACKNOWLEDGEMENT

The survey team, of Mr Steven Turner, Mr Brian Ratcliff and Mr Andrick Lal, is really thankful to the Lands and Surveys Department of Tonga and Fiji for their kind support and help during the survey visits of the South Pacific Sea Level and Climate Monitoring Project.

PROJECT BACKGROUND

The 20-year SPSLCMP [South Pacific Sea Level and Climate Monitoring Project] is funded by AusAID and technically supported by the [Australia's] National Tidal Facility (out of Flinders University) has entered its third, 5-year phase. This Project began in October 1992.

SOPAC was approached by the Australia Marine Science & Technology Limited (AMSAT), the agency set up to coordinate the SPSLCM Project in the region, to support the Project by way of sharing the costs of a suitably qualified and experienced **"Assistant Surveyor"** to directly support the routine surveying and monitoring in the South Pacific Sea Level and Climate Monitoring Project [Phase III]. SOPAC would also act as a regional data archive for sea level, CGPS with the related data; and assist in the maintenance of the sophisticated suite of equipment that are part and parcel of the Project.

This Project was set up to provide quality meteorological and sea level data through an array of latest climate monitoring stations, backed by the precise geodetic survey data; and a series of high-resolution sea level stations has been established in eleven countries of the South Pacific Forum with data transmission via satellites to the National Tidal Facility in Adelaide. Research and results drawn from analysis of this data is to assist Forum island countries with their sustainable development agendas.

A series of high-resolution sea level recording stations has been established in twelve countries of the South Pacific Forum with data transmission via satellites to the National Tidal Facility in Adelaide.

South Pacific Sea Level and Climate Monitoring Survey Sites.

OBJECTIVES

The South Pacific Sea Level and Climate Monitoring Project aims to help Pacific Island countries understand the implications and scale of sea level and climate changes. The AusAID-funded Project has the following objectives:

a. Set up high-resolution monitoring stations in the South Pacific region to compute relative motions of land and sea at each station based in each of the twelve countries.

b. Carry out a geodetic survey program to measure movements of the crust at other strategic sites in each country with respect to the reference station.

c. Help identify changes to sea levels with reference to a similar network of stations in Australia and elsewhere in the world, whether these changes are due to thermal expansion of the ocean, contributions from land ice or changing properties of water from different ocean zones.

d. Provide a measure of regional vertical controls and exchange information and data with national, regional and international climate change centres in relation to the ongoing international geodetic programmes, which incorporate satellite altimetry and radio astronomy.

The Assistant Surveyor was involved, during this survey, in Precise Differential Levelling activities in Tonga and Fiji Islands according to the following objectives:

- To provide assistance in the collection and reduction of precise leveling data between the Sea Level recorders, benchmark arrays and CGPS receivers in the field as part of the South Pacific Sea Level and Climate Phase III Project being funded by AusAID.
- To monitor and identify changes to sea levels in the South Pacific that is due to thermal expansion of the ocean, glaciations from the land ice or changing properties in the continental plates between zones.
- To accomplish the above tasks by providing survey assistance to Mr Steven Turner, Geodetic Surveyor of National Tidal Facility [NTF], Australia to carry out Differential Precise Leveling Survey in Tonga and Fiji Islands.

"Precise Differential Leveling" is being defined as the operation required to determine the heights of points on the surface of the earth in relation to a known point [benchmark] upon a vertical datum, whereby all possible sources of errors are identified and field procedures are adopted to eliminate or minimize their effect as possible. This survey satisfies the requirements of a **CLASS A** survey, the error accounted for should be less than $2\sqrt{k}$ where k is the distance to any station in kilometers. The survey team is constantly trying to eliminate errors and get misclosure to within $1\sqrt{k}$, which is even more accurate.

SURVEY TEAM

The Head of the Surveys and Geodesy Department of the National Tidal Facility, Mr Steven Turner is the team leader with Mr Brian Ratcliff who is the Senior Technical officer from the South Australian Lands Department and Mr Andrick Lal is the Assistant Surveyor from the South Pacific Applied Geoscience Commission are responsible for carrying out the Precise Differential Leveling survey in the Tonga and Fiji Islands as part of the South Pacific Sea Level & Climate Monitoring Project Phase III.

ACTIVITIES UNDERTAKEN

The precise differential leveling surveys are carried out in Nuku'alofa, Tonga and in Lautoka, Fiji Islands where the Tide Gauges are situated. This survey was carried out from the Sea Level Fine Resolution Acoustic Measuring Equipment [SEAFRAME] station to the Tide Gauge benchmark and to the inland Primary benchmarks, which are driven deep into the ground and along the temporary benchmarks.

The benchmarks have the property of exceptional stability and are also established in very stable rock formations or in structures established on stable formations. These benchmarks are referenced in terms of Mean Sea Level datum/Tide Gauge Zero or in terms of a country's datum where each benchmark has their known heights in relation to the datum.

This precise differential leveling survey is part of an ongoing 18-month cycle of re-survey at all sites. Deep benchmarks can be found to be undisturbed and as per other surveys some movement of marks are detectable.

Some of the holding marks (temporary benchmarks) were replaced and additional holding marks were placed in the survey network. As usual the in-county lead agencies and survey offices were consulted and visited. There were no unexpected happenings during the survey, but we had to stop the survey in Tonga for some time due to bad weather conditions. We continued as soon as the weather permitted us to. We were able to complete the survey. Survey team leader, Mr Steven Turner, of the National Tidal Facility, is processing the survey report detailing all the results for this survey.

Tonga Survey, 19-25 February 2002

I arrived in Tonga on the 18th February 2002 at 1745 hours from the Nausori airport with Mr Steven Turner and Brian Ratcliff arriving later at 2200 hours. It was unfortunate that their bags did not arrive with them but the survey equipment did. We proceeded from the airport to the Friendly Islander hotel in Tongatapu. The vehicle hired for the survey was from the Friendly Islander hotel.

The next morning on the 19th February we met in the hotel lounge at 0800 hours, packed up the survey equipment in the vehicle; however due to the very bad weather conditions, we could not start any serious surveying work during the day. Instead, a reconnaissance survey of the marks was carried out during the day; the old marks were located and the status of each mark was checked. We also went to the Continuous Global Positioning System site to see all the reference marks and the CGPS benchmark.

In this phase of the Project, a survey will be carried out to create a link between the SEAFRAME station at the Queen Salote Wharf and the CGPS station installed at the 'Apifou College compound. The tide gauge is based at the Queen Salote Wharf.

During our reconnaissance we met Mr Bob Twiley and Mr Steve Yates from Geoscience Australia, who are also project coordinators for the SPSLCMP installing the CGPS stations in all the twelve countries. They invited us to attend the Climate Change Workshop being held in Tonga at the same time we were there, to do a presentation. The official opening ceremony of the CGPS site at the 'Apifou College was scheduled for the 20th of February 2002.

The Regional Coordinator, Mr Chalapan Kaluwin, had organized a Climate Change Workshop for schoolteachers to tell them about the SPSLCM Project.

The following day, 20th February, we met at the lounge at 0800 hours; and again due to extremely bad weather conditions there was no precise differential leveling survey carried out. It was raining very heavily and almost all the low-lying areas of Tongatapu were flooded.

Mr Steven Turner from NTF and Mr Bob Twiley did their presentations as part of their contributions in the Project at the Workshop mentioned earlier.

The opening ceremony of the CGPS site was held in the afternoon from 2.00 t0 5.00 pm. The Minister of Lands & Natural Resources from the Tongan government and the Australian High Commissioner to Tonga officially unveiled the plaque. There was also a display of the surveying equipment used in the SPSLCM Project such as the GPS equipment, the Theodolite and the Digital Level. The Tongan Survey Department also displayed a collection of surveying equipment. A light meal and refreshments were provided.

The next day, 21st February, we met again at the same place and at the same time and proceeded to the Workshop where I did the presentation on the 'data and information'; while Steven and Brian placed the three deep benchmarks into the ground and cemented them with the help of Tongan surveyors.

Later in the day at 1200 hours I joined them at the survey site. After placing the three benchmarks we placed some of the new holding marks (temporary benchmarks) along the 'Alaivahamama'o by-pass road. This survey started from the NTF Tide Gauge at the Queen Salote Wharf and along the 'Alaivahamama'o by-pass road which had benchmarks (temporary and otherwise) all along it. One benchmark was at the junction of the Vuna road and 'Alaivahamama'o by-pass road; one at the entrance of 'Apifou College and the third was at the junction of the 'Alaivahamama'o by-pass road and the 'Apifou College access road. A total of six deep benchmarks are in the Tonga survey network.

Later in the afternoon we carried out the precise differential survey. The survey was carried out with Steven Turner and Brian Ratcliff setting the instrument and recording field data and I was in charge of setting up the starves. We followed this allocation of tasks throughout the Tonga survey. A total of two bays were surveyed.

On Friday, 22nd February 2002, we carried out the precise differential survey from the junction of Queen Salote Road and Vuna Road to the NTF tide gauge at the wharf. After completing that section we carried out the survey from the junction of Vuna Road and the 'Alaivahamama'o by-pass road and into the by-pass road. We continued with the survey despite the cloudy weather and the light showers experienced throughout the day.

The following day, 23rd February 2002, we carried out the survey along the 'Alaivahamama'o by-pass road to the exact location where the industrial area is located.

No surveying was done on Sunday, 24th February, as no-one works in Tonga on Sundays.

Monday, 25th February, we carried out a re-survey of two bays; from a temporary benchmark to the new benchmark. We returned to the hotel to re-confirmation our flights to Fiji and then went back to complete the fieldwork.

We surveyed along the access road to 'Apifou College and to the CGPS benchmarks to complete the survey for Tonga. All the field data were checked and reduced upon conclusion of the surveys. Data was within the limits of allowable error.

Next day we packed up all our equipment, covered all the survey marks, which were dug up and then went to the survey office to thank them for their kind support and help in the Project. Our flight to Fiji was at 2030, the same day.

Fiji Islands Survey, 27 February – 7 March 2002

We reached Nadi at 2200 hours. Upon arrival we hired a vehicle from Budget Rentals and left for Lautoka where Steven and Brian checked in at the Waterfront hotel and I checked in at the Cathay Hotel.

The next morning on the 27th February, I met Steven and Brian at the hotel, from where we went to Lands and Survey Department in Lautoka. After a visit to the Divisional Surveyor Western's office we went and did the reconnaissance survey to place three deep benchmarks. The three deep benchmarks were to be placed inside the Fiji Sugar Corporation compound. The deep benchmarks were driven into the ground with a dropper knocker. The benchmarks were stainless steel rods in lengths of 1.40 meters. Holes were dug for each benchmark and then the stainless steel rods were driven into the ground, length by length. We took turns to drive it down into the ground; until it reached the hardest substratum below ground surface. A stainless steel cap was then screwed onto the top of each rod. One of the three benchmarks went into the ground 7.0 meters and the other two went in 5.6 meters. After placing the survey marks we went and looked for the temporary benchmarks and the deep benchmarks that were already in the Lautoka network. The next day we placed the temporary benchmarks within the survey network.

These temporary benchmarks are stainless screws drilled and placed on hard surfaces such as concrete platforms; or glued into the ground.

To complete compacting the three deep benchmarks we went to Nadi to buy aggregates and cement from the Standard Concrete Industries Limited. Upon return we cemented the survey marks and placed a plastic case with cover around it. To stabilize its movement in the ground, a PVC pipe was placed in the ground around the rod and powdered grease was poured into it. After taking a short break at 1400 hours, we started with the fieldwork. We also acquired help from Rakesh who works for the Survey Department in Lautoka. We began the survey at the roundabout situated in Waterfront Road.

We set up the survey with Steven recording the field data onto the leveling sheets; and sometimes doing observations through the Digital Level; Brian doing observations through the Digital Level on the way backwards upon closing a circuit and setting up the starve; and me doing observations through the Digital Level on the way forward from one benchmark to the next; and also setting up starves.

We carried out the precise differential survey right to the gate of the Kings Wharf. Normally we make observations at intervals of 25 meters. We completed the fieldwork for the day at 1700 hours.

The following day, 1st March 2002, we carried out fieldwork from 0800 hours to 1600 hours. Mr Sami from the Survey Department helped us during the survey. The precise differential survey was carried out along the Waterfront road and along Nadovu Street; ending for the day at the junction of Nadovu Street and Navutu Street.

On the 2nd of March we carried out the precise differential survey from the junction of Nadovu and Navutu Street into the Fiji Sugar Corporation (FSC) headquarters compound, finishing off the fieldwork at the 1630 hours.

Next day we started the fieldwork at 0900 hours and finished off at 1600 hours with leveling from the CGPS benchmark to the new benchmarks established at the FSC compound. The Tonga weather of cloudy with light showers accompanied us to Lautoka.

On Monday, 4th March, we picked up Sami from the Survey department and then went to carry out the survey from the gate of the wharf to the Tide Gauge in one of the shed.

Safety gear was worn throughout the survey. After completing the survey at the wharf, we carried out the survey from the junction of Drasa Avenue and Tavakubu Road into the Girmit Center compound where one of our deep benchmarks is located.

The following day the survey was carried out from the gate of the FSC headquarters, which is towards Drasa Avenue road to the junction of Drasa Avenue and Tavakubu Road, between the hours of 0800 and 1630.

On the 6th of March the survey was carried out from the FSC mill and along the access road into the playing ground and to the benchmark located at the junction of Drasa Avenue and Tavakubu Road. This ended the precise differential survey for Lautoka, Fiji.

All field data were reduced and checked for any errors. After the reduction of the data, it was seen that the measurements were well within the limits of allowable error.

Next morning we met at the Waterfront Hotel; packed up all the survey equipment and left for Nadi Airport. We freighted all our survey equipment to Adelaide, Australia through TNT.

We kept the digital level with us because it is always hand carried to and from survey visits. We came back to Lautoka and covered all our deep benchmarks and took photographs of them for our records.

The data collection and reduction with a thorough check was completed on the 7th March 2002. The following day Steve and Brian picked me up from the Cathay Hotel and we left for Nadi airport. On the way we paid a visit to Mr Mohammed Yunus of the Meteorological Department and discussed the status of the NTF tide gauge.

I checked in at the Nadi Airport at 1500 hours for my flight to Nausori.

Concluding Remarks of the Tonga/Fiji Survey visit

There is a total of six primary [deep driven] benchmarks in Tonga and Fiji with known height datum from which holding points or temporary benchmarks were in connection to a known datum. The process of precise leveling is based on the practice that it should be started and finished off from a known benchmark through a series of set-ups. The datum derived for these points is technically known as Reduced Levels.

FIELD EQUIPMENT

Below is the list of instruments used in carrying out Precise Leveling in the South Pacific Sea Level & Climate Monitoring Project Phase III:

1. Leica NA3003 Digital Level
2. Instrument Tripods
3. Leica Invar Leveling Starves
4. Leveling Struts
5. Ground Plates
6. 50m Measuring Tape
7. Electric Drill
8. Stainless Steel Rods
9. Aluminum Screws
10. Dropper Knocker
11. Spade
12. Crow Bar
13. Bench Mark PVC casing

REFERENCE

- Turner, S. M., 1996, ***Precise Vertical Survey Control Course***, National Tidal Facility, Adelaide, Australia.

ATTACHMENT 1 – Travel Itinerary

1. Monday 18th February 2002: Depart Suva (1500)
   Arrive Tonga (1735)

2. Tuesday 26th February 2002: Depart Tonga (2100)
   Arrive Nadi (2130)

3. Friday 8th March 2002: Depart Nadi (1500)
   Arrive Suva (1530)

ATTACHMENT 2 – Photographs

Andrick setting up the Invar bar coded starve on the benchmark at the NTF Tide Gauge stationed at Queen Salote Wharf in Nuku'alofa, Tonga.

Andrick and Brian carrying out the Precise Differential Leveling at the Kings Wharf in Lautoka.

Brian Ratcliff and Andrick Lal mixing concrete in a plastic sheet to establish a new benchmark in the FSC compound in Lautoka, Fiji Islands.

The NTF Tide Gauge stationed in the Ports Authority shed in Lautoka, Fiji Islands.