



Australian Government

Geoscience Australia

South Pacific Sea Level and Climate Monitoring
Project (SPSLCMP)

Survey Report

EDM Height Traversing
Levelling Survey

Cook Islands

June 2008

This project is sponsored by the Australian Agency for International Development (AusAID), managed by the Bureau of Meteorology (BOM) and supported by the National Geospatial Reference Systems Project, Geospatial Earth Monitoring Division, GEOSCIENCE AUSTRALIA.

Geocat # 69396



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Introduction

This survey report outlines the levelling survey completed during the most recent visit to Rarotonga, Cook Islands during 15 - 22 June 2008.

Personnel: Steve Yates – Surveyor - **GEOSCIENCE AUSTRALIA**
Andrick Lal – Surveyor - **SOPAC**

This is the third EDM Height Traversing levelling survey of the deep driven bench mark array in Rarotonga, Cook Islands. These surveys follow the eight previous surveys from 1993 to August 2004, undertaken by the National Tidal Centre (NTC) using the Precise Differential Levelling technique.

The Survey

The EDM Height Traversing levelling survey was carried out between the 6 deep driven Bench Marks (BM):

BM26

BM27

BM28

BM33

BM34

BM35

Included in the survey is the CGPS Station bench mark, **CKISBM**, the SEAFRAME Sensor Bench Mark **COO56**, located at the Tide Gauge and **COO10**, the project plaque also located at the Tide Gauge.

The local Survey Department bench mark **BM18**, located across the road from the Tide Gauge, was found and included in the 2008 survey.

All the deep driven BM's were located and found undisturbed and in good order. Two Holding marks were established during this visit – **COO100** and **COO101** which consists of stainless steel bolts drilled in concrete and then glued in place with quality epoxy resin.

The EDM Height Traversing levelling technique was performed to the Class L2A, as per the Inter-Government Committee on Surveying and Mapping (ICSM), Standards and Practices for Control Surveys, SP1, Ver. 1.5, May 2002.



After reduction an internal precision of $1\text{mm} \sqrt{K}$ or better was achieved, where K is distance levelled in kilometres. The results are found to be well within the Project Specification requirement of $2\text{mm} \sqrt{K}$

Bench Mark Locality Map





The Cook Islands Datum

The Datum for the survey is Mean Sea Level (MSL).

Reduction of the data has been calculated holding BM27 fixed at 4.7407740 metres.

This value was determined by the NTC in 1998.

Equipment

LEICA Total Station Model TCA1800 (S/N 424936).

LEICA Precision Prisms GPH1P (2).

LEICA Rigid Tripod.

Stainless Steel Target Poles supported by LEICA telescopic Bi-Poles (2).

LEICA Cast Iron Change Plates (2).

KESTRAL 4000 Pocket Weather Tracker



Method

“Leap-Frog” EDM-Height-Traversing: “Leap-Frog” EDM-Height-Traversing involves the one target remaining at a particular change point for both sightings. To avoid the possibility of the target being placed on a different point the target is not moved between the back-sight and foresight. Two target/reflectors are employed (on reflector rods with struts). As in spirit levelling, it is imperative that the electronic tacheometer (total station) is set up in the middle between the two reflectors. Recorded are the height differences (between the instrument’s trunnion axis and the reflector) that are computed by the electronic tacheometers. In consequence, the ambient temperature and pressure must be input into the instrument since the slope distances must be corrected for temperature and pressure (first velocity correction) on-line. See Rüeger & Brunner (1982) and *The Canadian Surveyor*, 36(1): 69-87.

All observations were recorded digitally.

Reduction of the digital data was computed by the Geoscience Australia levelling program “leveling1.exe”

This program computes the height difference between the two reflectors at any one set-up. Results can also be gained with the EDM Height Traversing method by using a single set-up / single rod configuration. To achieve height differences when using this single rod configuration, a simple comment line is added, indicating this is the case before running the program.

This “single set-up / single rod” configuration is particularly useful when levelling between bench marks which are close together e.g. between the Project Plaque BM and the SEAFRAME Sensor BM.

All levelling bays started and finished with the same reflector and reflector rod, ie an even number of setups when the two reflector rod configuration was used – this eliminates any reflector rod zero error.

Atmospheric readings were obtained using a KESTRAL 4000 Pocket Weather Tracker. These atmospheric readings were recorded manually onto the Cook Islands Levelling Booking Sheets and entered into the Total Station prior to each level run and approximately every hour thereafter or when ever an obvious change in weather conditions was observed.



Survey Support

The survey team very much appreciated the assistance from Lands and Survey Department (Ministry of Works) and the Meteorological Department.

Personnel consulted during the visit were:

Mr. Atatoa Herman	Secretary, Ministry of Works
Keu Mataora	Director, Ministry of Works
Mr. Timoti Tangirua	Project Officer, Ministry of Works
Mr. Vaipo Matoara	GIS, Ministry of Works

Mr Arona Ngari, Director of the Cook Islands Meteorological Office was away during this visit.

Both departments have a keen interest in the SPSLCMP and are always supportive with any associated project matters.

Issues

No issues or concerns of note were encountered during the 2008 visit.

However, it is worth mentioning the level of security at the airport has increased and it is advisable to arrange access and security passes to the airport area prior to arrival in Cook Islands. This can be done through personnel from Ministry of Works.



Description of Marks - RAROTONGA, COOK ISLANDS

BM 27 is the bench mark held fixed with **RL = 4.7407440 metres**

The height of **BM27** was derived by NTC by:

1993 Adopting the **MSL** height of **BM 18** for the 1993 survey. RL = 3.618m MSL

1998 Adopting the MSL height of **BM27** as derived from the 1993 survey. RL = 4.7407740m MSL.

Bench Marks:

BM26, BM33, BM27, BM34, BM28 and BM35 are all Deep Driven BM's

Points:

BM18 – a local Survey Department Bench Mark.

COO56 – the SEAFRAME Sensor Bench Mark.

COO10 – the Project Plaque point.

CKISBM – the Reference Bench Mark for the CGPS Pillar.

CKIS – the CGPS mark.

RM1, RM2 and RM3 are Deep Driven reference marks for monitoring local movement around the CGPS mark

All other points used with the prefix of **COO** are holding marks.



Table of Results for 2008 and Comparison between 2007 - 2008

Cook Islands 2008 - EDM Height Traversing Levelling Comparison 2007 - 2008 and Table of Results

BM27 - Adopted fixed height (MSL) 4.740744

FROM	TO	Levelled Height Difference	Reduced Level 2008	Misclose (mm)	Distance (Km)	1mm√K	Reduced Level 2007	Difference (mm) 2007 - 2008
BM27	BM33	-1.28013	3.46062	-0.100	0.210	0.458	3.46030	-0.00032
BM33	BM18	0.13586	3.59648	0.300	0.228	0.477	3.61010	0.01362
BM18	COO10	-2.04913	1.54736	0.025	0.048	0.219	1.54730	-0.00006
COO10	COO56	1.13461	2.68197	-0.025	0.017	0.130	2.68310	0.00113
COO10	BM26	0.59813	2.14548	0.000	0.086	0.293	2.14610	0.00062
BM27	COO77	0.13095	4.87169	-0.175	0.186	0.431	4.87230	0.00061
COO77	COO92	0.30106	5.17275	0.012	0.126	0.355	5.17270	-0.00005
COO92	COO100	-0.17694	4.99581	0.200	0.208	0.456	<i>New Mark established in 2008</i>	
COO100	BM34	-0.34328	4.65254	-0.050	0.046	0.214	4.65430	0.00176
BM34	COO84	-1.16676	3.48578	0.137	0.191	0.437	<i>Not Levelled in 2007</i>	
COO84	BM28	-0.29003	3.19575	-0.087	0.125	0.354	3.19760	0.00185
BM28	BM35	0.16981	3.36556	0.087	0.144	0.379	3.36770	0.00214
BM35	COO85	0.39115	3.75670	0.050	0.171	0.414	3.75910	0.00240
COO85	COO101	-0.63647	3.12024	0.362	0.148	0.385	<i>New Mark established in 2008</i>	
COO101	CKISBM	0.13327	3.25350	0.087	0.074	0.272	3.25610	0.00260

Precision for all bays levelled 1mm√K

Allowable Misclose is 2mm√K

An internal precision of 1mm√K was achieved for all bays levelled - this is well within the Project Specification of 2mm√K



Combined Comparisons 1993 to 2008

COOK ISLANDS - Comparison of RL's for Precise Differential Levelling (1993 - 2004) and EDM Height Traversing (2004 - 2008)

YEAR	MARK										CKISBM
	BM 18	BM 26	BM 27	BM 28	BM 29	BM 33	BM 34	BM 35	COO 10	COO 56	
1993	3.6180	2.1587	4.7407	3.1986	2.6141				1.5487		
1994	3.6170	2.1564	4.7407	3.1973	2.6121				1.5484		
1996	3.6156	2.1549	4.7407	3.1980	2.6132				1.5481		
1998	3.6155	2.1539	4.7407	3.1978	2.6133				1.5489	2.6843	
1999	3.6147	2.1523	4.7407	3.1974	2.6121				1.5484	2.6844	
2001	3.6181	2.1545	4.7407	3.1976	2.6134	3.4606	4.6542	3.3664	1.5518	2.6904	
2002	3.6147	2.1499	4.7407	3.1984	2.6131	3.4615	4.6555	3.3680	1.5485	2.6867	3.2560
2004	3.6131	2.1474	4.7407	3.1971		3.4615	4.6555	3.3680	1.5472	2.6855	3.2547
2004 EDM		2.1487	4.7407	3.1972		3.4609	4.6546	3.3671	1.5481	2.6864	3.2562
2007 EDM	3.6101	2.1461	4.7407	3.1976		3.4603	4.6543	3.3677	1.5473	2.6831	3.2561
2008 EDM	3.5965	2.1455	4.7407	3.1958		3.4606	4.6525	3.3656	1.5474	2.6820	3.2535



Cook Islands 2008 Reduced Levels

Date: 14 – 21 June 2008

Datum: Mean Sea Level

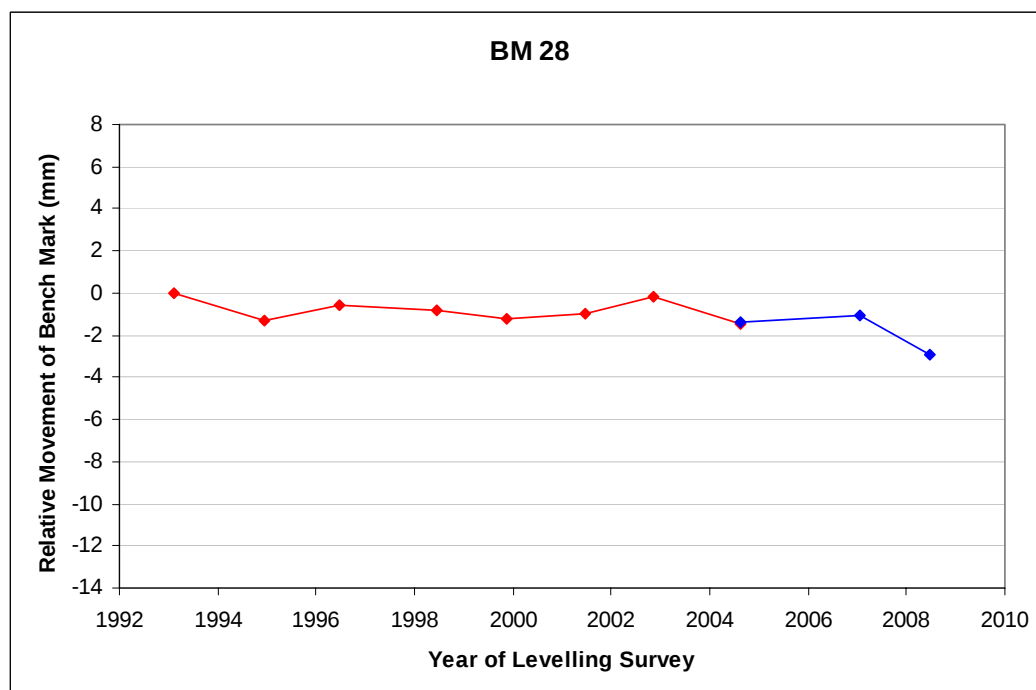
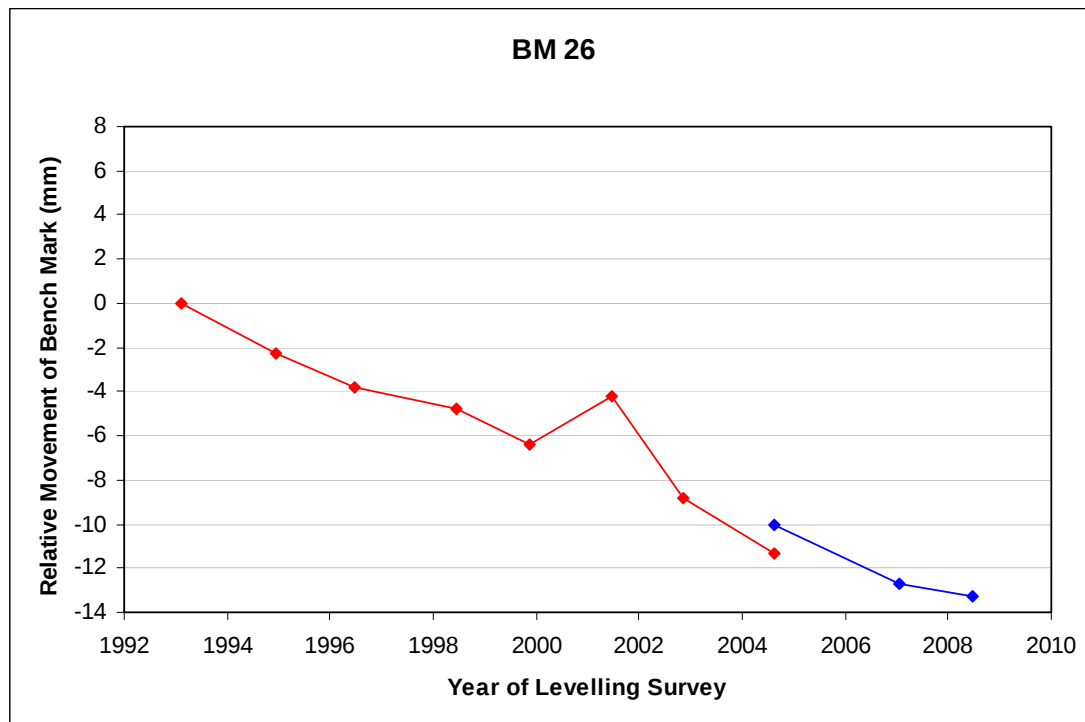
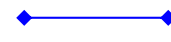
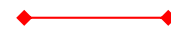
POINT#	2008 levelled diff. ht.	2008 RL
<u>BM27</u>		<i>4.7407440 (fixed)</i>
BM33	-1.28013	3.46062
BM18	+0.13586	3.59648
COO10	-2.04913	1.54736
COO56	+1.13461	2.68197
COO10		1.54736
BM26	+0.59813	2.14548
<u>BM27</u>		<i>4.7407440 (fixed)</i>
COO77	+0.13095	4.8717
COO92	+0.30106	5.1728
COO100	-0.17694	4.9958
BM34	-0.34328	4.6525
COO84	-1.16676	3.4858
BM28	-0.29003	3.1958
BM35	+0.16981	3.3656
COO85	+0.39115	3.7567
COO101	-0.63647	3.1202
CKISBM	+0.13327	3.2535
CKIS	+1.26191	4.5154
CKISBM		3.2535
RM1	-0.61975	2.6338
RM2	-0.19870	2.4441
RM3	+0.36286	2.8069

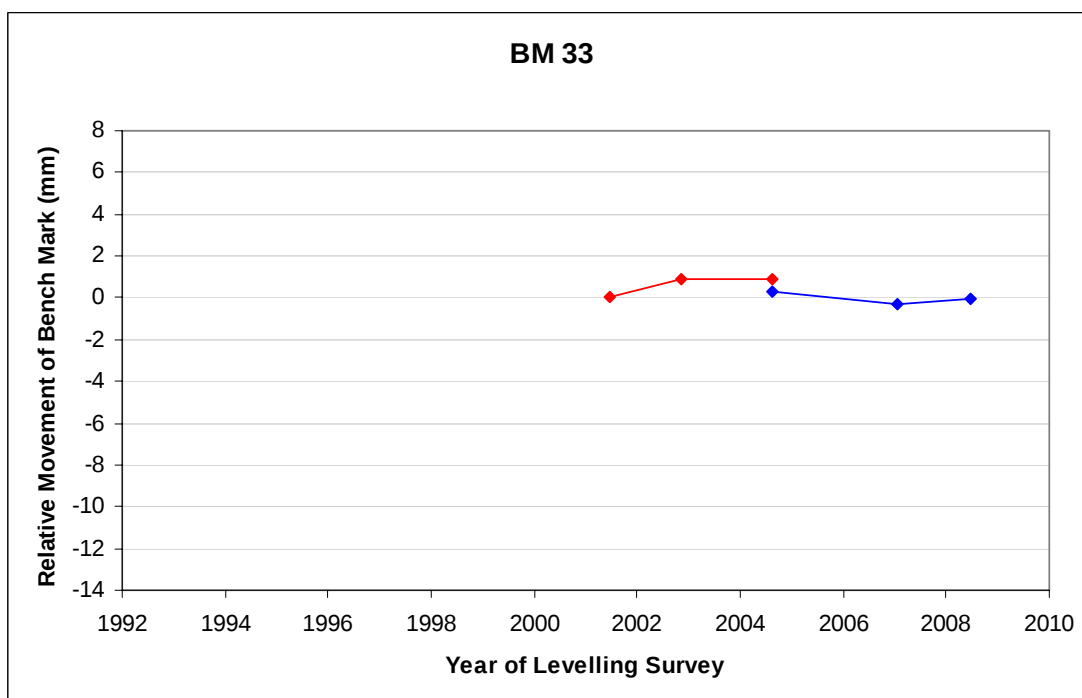
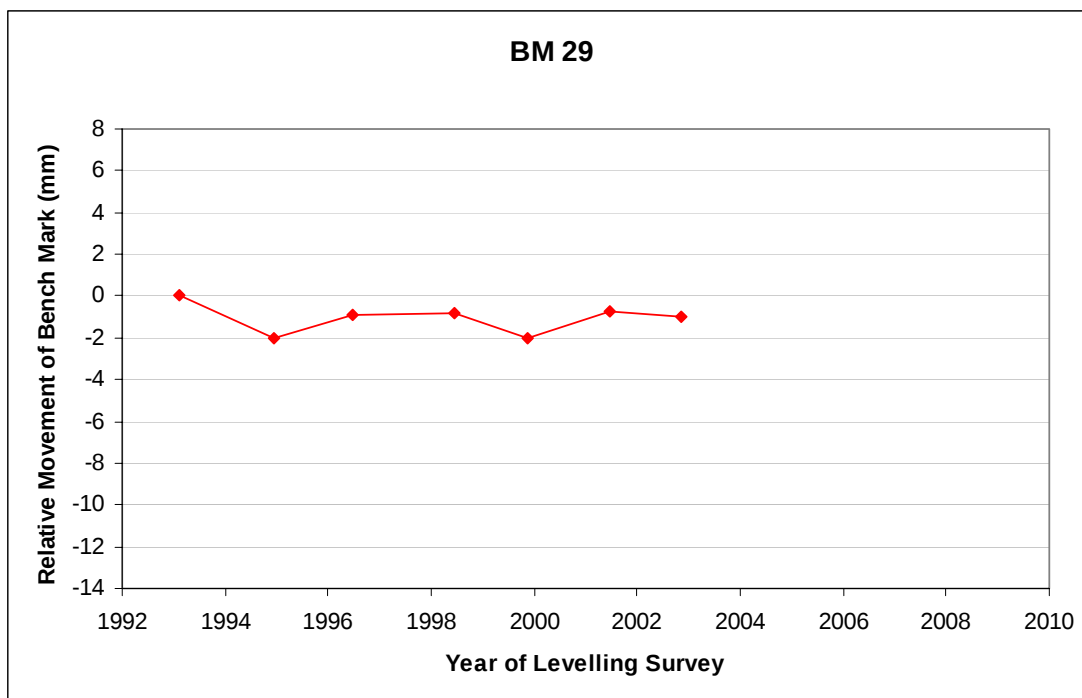


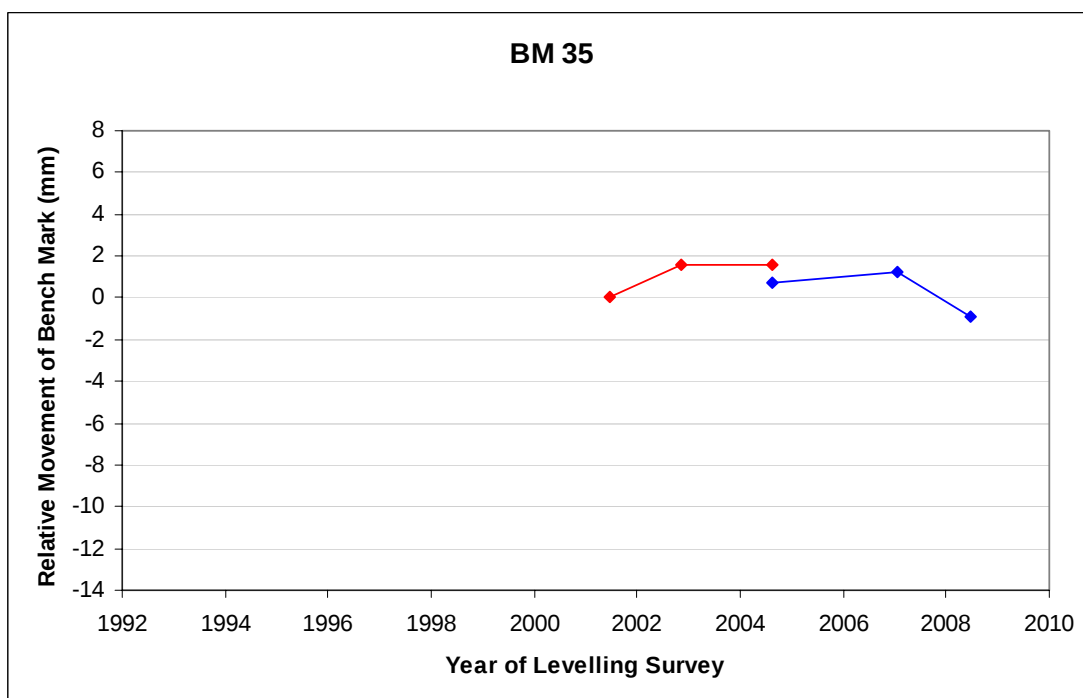
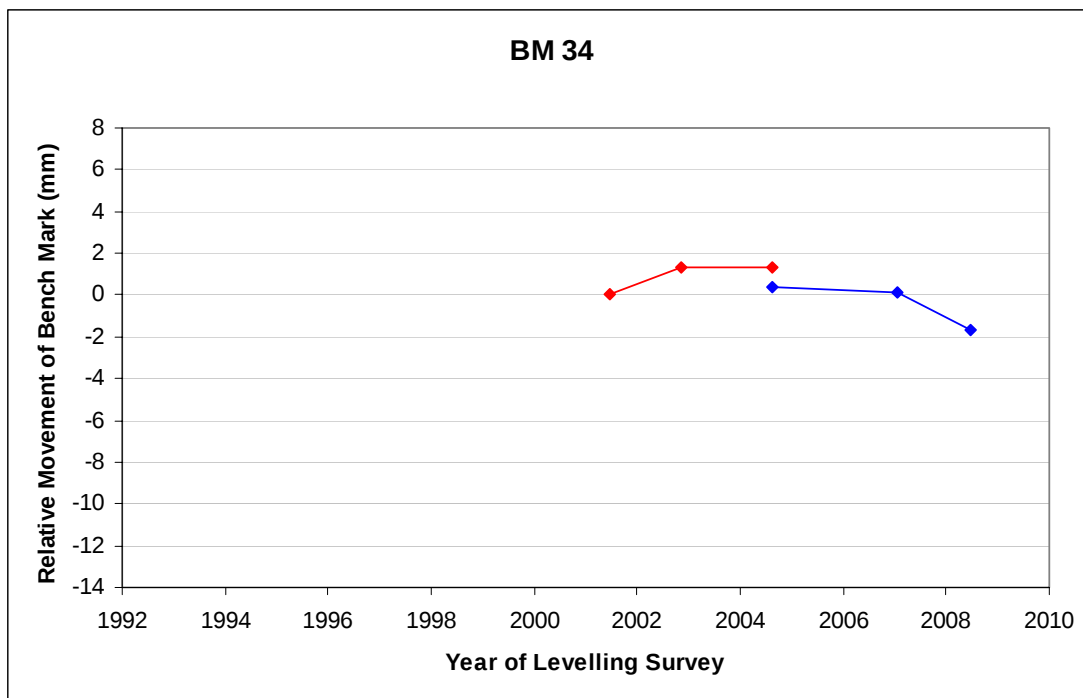
Time Series of Bench Mark movement relative to the Fixed Deep Bench Mark - BM 27

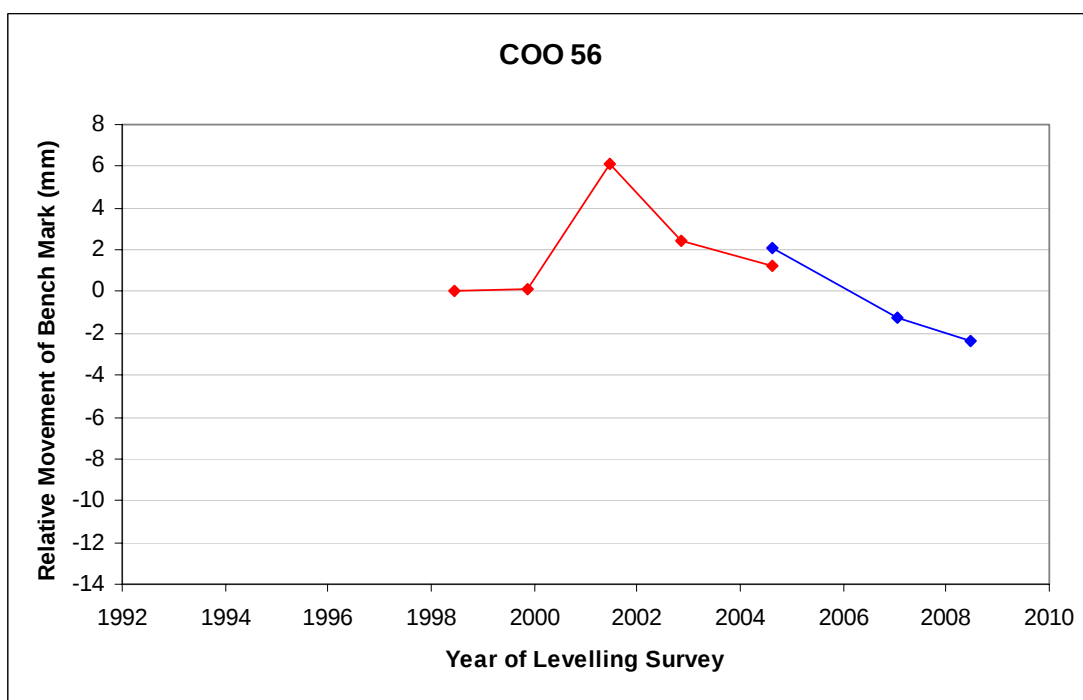
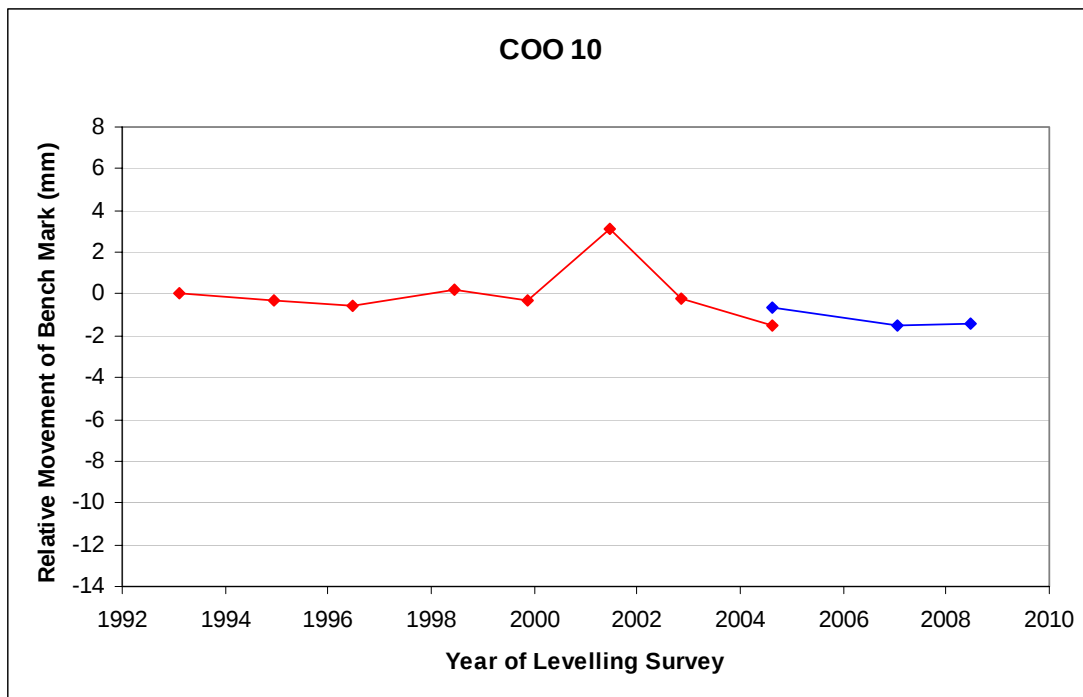
Precise Differential Levelling - 1993 to 2002 (2004)

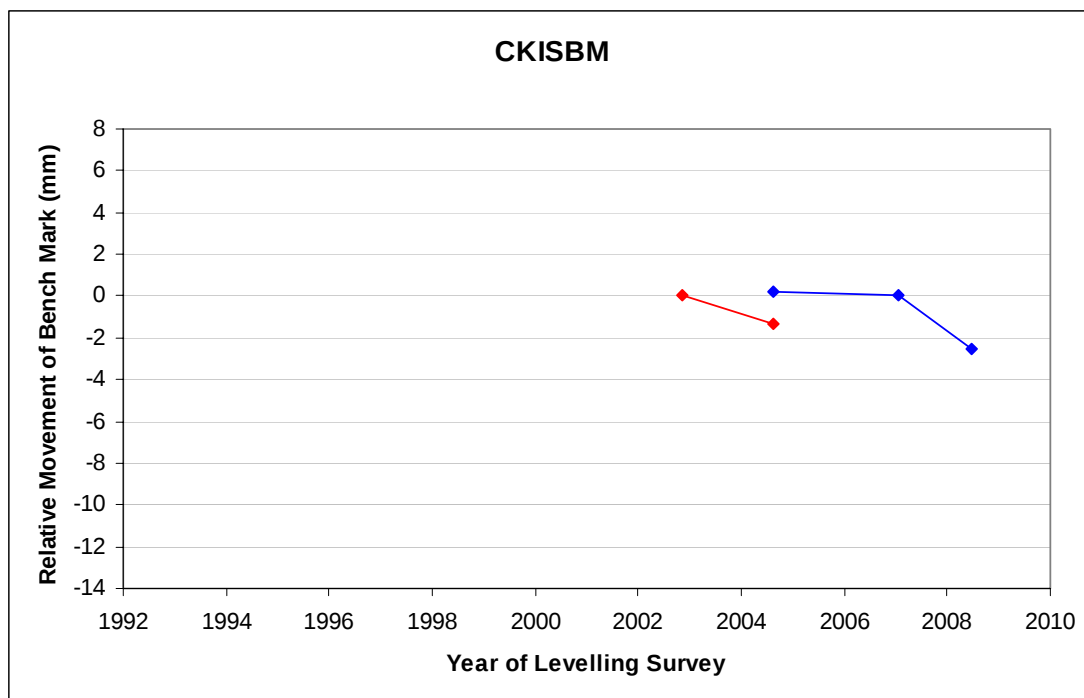
EDM Height Traversing - commenced 2004











Deep Bench Mark Locality Diagrams



**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: BM26

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	Date: 03-12-91
Existing Bench Mark Established by:	Date:
Notes / References: Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.	
Country: Cook Islands Island: Rarotonga	City: Avatiu
<u>Marking and locality sketch</u> Bench Mark: 11.0m of 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 0.6m. Top of mark 0.2m below ground level. Locality sketch: Mark approximately 50m from the tide gauge station.	

Not to scale Distances in Metres Magnetic bearings	
Approved by: Geoscience Australia / SOPAC	
Date: January 2007 c:\users\andrick\sos\comp\local\tydiaagrams\cooks	




SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT



Survey Bench Mark Record

Bench Mark Number: BM27

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA. Date: 03-12-91

Existing Bench Mark Established by: Date:

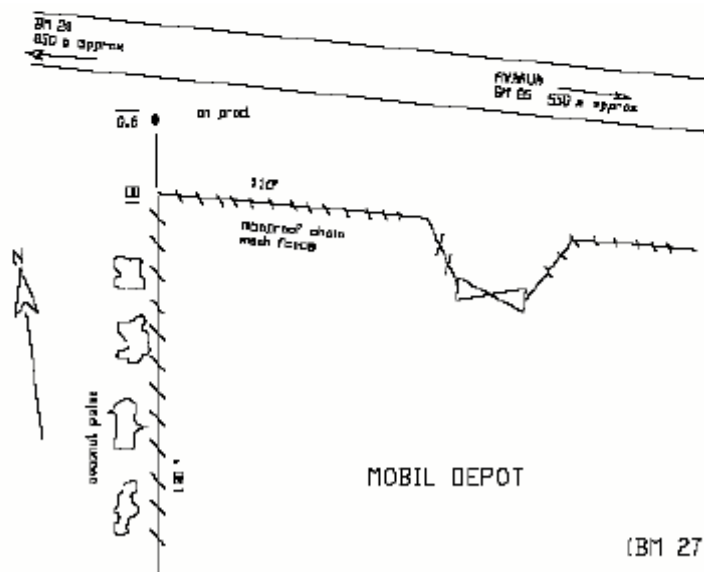
Notes / References: Deep Survey Benchmark
This survey mark is in a good locality for GPS occupation.

Country: Cook Islands
Island: Rarotonga City: Avatiu

Marking and locality sketch

Bench Mark: 5.0m of 19mm diameter stainless steel capped rod driven to refusal.
Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 0.4m. Top of mark 0.2m below ground level.

Locality sketch: Mark approximately 550m from the tide gauge station.



Not to scale Distances in Metres Magnetic bearings

Approved by: Geoscience Australia / SOPAC

Date: January 2007

c:\users\andrick\spslomp\localitydiagrams\cooks





SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT



Survey Bench Mark Record

Bench Mark Number: BM28

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA. Date: 03-12-91

Existing Bench Mark Established by: Date:

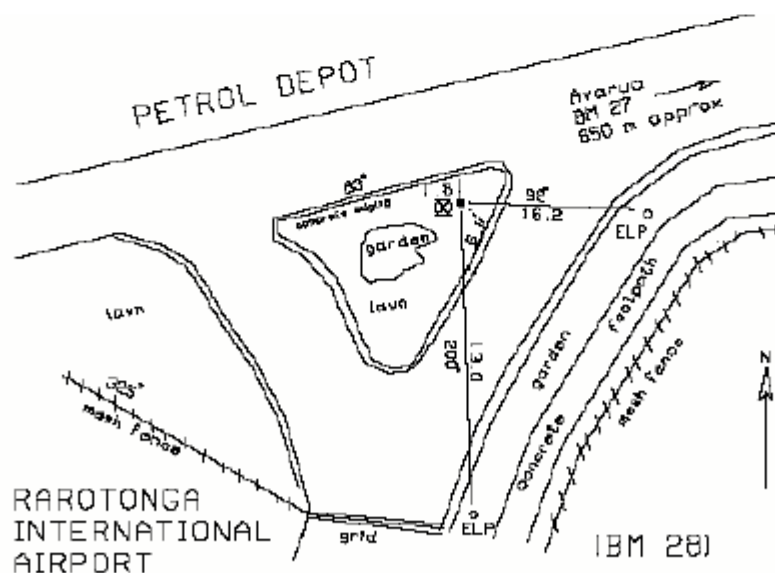
Notes / References: Deep Survey Benchmark
This survey mark is in a good locality for GPS occupation.

Country: Cook Islands
Island: Rarotonga City: Avatiu

Marking and locality sketch

Bench Mark: 2.6m of 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 0.5m. Top of mark 0.2m below ground level. ROD NOT DRIVEN TO REFUSAL

Locality sketch: Mark approximately 1400m from the tide gauge station.



Not to scale Distances in Metres Magnetic bearings

Approved by: Geoscience Australia / SOPAC Date: January 2007

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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT



Survey Bench Mark Record

Bench Mark Number: BM33

<i>Original Bench Mark Established by:</i> National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.		<i>Date:</i> 18-11-02
<i>Existing Bench Mark Established by:</i>		<i>Date:</i>
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.		
<i>Country:</i> Cook Islands <i>Island:</i> Rarotonga		<i>City:</i> Avatiu
<u>Marking and locality sketch</u> Bench Mark: 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 0.5m. Top of mark 0.2m below ground level. Locality sketch: Mark approximately 480m from the tide gauge station. CHURCH OF JESUS CHRIST OF LATTER-DAY SAINTS Lawn concrete base welcome sign 1.10 1.80 2.00 low white painted MAIN ENTRANCE Lawn concrete kerb ARA TAPU		
Not to scale	Distances in Metres	Magnetic bearings
Approved by: Geoscience Australia / SOPAC		Date: January 2007 c:\users\landrick\spslcomp\localitydiagrams\cooks





**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: BM34

<i>Original Bench Mark Established by:</i> National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	<i>Date:</i> 18-11-02
<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.	
<i>Country:</i> Cook Islands <i>Island:</i> Rarotonga	<i>City:</i> Avatiu
<u>Marking and locality sketch</u> Bench Mark: 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 0.5m. Top of mark 0.2m below ground level. Locality sketch: Mark approximately 1200m from the tide gauge station. The diagram is a locality sketch on a light pink background. At the top, the word 'CEMETERY' is written in bold. Below it, a horizontal line represents a road or path. To the left of this line is a 'low white painted' mark, indicated by a vertical line with a horizontal bar. To the right is a 'concrete wall' mark, indicated by a vertical line with a horizontal bar. Below the road line, there are two points marked with dots. The first point is labeled '0.47' and the second point is labeled '1.30'. At the bottom of the sketch, there are three labels: 'AIRPORT' on the left, 'ARA TAPU ROAD' in the center, and 'AVATIU' on the right, all underlined. Arrows point from the road line towards each of these three labels.	
Not to scale	Distances in Metres
Magnetic bearings	
Approved by: Geoscience Australia / SOPAC	
Date: January 2007 c:\users\andrick\spslcomp\localitydiagrams\cooks	





**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



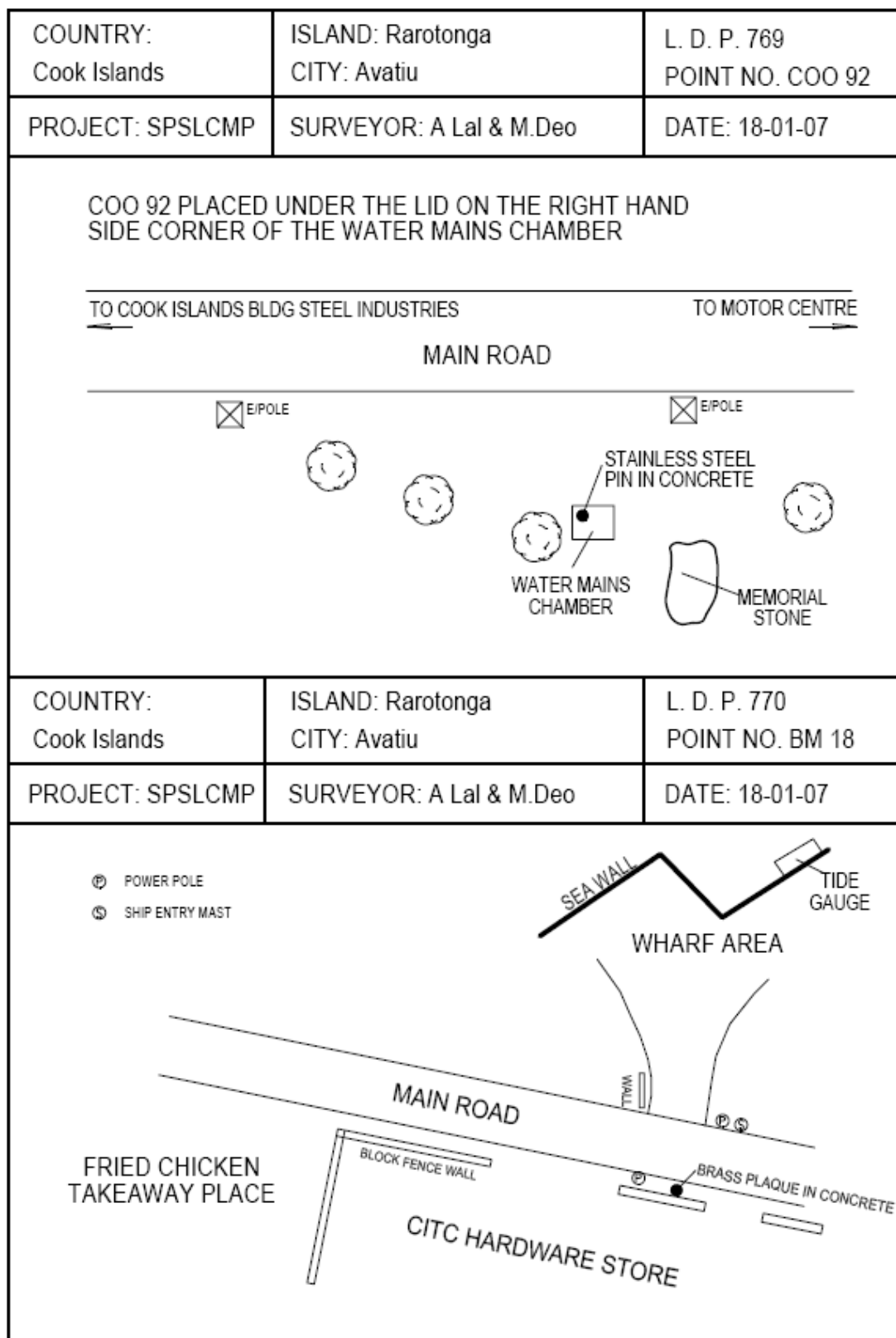
Survey Bench Mark Record

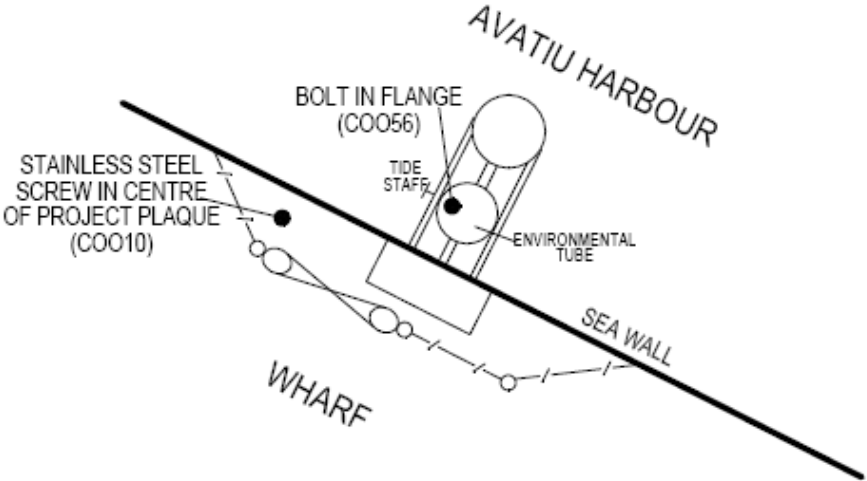
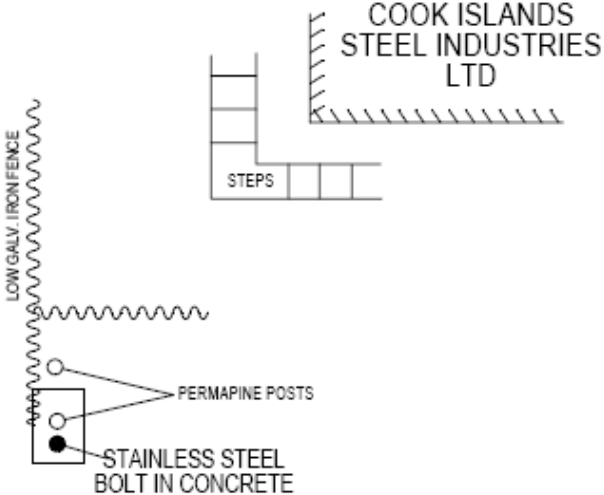
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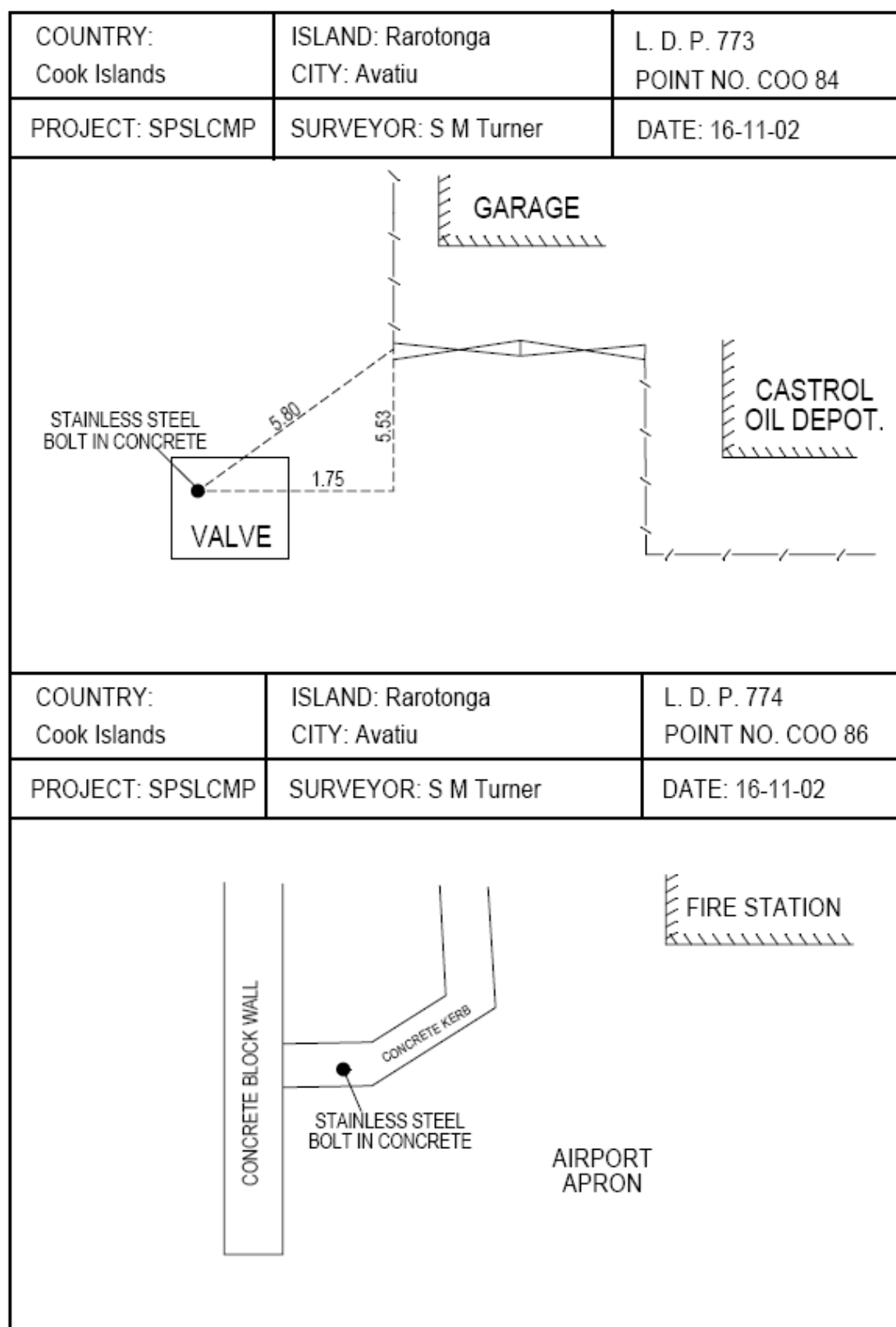
<i>Original Bench Mark Established by:</i> National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.		<i>Date:</i> 18-11-02
<i>Existing Bench Mark Established by:</i>		<i>Date:</i>
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.		
<i>Country:</i> Cook Islands <i>Island:</i> Rarotonga		<i>City:</i> Avatiu
<u>Marking and locality sketch</u> Bench Mark: 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 0.5m. Top of mark 0.2m below ground level. Locality sketch: Mark approximately 1500m from the tide gauge station. ARA TAPU Boundary Fence 0.66 0.66 1.2 GARDEN BED Bitumen Car Park COO8 Not to scale Distances in Metres Magnetic bearings Approved by: Geoscience Australia / SOPAC Date: January 2007 c:\users\andrick\spslcomp\localitydiagrams\cooks		



Permanent Holding Marks - Locality Diagrams



COUNTRY: Cook Islands	ISLAND: Rarotonga CITY: Avatiu	L. D. P. 771 POINT NO. COO 10 & 56
PROJECT: SPSLCMP	SURVEYOR: S M Turner	DATE: 11-02-93
		
COUNTRY: Cook Islands	ISLAND: Rarotonga CITY: Avatiu	L. D. P. 772 POINT NO. COO 77
PROJECT: SPSLCMP	SURVEYOR: S M Turner	DATE: 16-11-02
		



CKISBM and CKIS Reference Mark Locality Diagrams

COOK CGPS Station, Rarotonga – Reference Marks

REFERENCE MARKS

All RM's are capped 20 mm stainless steel rods driven to refusal and protected by 150 mm PVC pipe within circular poly carbonate valve boxes. The valve box lids are approximately 200mm below ground level.

