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Record 2014/30 | GeoCat 78481

EDM Height Traversing Levelling Survey Report

Funafuti, Tuvalu, July 2013

S. J. K. Yates, A. Lal

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GEOSCIENCE AUSTRALIA
RECORD 2014/30

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Australian Government
Geoscience Australia

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ISSN 2201-702X (PDF)

ISBN 978-1-925124-19-4 (PDF)

GeoCat 78481

Bibliographic reference: Yates S. J. K, Lal A., 2014. *EDM Height Traversing Levelling Survey Report, Funafuti, Tuvalu, July 2013*. Record 2014/30. Geoscience Australia, Canberra.

<http://dx.doi.org/10.11636/Record.2014.030>

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1 Introduction

This report outlines the high precision level survey completed between the Sea Level Fine Resolution Acoustic Measuring Equipment (SEAFRAME) tide gauge and the Continuous Global Navigation Satellite System (CGNSS) Station in Funafuti, Tuvalu from 18th – 25th July 2013.

Personnel involved in the survey were Steve Yates, Project Officer, Geoscience Australia and Andrick Lal, Surveyor, Secretariat of the Pacific Islands Community (SPC).

The Electronic Distance Measurement (EDM) Height Traversing levelling technique was employed to observe differences in height between the deep bench mark arrays in Funafuti, which runs approximately 4km from the tide gauge sensor to the CGNSS Station. Previous levelling surveys have been conducted along the route using this technique in 2005, 2007, 2009, 2010 and 2012.

In addition, precise differential levelling surveys were performed along the deep bench mark array from 1993 to 2005 by the National Tidal Centre Australia (NTCA) and the survey in 2005 included a comparison between the precise differential levelling and EDM height traversing technique. This report contains a comparison between the 2013 and 2012 EDM height traversing results as well as a combined comparison since the first levelling survey.

2 The Survey

The EDM height traversing levelling survey was carried out between the SEAFRAME tide gauge sensor, the CGNSS station and the deep driven bench mark array:

BM22	– reference deep driven bench mark
BM23	– deep driven bench mark
BM24	– deep driven bench mark
BM26	– deep driven bench mark
BM27	– deep driven bench mark
BM28	– deep driven bench mark
TUV19	– SEAFRAME sensor bench mark
TUV20	– SEAFRAME Project plaque bench mark
TUVABM	– reference bench mark for the GNSS pillar

Also included in the survey were temporary holding marks – TUV102, TUV42, TUV103, TUV44, TUV107, TUV104, TUV101, TUV105, TUV61, TUV48, TUV49, TUV74, TUV73, TUV106, TUV71 and TUV69.

The Continuous GNSS (CGNSS) Reference Point - TUVa and the two CGNSS Reference Marks - RM2 and RM3 were also levelled. Unfortunately RM1, CGNSS Reference Mark was removed from the ground due to excavation works otherwise all the deep bench marks were located and found in good order and undisturbed.

The EDM Height Traversing levelling technique was performed to the Class L2A specifications. After reduction an internal precision of $1\text{mm } \sqrt{K}$ or better was achieved, where K is distance in kilometres. This is well within the project specification of $2\text{mm } \sqrt{K}$. A table of results and comparisons and the 2013 reduced levels are detailed later in this report.

2.1 Bench Mark Locations – Funafuti



2.2 The Tuvalu Datum

The Datum for the survey is the University of Hawaii Tide Staff Zero (TSZ).

Reduction of the data has been calculated holding BM22 fixed at 3.22540 metres TSZ, this value was determined by the NTCA in 1993 by:

Adopting the height of UH 1 (RL = 3.0072 metres TSZ)

Adopting the height of BM22 as derived from the 1993 survey (RL = 3.22540 metres)

2.3 Equipment

- LEICA total station model TCA2003 and TM30 (Serial No: 361441)
- LEICA precision prisms GPH1P (2)
- LEICA rigid tripod
- Stainless steel target poles supported by LEICA telescopic bi-poles (2)
- Shortened stainless steel target pole for the SEAFRAME sensor BM connection
- LEICA cast iron change plates (2)
- KESTRAL 4000 pocket weather tracker

2.4 Method

The “Leap-Frog” EDM height traversing technique was employed for the Funafuti tide gauge levelling survey. This technique involves setting up a total station (TCA1800L) midway between two target/reflectors (on reflector rods with struts). The targets remain at a particular change point for the back-sight and fore-sight observations. The instrument measures slope distances ($\pm 1\text{mm}$) and vertical angle ($1''$) to derive height differences (between the instrument’s trunnion axis and the reflectors). In support of the slope distance observations, the ambient temperature, pressure and humidity are recorded (Kestral 4000 pocket weather tracker) and input into the instrument to apply the first velocity correction to the observed distances (Rüeger & Brunner, 1982). Four rounds of observations are taken to the back-sight and fore-sight targets from each instrument setup. All levelling runs started and finished with the same reflector and reflector rod, i.e. an even number of setups when the two reflector rod configuration was used. This eliminates any reflector rod zero error. This technique can also be performed using a single set-up / single rod configuration which is particularly useful when levelling between bench marks which are close together e.g. between the CGNSS RMs.

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.

2.5 Tuvalu 2013 Reduced Levels

Table 2.1 Funafuti, Tuvalu – Reduced levels 2013 survey

Date: 18 – 25 July 2013

Datum: TSZ (1993)

Point ID	Reduced Level 2013	Type
BM22	3.2254	Stainless Steel Rod in Ground
TUV102	3.7604	Stainless Steel Pin in Concrete
TUV42	3.7605	Stainless Steel Pin in Concrete
TUV103	3.5773	Stainless Steel Pin in Concrete
TUV19	3.4893	Stainless Steel Pin in Concrete
TUV20	4.4585	Stainless Steel Pin
TUV44	3.3249	Stainless Steel Pin in Concrete
TUV107	2.7287	Stainless Steel Pin in Concrete
BM23	3.1372	Stainless Steel Rod in Ground
TUV104	2.9832	Stainless Steel Pin in Concrete
TUV101	3.0905	Stainless Steel Pin in Concrete
TUV105	2.8240	Stainless Steel Pin in Concrete
TUV61	2.8766	Stainless Steel Rod in Ground
TUV48	3.0606	Stainless Steel Pin in Concrete
TUV49	3.2472	Stainless Steel Pin in Concrete
TUV74	2.5841	Stainless Steel Pin in Concrete
BM24	3.7955	Stainless Steel Rod in Ground

Point ID	Reduced Level 2013	Type
TUV73	2.2977	Stainless Steel Pin in Concrete
TUV106	2.2070	Stainless Steel Pin in Concrete
TUV71	2.2400	Stainless Steel Pin in Concrete
BM28	2.2160	Stainless Steel Rod in Ground
TUV69	2.2144	Stainless Steel Pin in Concrete
BM27	2.2154	Stainless Steel Rod in Ground
TUVABM	2.7413	Stainless Steel Pillar Pin
*TUVA	3.7045	Pillar Plate (ARP)
P-S	2.4176	Top of Tuvalu Met. Office Pressure Sensor
BM26	3.1072	Stainless Steel Rod in Ground
TUVARM2	2.1584	Stainless Steel Rod in Ground
TUVARM3	1.9312	Stainless Steel Rod in Ground

**The RL of the Reference Point TUVA (ARP) is derived from adding the static height difference of 0.9631m (TUVABM to TUVA) to the 2013 levelled RL of TUVABM.*

2.6 Survey Support

Due to a recent change in field procedures, field survey technician, Samisoni Finikaso, was hired to carry the Leica total station in the carry case during the survey. This was arranged through the kind assistance of Mr Fa’atasi Malologa, Director – Lands and Survey.

The Director of Tuvalu Meteorological Service, Ms Hilia Va’ave and her staff provided valuable support during our visit.

2.7 Issues

Please note that due to fewer flights and unreliable air freight services for cargo to Funafuti, it is advisable to pre-book two (2) cargo seats for the survey equipment to and from Funafuti as DHL cannot guarantee the air freight to arrive.

RM1 was found to be destroyed therefore in the next survey visit; it has to be replaced with a new Reference Mark 4.

2.8 Description of Marks – Funafuti, Tuvalu

- BM22 – reference deep driven bench mark (within Catholic Church Compound)
- BM23 – deep driven bench mark (along the road on lagoon side)
- BM24 – deep driven bench mark (on the north end of airport runway)
- BM26 – deep driven bench mark (on south corner of Vaiaku Lagi Hotel)
- BM27 – deep driven bench mark (within airport compound)
- BM28 – deep driven bench mark (in front of Mosque)

- TUV19 – SEAFRAME sensor bench mark (on the old wharf)
- TUV20 – SEAFRAME Project plaque bench mark (on the old wharf)
- TUVABM – reference bench mark for the CGNSS pillar (within meteorology compound)
- TUVA RM2 – CGNSS Pillar reference bench mark (within meteorology compound)
- TUVA RM3 – CGNSS Pillar reference bench mark (within meteorology compound)
- TUVA – CGNSS Pillar bench mark (within meteorology compound)

Holding pins along survey route from tide gauge to CGNSS (as listed previously) are all stainless steel bolts, drilled in concrete and glued in place.

3 Comparisons

3.1 Comparisons between 2013 and 2012 EDM Surveys

Table 3.1 Results of Funafuti, Tuvalu 2013 EDM Height Traversing Comparison 2013 – 2012. BM22 - adopted fixed height of 3.22540m

From	To	Levelled Ht. Diff.	RL 2013	Misclose (mm)	Dist. (km)	1mm/k	RL 2012	Difference (mm) 2013 - 2012
BM22			3.2254					
TUV102	TUV102	0.5350	3.7604	0.389	0.207	0.455	3.7613	-0.93
TUV42	TUV42	0.0001	3.7605	-0.301	0.119	0.344	3.7612	-0.69
TUV103	TUV103	-0.1832	3.5773	-0.231	0.157	0.397	3.5768	0.55
TUV19	TUV19	-0.0881	3.4893	-0.176	0.082	0.286	3.4881	1.18
	TUV20	0.9693	4.4585	0.051	0.013	0.114	4.4576	0.94
BM22			3.2254					
TUV44	TUV44	0.0995	3.3249	-0.342	0.190	0.436	3.3255	-0.62
TUV107	TUV107	-0.5961	2.7287	-0.150	0.119	0.345	New Mark	New Mark
BM23	BM23	0.4085	3.1372	0.103	0.181	0.426	3.1381	-0.89
TUV104	TUV104	-0.1540	2.9832	0.403	0.177	0.420	2.9844	-1.20
TUV101	TUV101	0.1073	3.0905	-0.345	0.199	0.446	3.0911	-0.62
TUV105	TUV105	-0.2664	2.8240	-0.430	0.215	0.463	2.8241	-0.07
TUV61	TUV61	0.0525	2.8766	-0.006	0.111	0.333	2.8767	-0.13
TUV48	TUV48	0.1841	3.0606	-0.011	0.119	0.344	3.0603	0.35
TUV49	TUV49	0.1866	3.2472	0.065	0.161	0.401	3.2470	0.23
TUV74	TUV74	-0.6631	2.5841	0.164	0.085	0.291	2.5838	0.35
	BM24	1.2113	3.7955	0.097	0.108	0.329	3.7955	-0.01
TUV74			2.5841					
TUV73	TUV73	-0.2865	2.2977	0.308	0.201	0.449	2.2980	-0.33
TUV106	TUV106	-0.0907	2.2070	0.353	0.199	0.446	2.2074	-0.39
TUV71	TUV71	0.0330	2.2400	-0.055	0.099	0.315	2.2414	-1.35
BM28	BM28	-0.0240	2.2160	0.074	0.106	0.326	2.2161	-0.08
TUV69	TUV69	-0.0016	2.2144	0.046	0.205	0.453	2.2154	-0.96
BM27	BM27	0.0009	2.2154	0.136	0.152	0.389	2.2161	-0.72
TUVABM	TUVABM	0.5260	2.7413	-0.045	0.144	0.379	2.7418	-0.46
	P-S	-0.3237	2.4176	0.177	0.035	0.186	New Mark	New Mark
BM27			2.21538					

From	To	Levelled Ht. Diff.	RL 2013	Misclose (mm)	Dist. (km)	1mm√k	RL 2012	Difference (mm) 2013 - 2012
	BM26	0.89183	3.10722	-0.124	0.121	0.347	3.1077	-0.48
			Misclose for all bays levelled =	0.149	3.504	1.872		

All levelling was performed within the project specifications of 2 √k

From	To	Levelled Ht. Diff.	RL 2013	Misclose (mm)	Dist. (km)	1mm√k	RL 2012	Difference (mm) 2013 - 2012
TUVABM			2.74134					
	RM2	-0.58289	2.15845	-0.039	0.047	0.217	2.159	-0.55
TUVABM			2.74134					
	RM3	-0.81016	1.93117	-0.001	0.057	0.239	1.932	-0.83

All levelling was performed within the project specifications of 2 √k

3.2 Combined Comparisons

Examination of the level survey results do not show any significant changes in reduced levels from the 2013 survey. All indications show that no immediate or significant displacement of any of the deep driven bench marks has occurred.

Table 3.2 Funafuti, Tuvalu – Deep Bench Mark final RL's for Precise Differential Levelling (1993 - 2005) and EDM Height Traversing (2005 - 2013).

Year	BM22	BM23	BM24	BM26	BM27	BM28	TUVABM	TUV19	TUV20
1993.21	3.2254	3.1385	3.7982					3.4813	4.4599
1994.46	3.2254	3.1394	3.7968					3.4826	4.4603
1995.46	3.2254	3.1392	3.7972					3.4833	4.4609
1997.96	3.2254	3.1387	3.7958					3.4834	4.4608
1998.54	3.2254	3.1383	3.7953					3.4848	4.4615
2000.13	3.2254	3.1386	3.7951					3.4842	4.4600
2001.63	3.2254	3.1390	3.7952					3.4848	4.4599
2003.38	3.2254	3.1391	3.7960	3.1099	2.2165		2.7414	3.4851	4.4593
2005.63	3.2254	3.1386	3.7959	3.1102	2.2176		2.7425	3.4864	4.4592

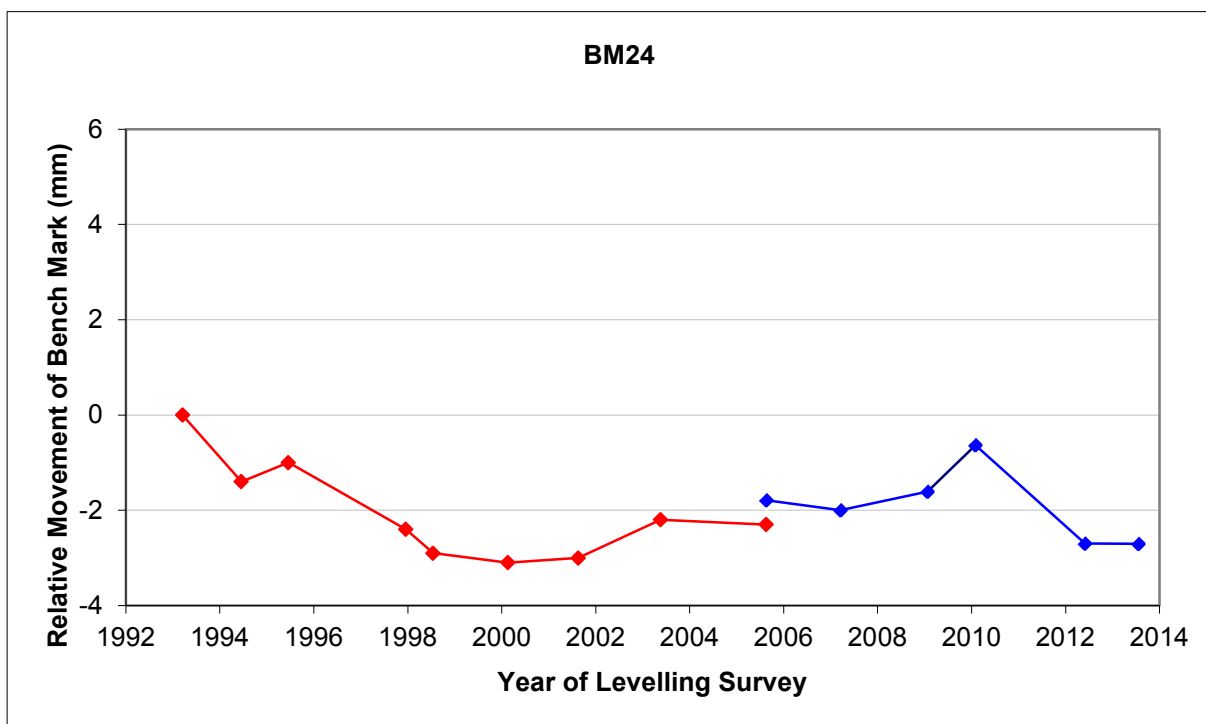
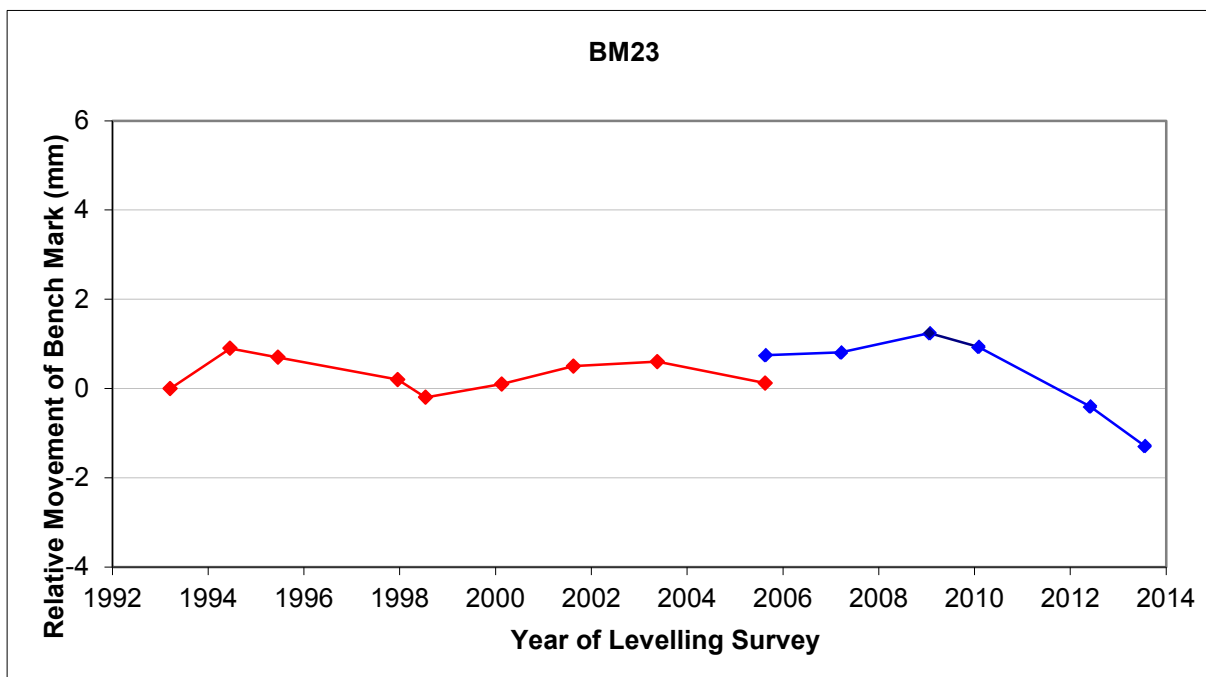
Year	BM22	BM23	BM24	BM26	BM27	BM28	TUVABM	TUV19	TUV20
2005.63	3.2254	3.1393	3.7964	3.1099	2.2177		2.7432	3.4867	4.4593
2007.21	3.2254	3.1393	3.7962	3.1079	2.2157		2.7407	3.4879	4.4596
2009.06	3.2254	3.1397	3.7966	3.1082	2.2162	2.2171	2.7418	3.4877	4.4588
2010.08	3.2254	3.1394	3.7976	3.1108	2.2184	2.2188	2.7442	3.4889	4.4592
2012.41	3.2254	3.1381	3.7955	3.1077	2.2161	2.2161	2.7418	3.4881	4.4576
2013.55	3.2254	3.1372	3.7955	3.1072	2.2154	2.2160	2.7413	3.4893	4.4585

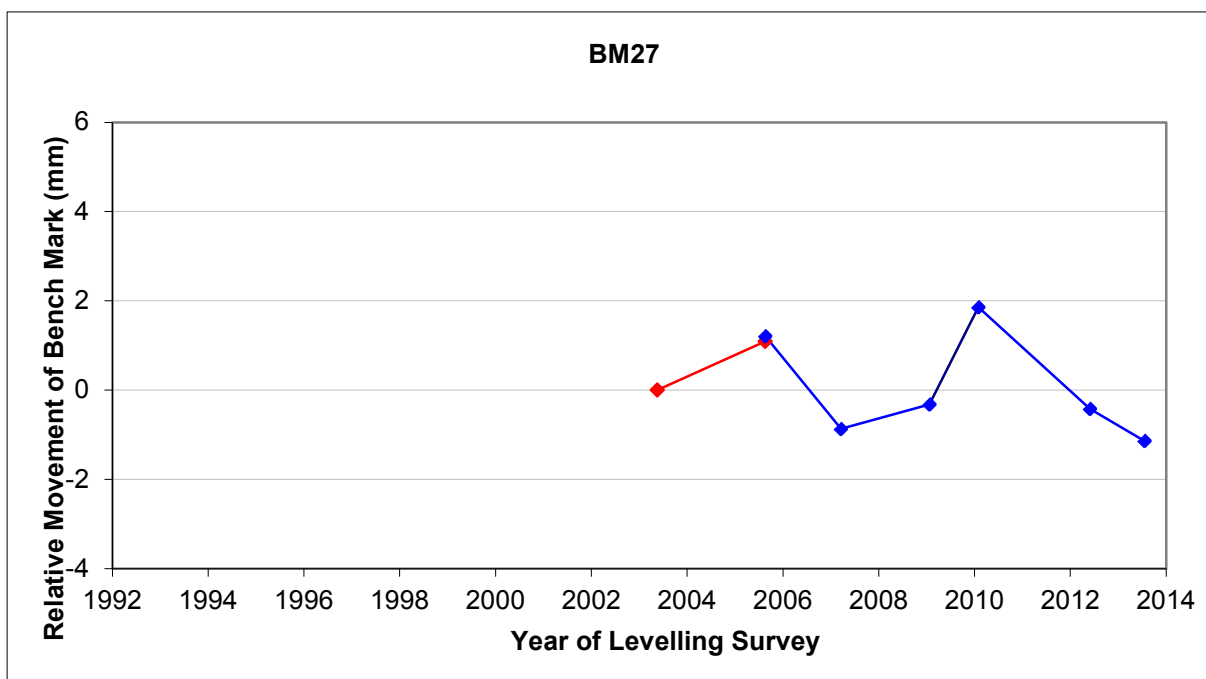
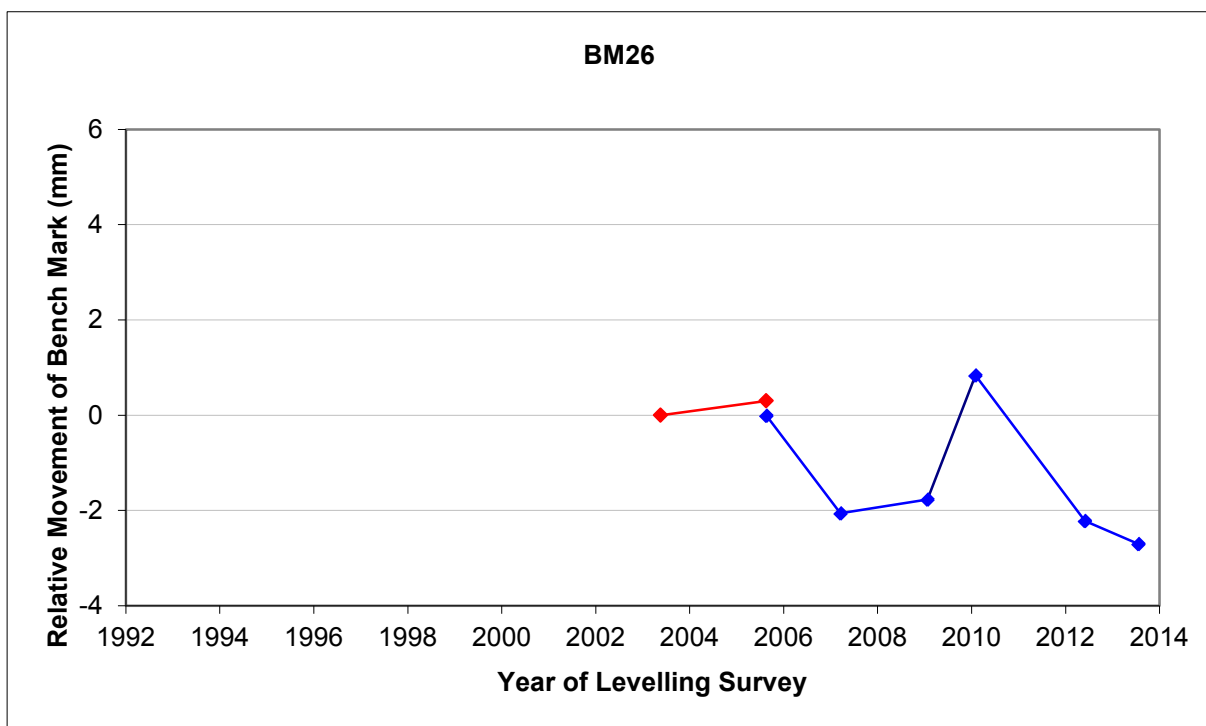
The 2013 RL of TUVA is 3.7045

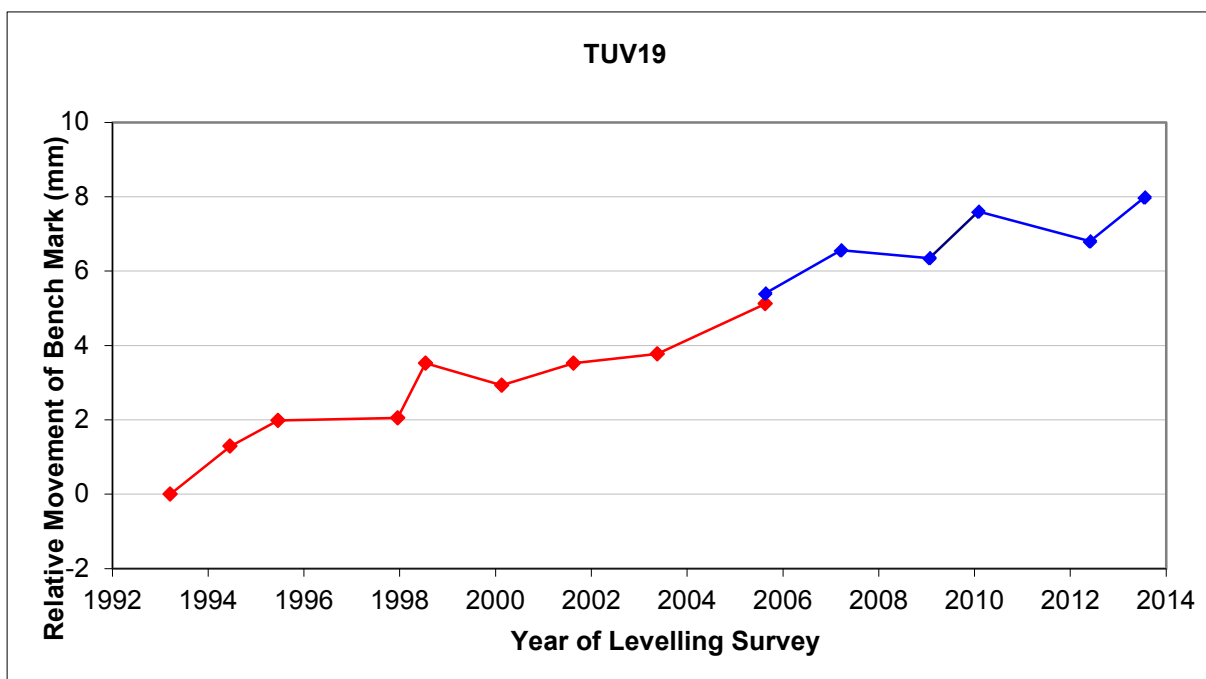
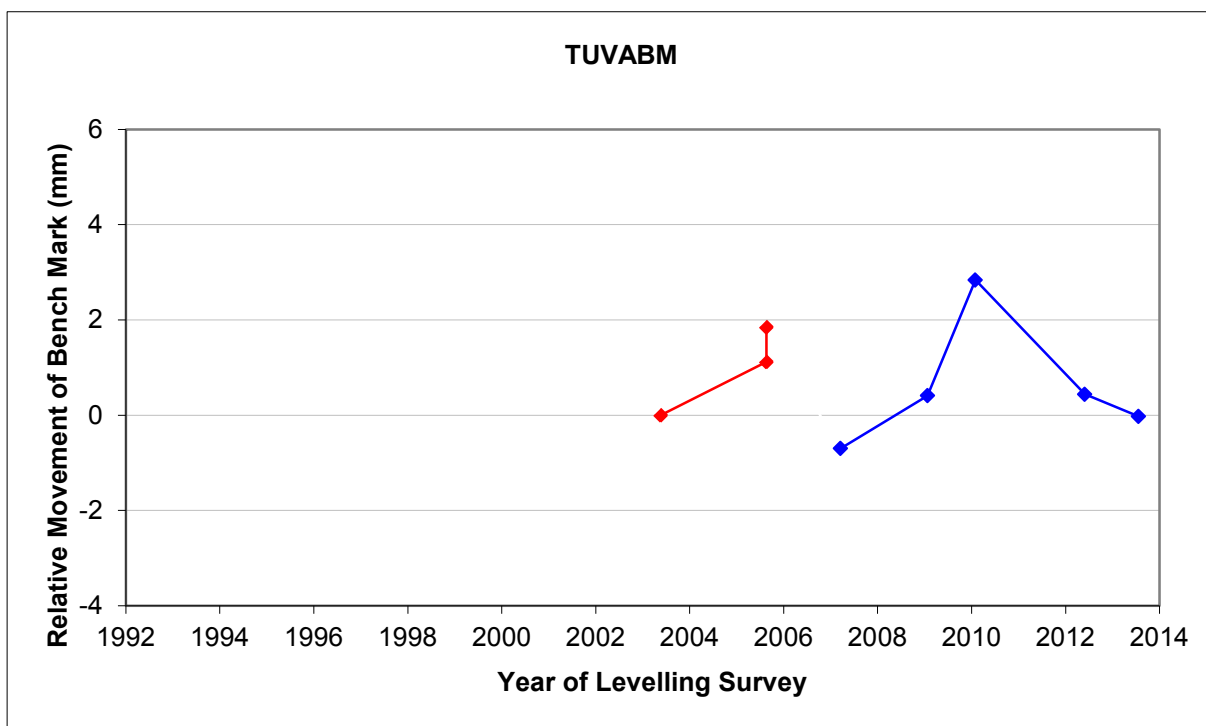
**The RL of the Reference Point TUVA (ARP) is derived from adding the static height difference of 0.9631m (TUVABM to TUVA) to the 2013 levelled RL of TUVABM.*

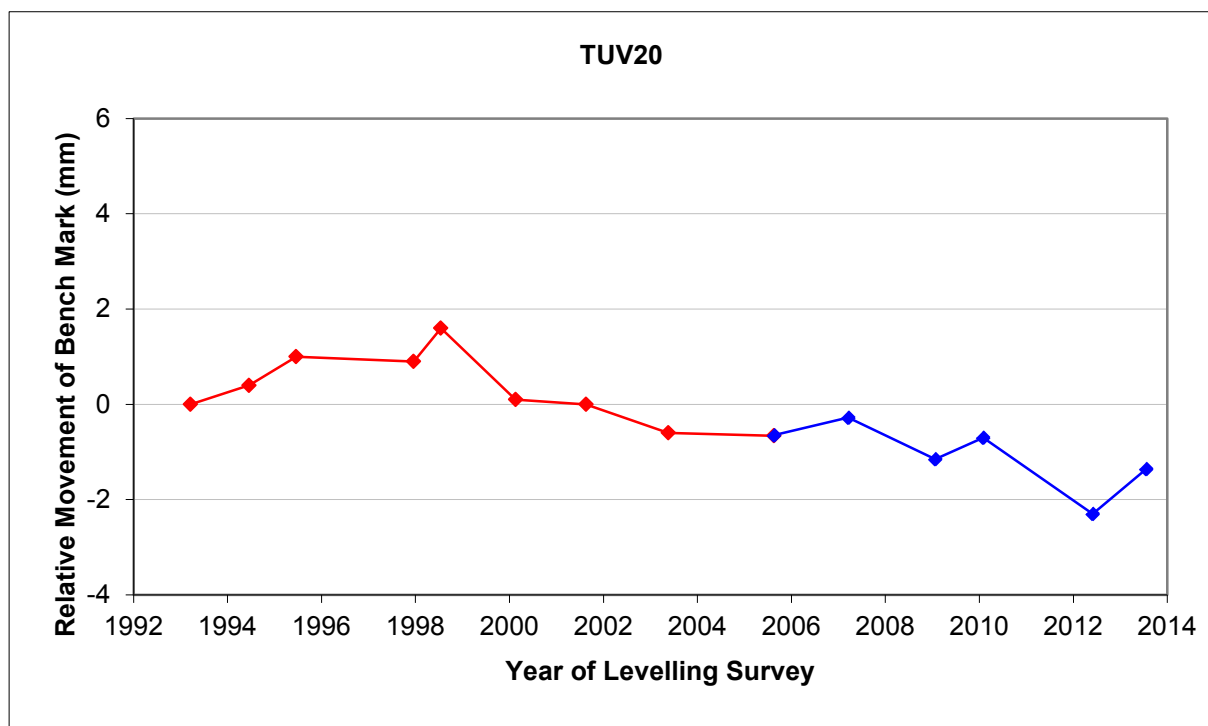
3.3 Time Series of Bench Mark movement relative to Fixed Deep Bench Mark BM22

Precise Differential Levelling: 1993 - 2005 ◆ — ◆
 EDM Height Traversing: 2005 onwards ◆ — ◆









4 Deep Bench Mark Locality Diagrams



SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT



Survey Bench Mark Record

Bench Mark Number: BM22

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	Date: 04-02-92
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Existing Bench Mark Established by:	Date:
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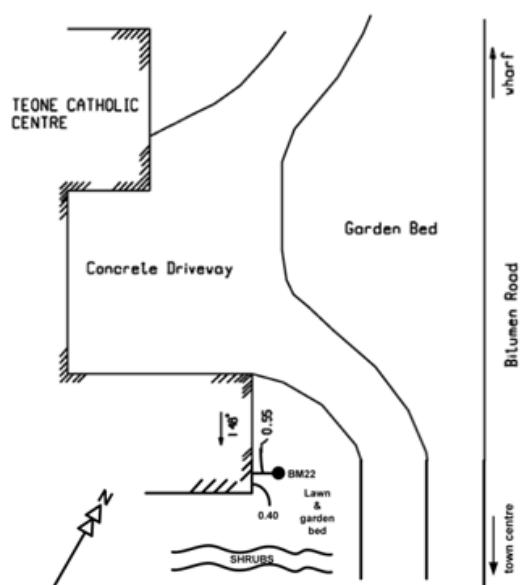
Notes / References: Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.

Country: Tuvalu Island: Funafuti	Atoll: Fongafale
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Marking and locality sketch

Bench Mark: 2.2m 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 0.25m below ground level.

Locality sketch: Mark approximately 500m from the tide gauge station.



Not to scale	Distances in Metres	Magnetic bearings
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Approved by: Geoscience Australia / SOPAC	Date: November 2006
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**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: BM23

<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> 03-02-92
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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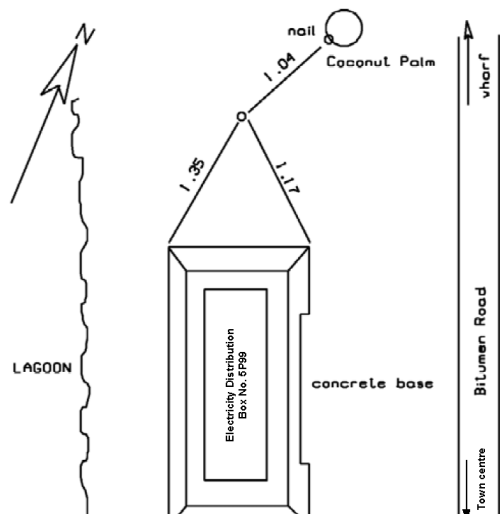
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.
--

<i>Country:</i> Tuvalu <i>Island:</i> Funafuti	<i>Atoll:</i> Fongafale
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Marking and locality sketch

Bench Mark: 1.0m 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 500m from the tide gauge station.



Not to scale	Distances in Metres	Magnetic bearings
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Approved by: Geoscience Australia / SOPAC	Date: November 2006
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**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: BM24

<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> 03-02-92
<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> Tuvalu <i>Island:</i> Funafuti	<i>Atoll:</i> Fongafale
<u>Marking and locality sketch</u> Bench Mark: 3.8m of 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 0.8m. Top of mark 0.15m below ground level. Locality sketch: Mark approximately 2000m from the tide gauge station.	
Not to scale Distances in Metres Magnetic bearings	
Approved by: Geoscience Australia / SOPAC Date: November 2006	



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



Survey Bench Mark Record

Bench Mark Number: BM26

<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> 15-05-03
<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.	
<i>Country:</i> Tuvalu <i>Island:</i> Funafuti	<i>Atoll:</i> Fongafale
<u>Marking and locality sketch</u> Bench Mark: 3.3m 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 0.1m below ground level. Locality sketch: Mark approximately 3100m from the tide gauge station.	
Not to scale Distances in Metres Magnetic bearings	
Approved by: Geoscience Australia / SOPAC Date: November 2006	



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



Survey Bench Mark Record

Bench Mark Number: BM27

<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> 15-05-03
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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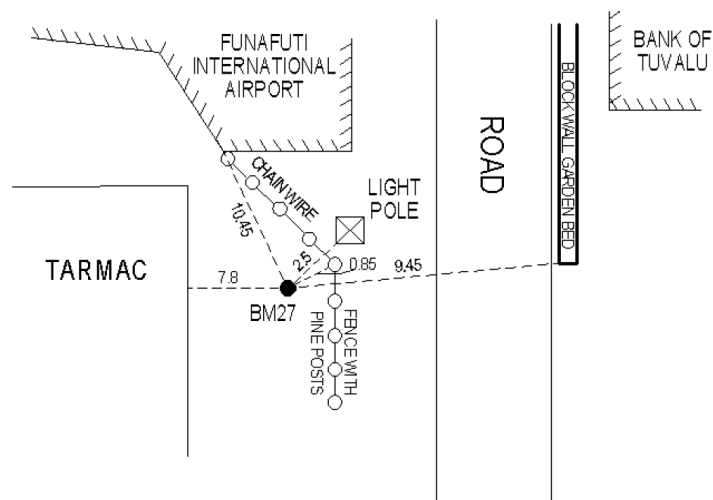
Notes / References: Deep Survey Benchmark
 This survey mark is in a good locality for GPS occupation.

<i>Country:</i> Tuvalu <i>Island:</i> Funafuti	<i>Atoll:</i> Fongafale
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Marking and locality sketch

Bench Mark: 2.4m 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 0.1m below ground level.

Locality sketch: Mark approximately 3200m from the tide gauge station.



Not to scale	Distances in Metres	Magnetic bearings
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Approved by: Geoscience Australia / SOPAC	Date: November 2006
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**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: BM28

Original Bench Mark Established by: Geoscience Earth Monitoring Geodetic Operations Geoscience Australia, Cnr Jerrabomberra Ave & Hindmarsh Drive, Australia	Date: 17-01-09
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Existing Bench Mark Established by:	Date:
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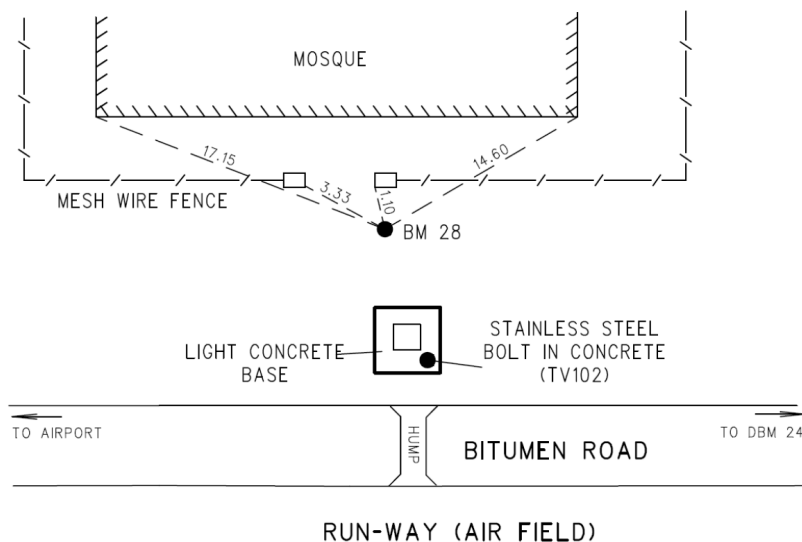
Notes / References: Deep Survey Benchmark
This survey mark is in a good locality for GPS occupation.

Country: Tuvalu Island: Funafuti	Atoll: Fongafale
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Marking and locality sketch

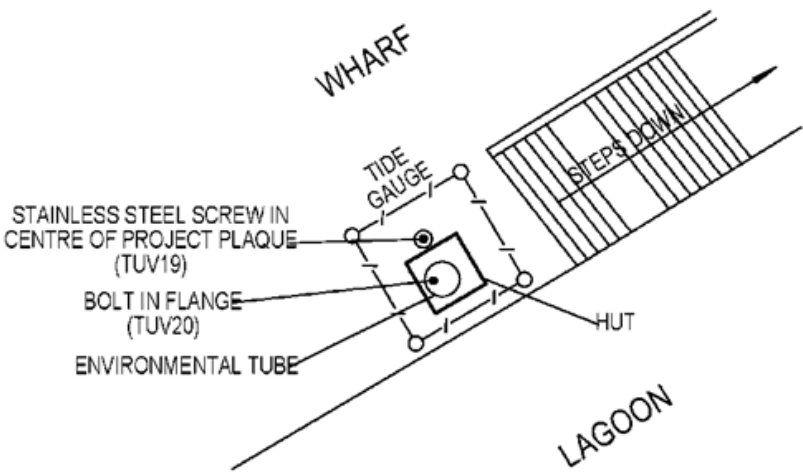
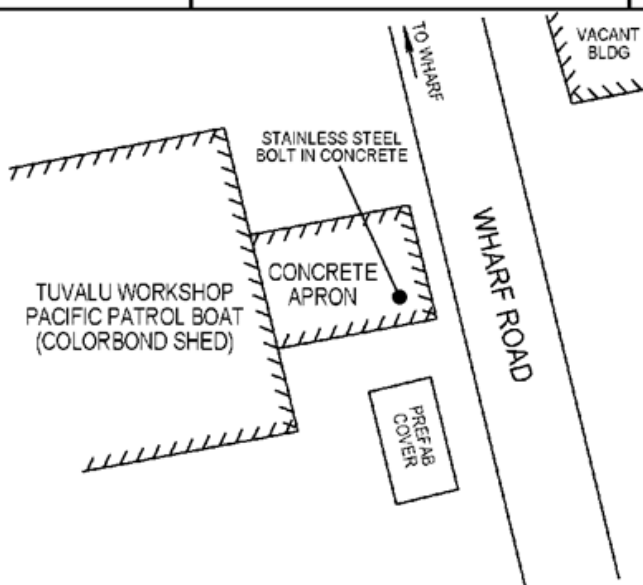
Bench Mark: 2.14m of 13mm diameter stainless steel capped rod driven to refusal.
Rod sheathed with 200mm diameter PVC pipe, Top of mark 0.1m below ground level.

Locality sketch: Mark approximately 600m from the CGPS station.

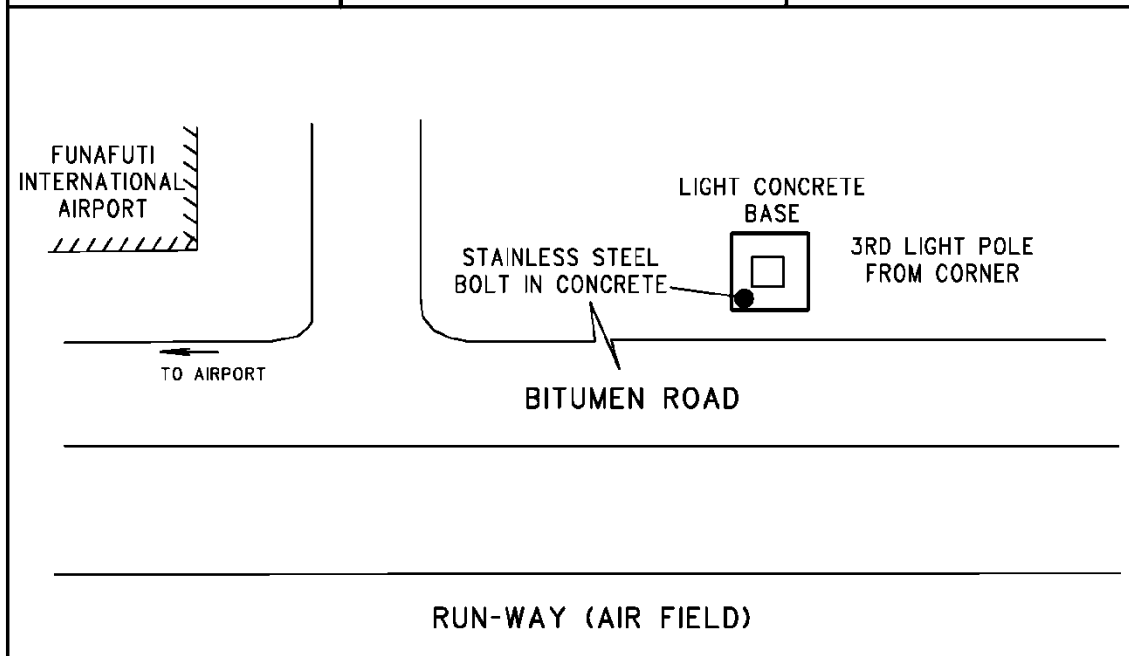


Not to scale	Distances in Metres	Magnetic bearings
Approved by: Geoscience Australia / SOPAC		Date: January 2009

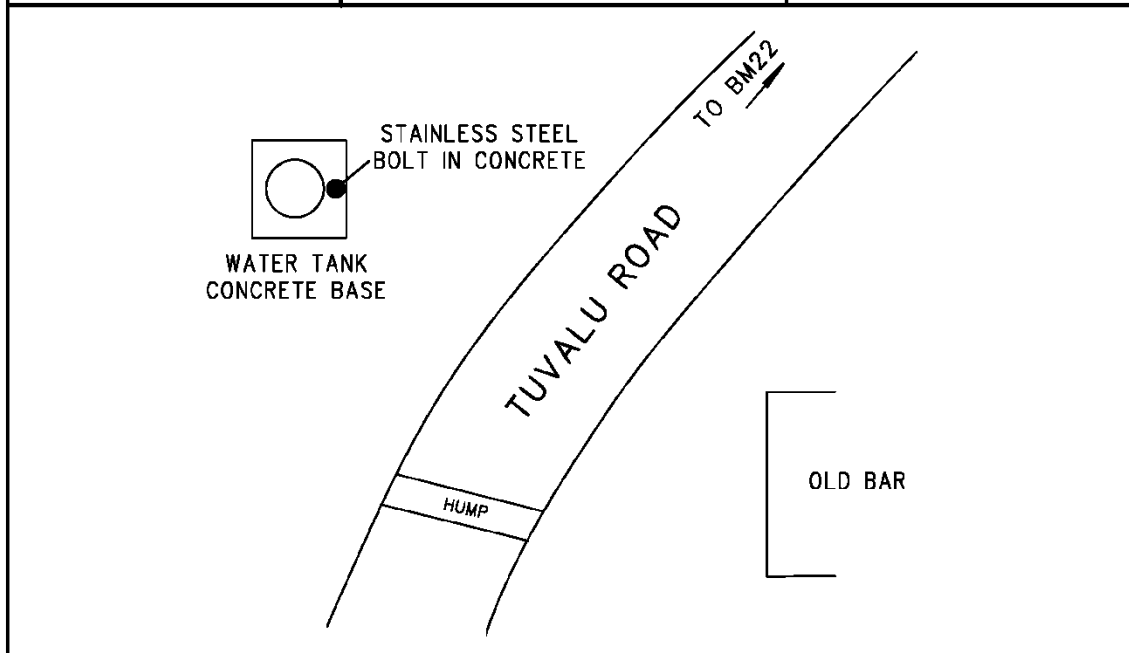
5 Temporary Holding Mark Locality Diagrams

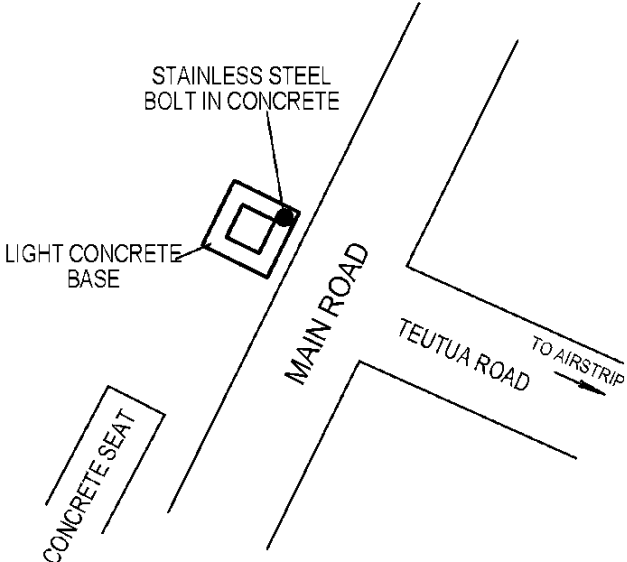
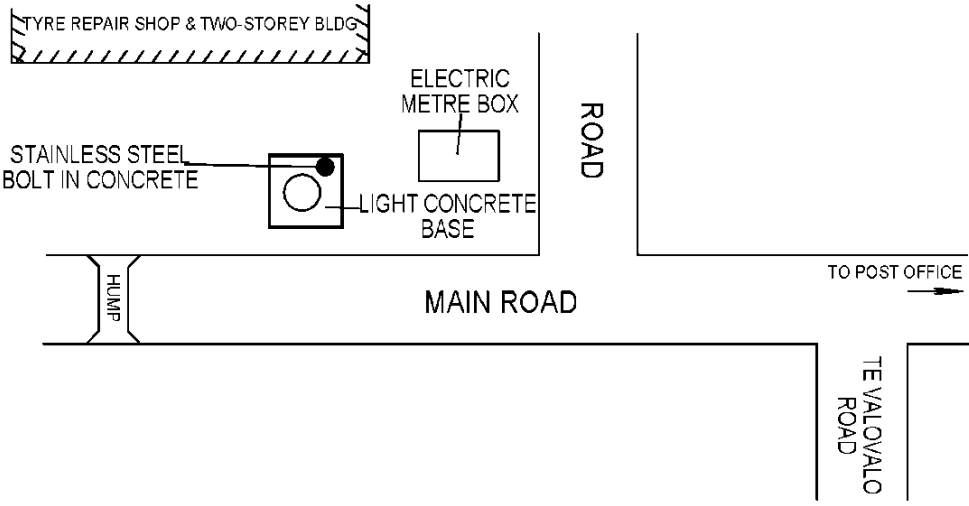
COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 775 POINT NO. TUV 19 & 20
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 29-03-07
		
COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 776 POINT NO. TUV 42
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 18-01-07
		

COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 890 POINT NO. TUV69
PROJECT: SPSLCMP	SURVEYOR: S. Turner	DATE: 24-08-01



COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 891 POINT NO. TUV44
PROJECT: SPSLCMP	SURVEYOR: S. Turner	DATE: 24-08-01



COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 777 POINT NO. TUV 48
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 29-03-07
 Diagram of Point TUV 48: A stainless steel bolt is embedded in a light concrete base. A concrete seat is located nearby. The point is situated near a main road and Teutua Road, which leads to an airstrip.		
COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 778 POINT NO. TUV 61
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 18-01-07
 Diagram of Point TUV 61: A stainless steel bolt is embedded in a light concrete base. An electric metre box is located nearby. The point is situated near a main road, a tyre repair shop, and Tevalovo Road, which leads to a post office.		

COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 892 POINT NO. TUV49
PROJECT: SPSLCMP	SURVEYOR: S. Turner	DATE: 24-08-01

TIMBER
HARDWARE

TUVALU ROAD

CONCRETE
BASE

STAINLESS STEEL PIN
IN CONCRETE

ELECTRICITY
DISTRIBUTION
BOX * 4P66

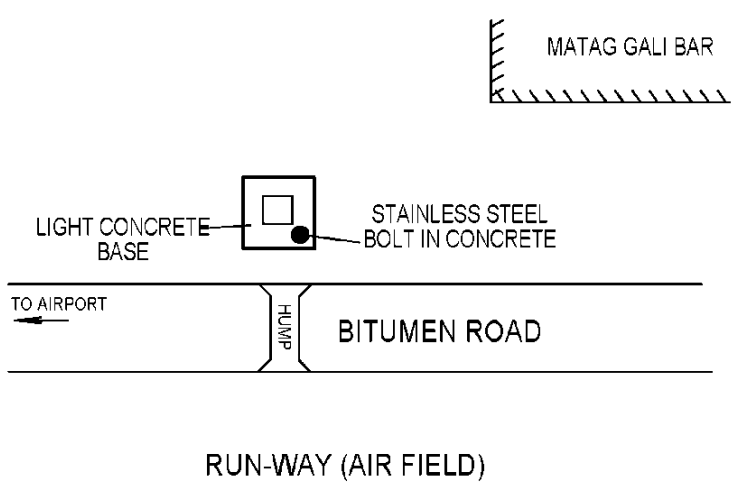
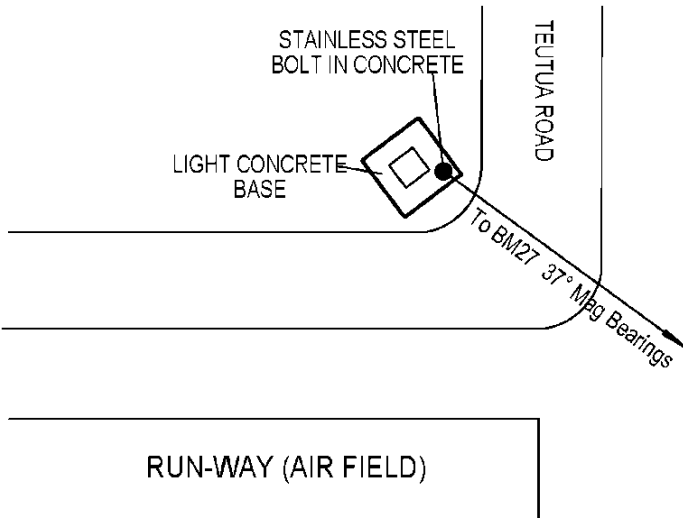
COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 893 POINT NO. TUV71
PROJECT: SPSLCMP	SURVEYOR: S. Turner	DATE: 18-05-03

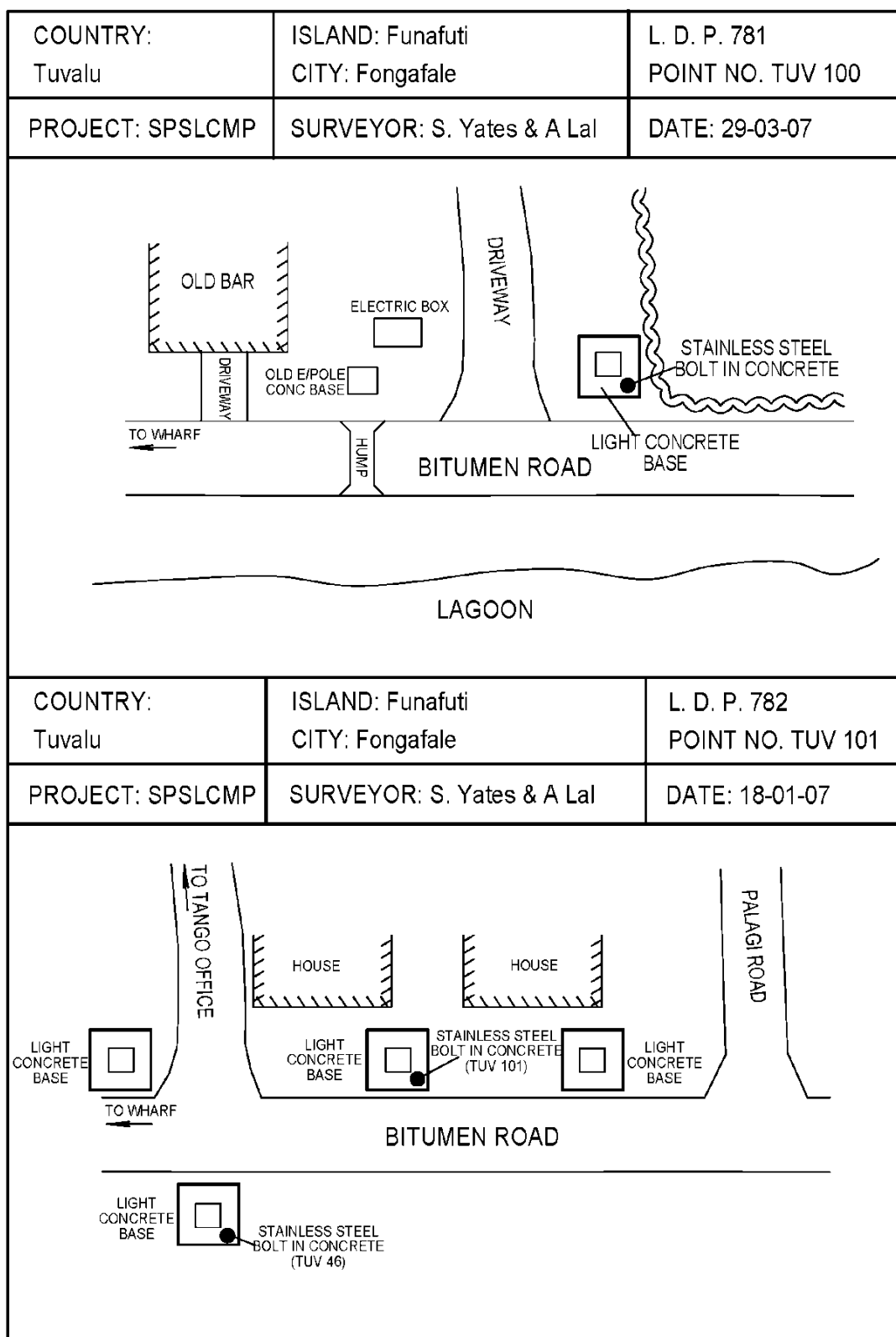
LIGHT CONCRETE
BASE

STAINLESS STEEL
BOLT IN CONCRETE

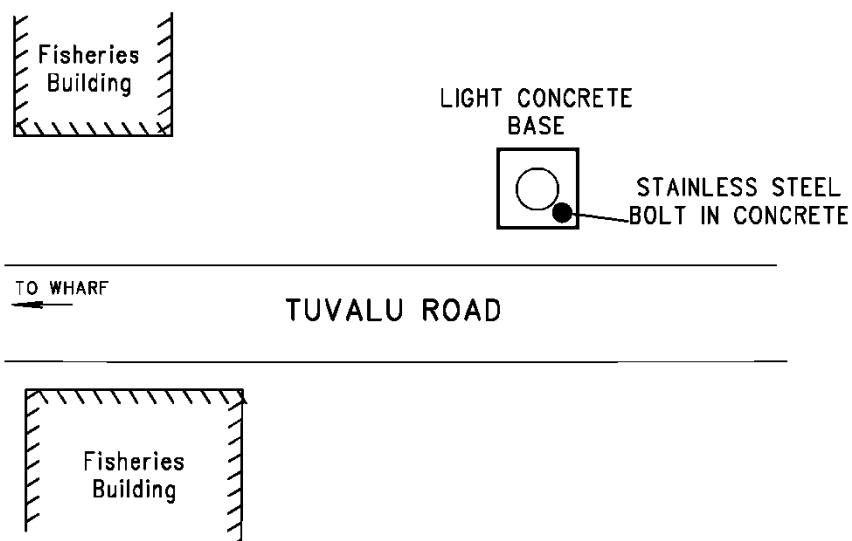
9TH LIGHT POLE
FROM CORNER

BITUMEN ROAD

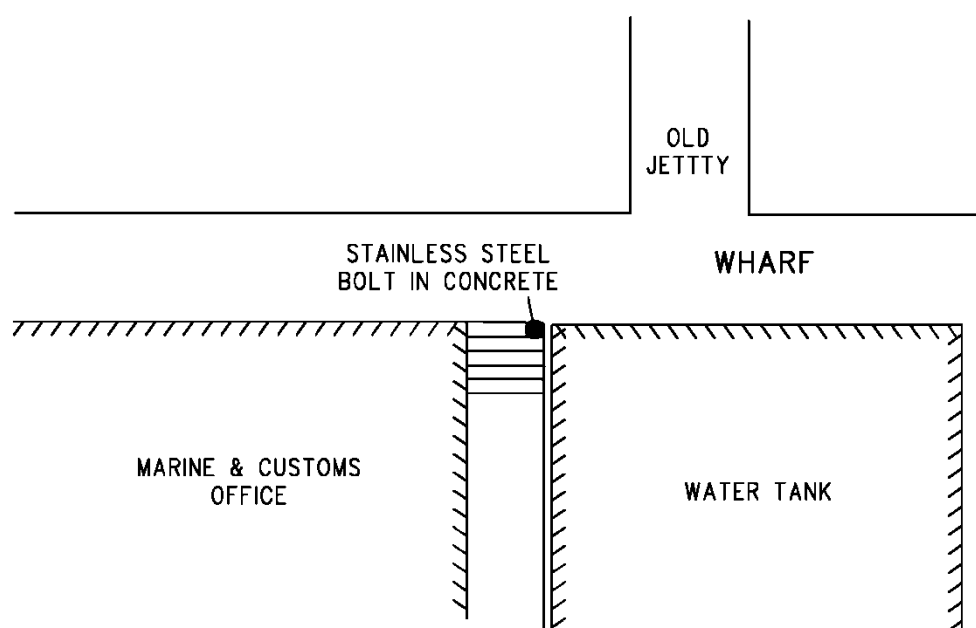
COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 779 POINT NO. TUV 73
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 29-03-07
 MATAG GALI BAR LIGHT CONCRETE BASE STAINLESS STEEL BOLT IN CONCRETE TO AIRPORT HUMP BITUMEN ROAD RUN-WAY (AIR FIELD)		
COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 780 POINT NO. TUV 74
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 18-01-07
 STAINLESS STEEL BOLT IN CONCRETE LIGHT CONCRETE BASE TEUTUA ROAD To BM27 37° Mag Bearings RUN-WAY (AIR FIELD)		



COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 894 POINT NO. TUV102
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A. Lal	DATE: 23-05-12



COUNTRY: Tuvalu	ISLAND: Funafuti CITY: Fongafale	L. D. P. 895 POINT NO. TUV103
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A. Lal	DATE: 23-05-12

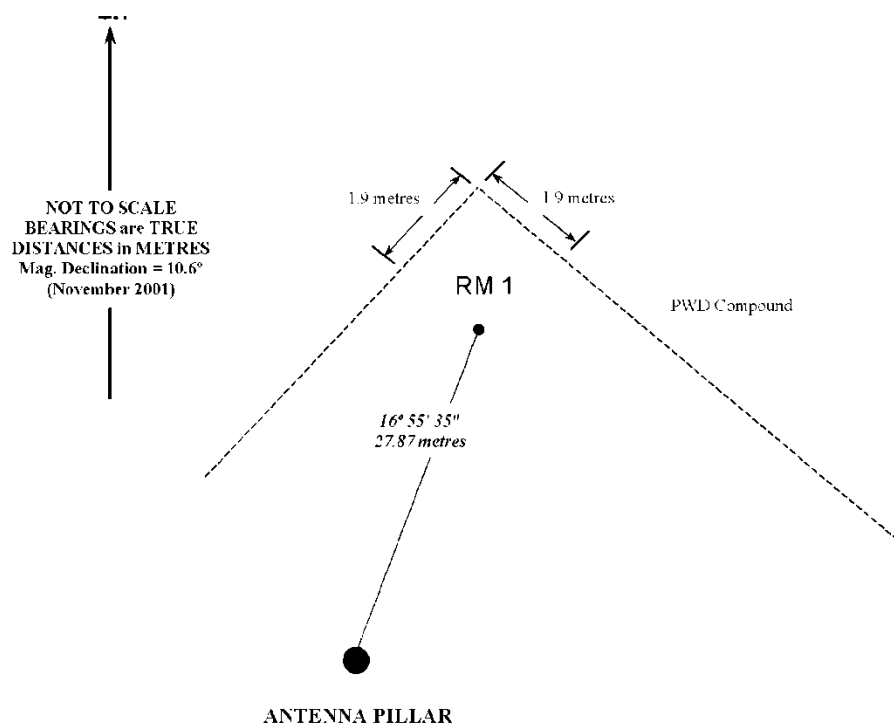


6 TUVABM and TUVA Reference Mark Locality Diagrams

TUVALU CGPS Station, Funafuti – RM 1

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 50mm below ground level.

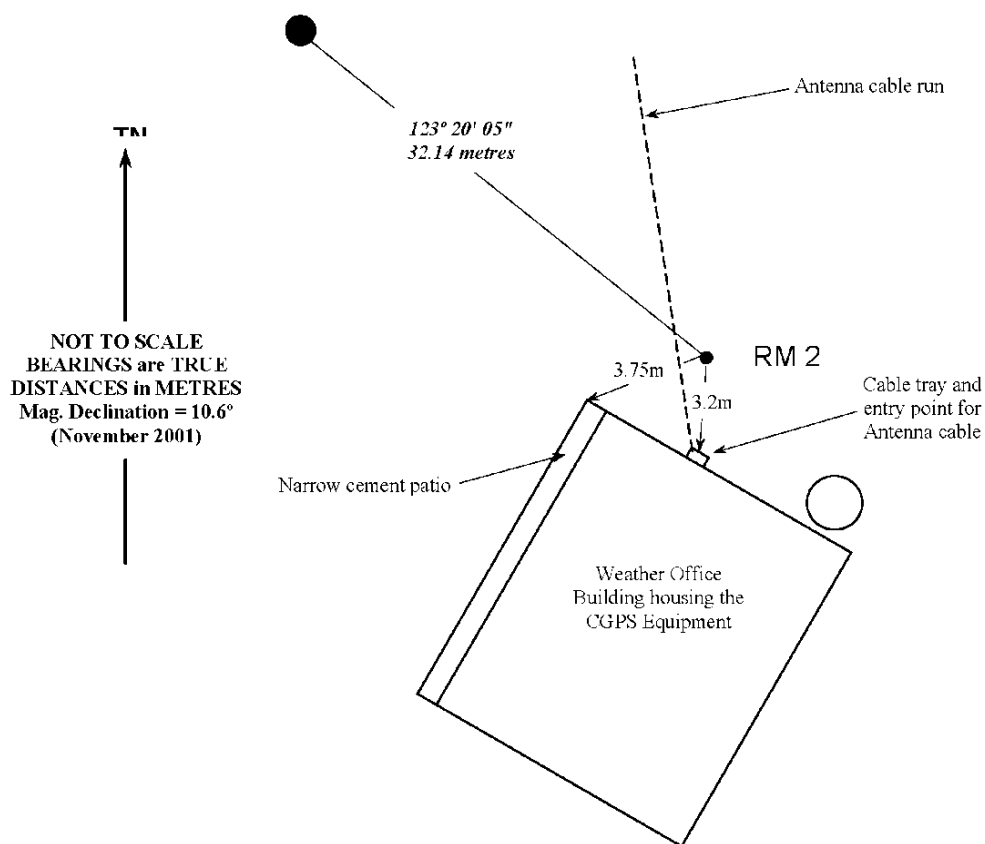


TUVALU CGPS Station, Funafuti – RM 2

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 50mm below ground level.

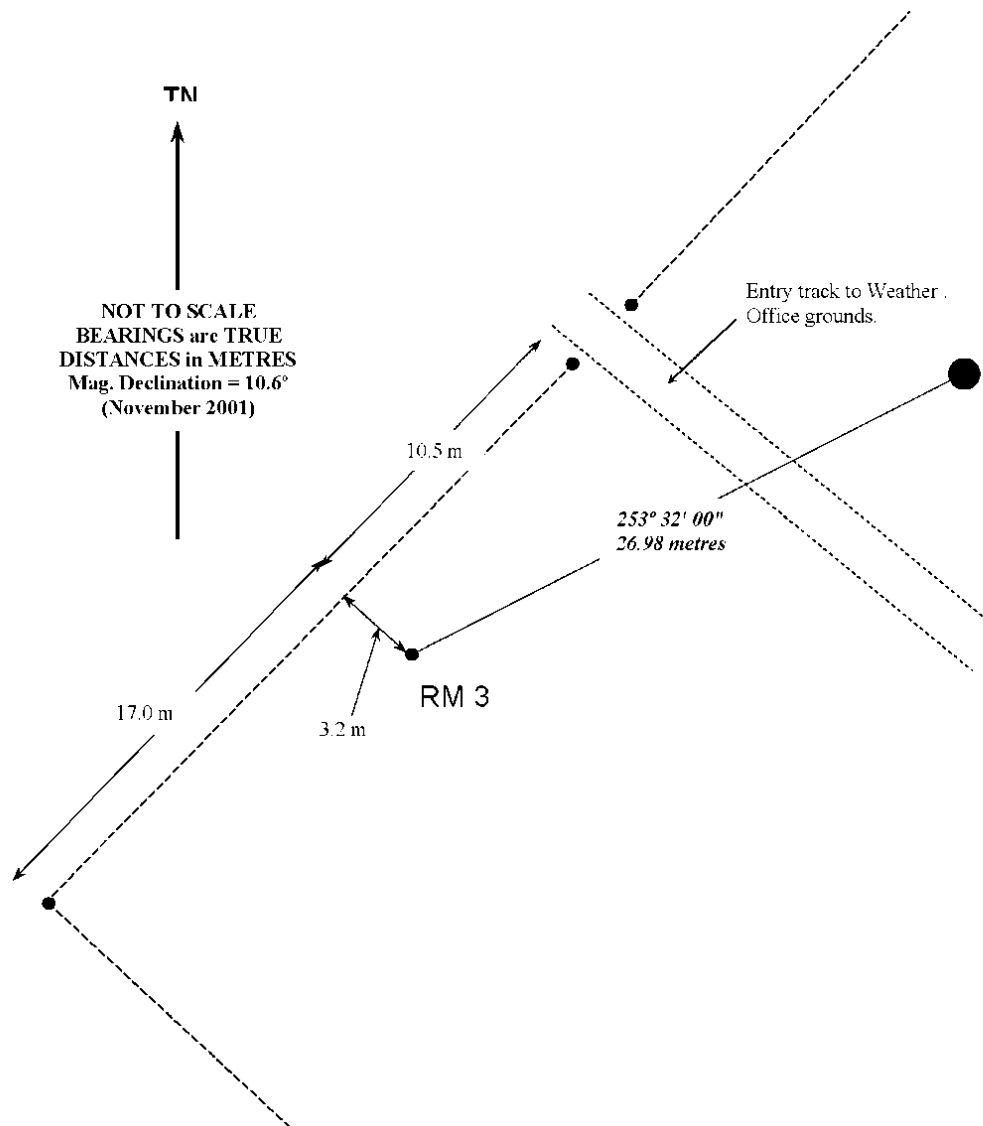
ANTENNA PILLAR



TUVALU CGPS Station, Funafuti – RM 3

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 50mm below ground level.



7 References

- Rüeger, J.M. & Brunner, F.K. 1982, 'EDM Height Traversing versus Geodetic Levelling', The Canadian Surveyor, vol. 36, no. 1, pp. 69-87.
- Inter-Government Committee on Surveying and Mapping (ICSM) 2002, Standards and Practices for Control Surveys, SP1, Ver. 1.5, May 2002.