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Record 2014/20 | GeoCat 76784

EDM Height Traversing Levelling Survey Report

Majuro, Marshall Islands, June 2012

A.R.Hill, A. Lal

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GEOSCIENCE AUSTRALIA
RECORD 2014/20

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Australian Government
Geoscience Australia

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ISSN 2201-702X (PDF)

ISBN 978-1-925124-09-5 (PDF)

GeoCat 76784

Bibliographic reference: Hill, A. R. & Lal, A., 2014, *EDM Height Traversing Levelling Survey Report: Majuro, Marshall Is. June 2012*. Record 2014/20. Geoscience Australia, Canberra.
<http://dx.doi.org/10.11636/Record.2014.020>

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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 continuous Global Navigation Satellite System (CGNSS) station in Majuro, Marshall Islands from 12-18 June 2012.

Personnel involved in the survey were Anna Hill, Project Officer, Geoscience Australia and Andrick Lal, Surveyor, Secretariat of the Pacific 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 Majuro, which runs approximately 4 km from the tide gauge sensor to the Continuous Global Navigation Satellite System (CGNSS) antenna. Previous levelling surveys using this technique have been conducted along the route in 2006, 2007, 2009 and 2010.

In addition, precise differential levelling surveys were performed along the deep bench mark (BM) array from 1993 to 2006 by the National Tidal Centre Australia (NTCA). This report contains a comparison between the 2012 and 2010 EDM height traversing results as well as a combined comparison since the first levelling survey in 1993.

2 The Survey

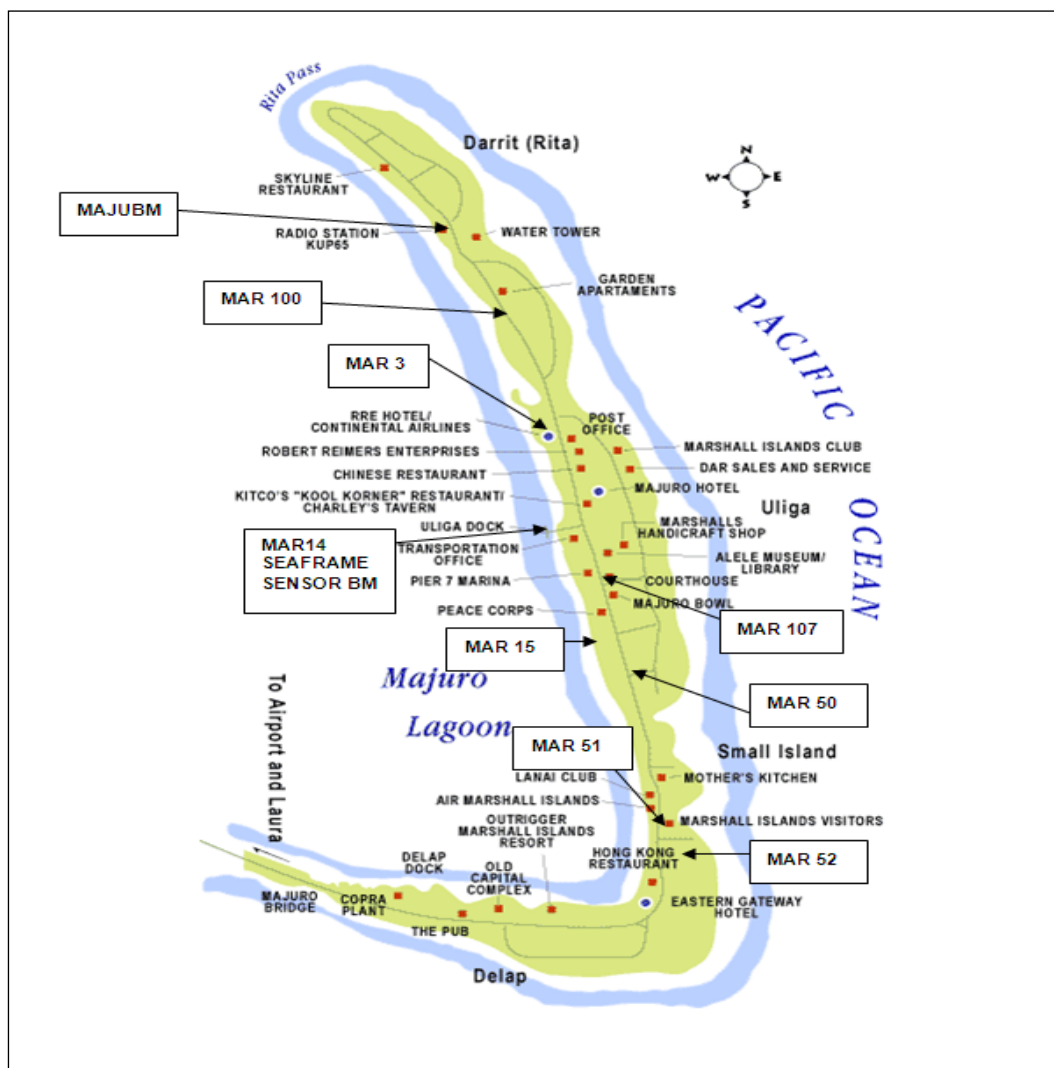
The EDM height traversing levelling survey was carried out between the SEAFRAME tide gauge sensor, continuous GNSS station and the deep driven bench marks:

MAJUBM	– GPS Benchmark
MAR 13	- Project plaque at tide gauge
MAR 14	- SEAFRAME sensor benchmark
MAR 3	- Deep Driven BM
MAR 15	- Deep Driven BM
MAR 50	- Deep Driven BM
MAR 51	- Deep Driven BM
MAR 52	- Deep Driven BM
MAR 100	- Deep Driven BM
MAR 107	- Deep Driven BM

All the deep bench marks were located and found in good order and undisturbed, including MAR3 which is located within a shop out the front of Robert Reimers Hotel. Also included in the survey were permanent holding marks MAR25, MAR31, MAR36, MAR40, MAR44, MAR54 and temporary holding marks MAR101, MAR102, MAR104, MAR105, MAR106, MAR108, MAR109, MAR110, MAR112, MAR113, MAR114.

The EDM height traversing levelling technique was performed to the Class L2A specifications (ICSM, Standards and Practices for Control Surveys). After reduction an internal precision of $1\text{mm}\sqrt{K}$ or better was achieved (zero order); well within the specifications of the project which is $2\sqrt{K}$ where K is the distance in kilometres. A table of results and comparisons and the 2012 reduced levels are detailed later in this report.

2.1 Bench Mark Locality Diagram



2.2 The Marshall Islands Datum

The adopted reference point for this survey is MAR3. Reduction of the data was calculated holding MAR3 fixed at 1.60834 metres.

The height of MAR3 was derived by:

1993 - Adopting the MSL height of USCG BM 4; RL = 1.91414m MSL (Nov 68 – May 69)

1994 – Adopting the height of MAR3 as derived in the 1993 survey.

Initially, MAR2 was the reference point for the surveys, but this was found to be destroyed during the 2006 survey. In order to keep all the reduced levels consistent in reference to a unique benchmark, the RL of MAR3 as determined in the 1993 survey is adopted as the datum for all the surveys.

2.3 Equipment

- Leica total station model 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 Majuro 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 Survey Support

The survey team very much appreciated the assistance from Meteorological Office, Survey Department and Marshall Islands National Telecommunications Authority (NTA). Personnel consulted during the visit were:

Mr. Lee Jacklick – Meteorological Office

Mr. Reginald White – Meteorological Office

Mr. Steven R – Meteorological Office

Mr. Melvin Aliven – NTA

Mr Wase Hackney – Survey Department

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

2.6 Issues

As mentioned in the 2010 report, MAR3 is now inside a building located on the street outside the Robert Reimers Hotel. In the last visit, permission for occupying the benchmark was obtained from the then owner Mr. Rodriguez Reimers, (email: rod.reimers@rreinc.com) to occupy the site. During this visit however, it appears there are new owners of the building and it is now used as a supermarket. The room where MAR3 is located is now a store room. The Project should probably develop a plan to shift the datum reference point to another site as it seems it will become more and more difficult to access this mark in the coming years.

Access to the deep benchmark, MAR15, is also restricted as it is in the Mobile Depot compound; therefore approval to survey the benchmark is necessary from the security gate at the depot.

Another concern is that the CGPS monument and the three RM's inside the NTA facility at Rita are collocated with several TV satellite dishes and care must be taken during the reference mark monitoring survey to ensure clear line of sight. Contact NTA personal for access into the compound and other survey related matters.

3 Comparisons

3.1 Comparisons between 2012 and 2010 EDM Surveys.

Table 3.1 Majuro, Marshall Islands 2012 EDM Height Traversing Levelling & Comparison 2012 – 2010. MAR3 - adopted fixed height of 1.60834 m

From	To	Levelled Ht. Diff.	RL 2012	Misclose (mm)	Dist. (km)	1mm√k	RL 2010	Difference (mm) 2012 - 2010
MAR3			1.6083				1.6083	
MAR108	MAR108	0.13371	1.7420	-0.061	0.021	0.14	1.7421	-0.02
MAR109	MAR109	0.00608	1.7481	-0.183	0.198	0.45	1.7486	-0.44
MAR101	MAR101	0.04099	1.7891	-0.048	0.208	0.46	1.7897	-0.59
MAR100	MAR100	-0.30621	1.4829	0.316	0.241	0.49	1.4838	-0.89
MAR110	MAR110	0.45049	1.9334	0.389	0.207	0.46	1.9354	-2.00
MAR102	MAR102	-0.15265	1.7808	0.026	0.180	0.42	1.7825	-1.71
	MAJUBM	1.36148	3.1422	-0.048	0.081	0.29	3.1428	-0.61
MAR54			1.8899				1.8894	0.49
MAR31	MAR31	-0.08981	1.8001	0.309	0.182	0.43	1.7997	0.40
	MAR108	-0.05805	1.7420	-0.070	0.219	0.47	1.7421	-0.02
MAR54			1.8899				1.8894	0.49
	MAR107	-0.22376	1.6661	0.044	0.048	0.22	1.6659	0.25
MAR54			1.8899				1.8894	0.49
MAR13	MAR13	-0.29615	1.5938	-0.225	0.168	0.41	1.5934	0.36
	MAR14	0.19665	2.7903	-0.033	0.018	0.13	2.7934	-3.14
MAR15			1.7443				1.7453	-0.99
MAR25	MAR25	0.16297	1.9073	0.044	0.194	0.44	1.9086	-1.36
MAR114	MAR114	-0.01029	1.8970	-0.294	0.197	0.44	New Mark in 2012	New Mark in 2012
MAR106	MAR106	0.03568	1.9327	-0.198	0.157	0.40	1.9333	0.62
	MAR54	-0.04275	1.8899	0.057	0.031	0.17	1.8894	-0.49
MAR25			1.9073				1.9086	1.36
MAR104	MAR104	0.03740	1.9447	0.439	0.207	0.46	1.9454	0.69
MAR50	MAR50	-0.43417	1.5105	-0.035	0.045	0.21	1.5115	1.02
MAR36	MAR36	0.14924	1.6597	-0.233	0.111	0.33	1.6611	1.33
MAR113	MAR113	0.12236	1.7821	-0.413	0.200	0.45	1.7829	0.85
MAR40	MAR40	-0.02442	1.7577	-0.099	0.208	0.46	1.7595	1.84

From	To	Levelled Ht. Diff.	RL 2012	Misclose (mm)	Dist. (km)	1mm√k	RL 2010	Difference (mm) 2012 - 2010
MAR105	MAR105	0.07426	1.8319	-0.314	0.202	0.45	1.8326	0.62
MAR51	MAR51	-0.01158	1.8203	0.272	0.116	0.34	1.8217	1.33
MAR44	MAR44	0.21644	2.0368	-0.291	0.146	0.38	2.0390	2.17
	MAR52	-0.69964	1.3371	0.232	0.187	0.43	1.3378	0.62
			Total misclose for all bays levelled	-0.414	3.771	1.94		

3.2 Combined Comparisons 1993 to 2012

Table 3.2 Majuro, Marshall Islands - Comparison of the RL's for Precise Differential Levelling (1992 - 2006) and EDM Height Traversing (2006 - 2012). Units are in metres.

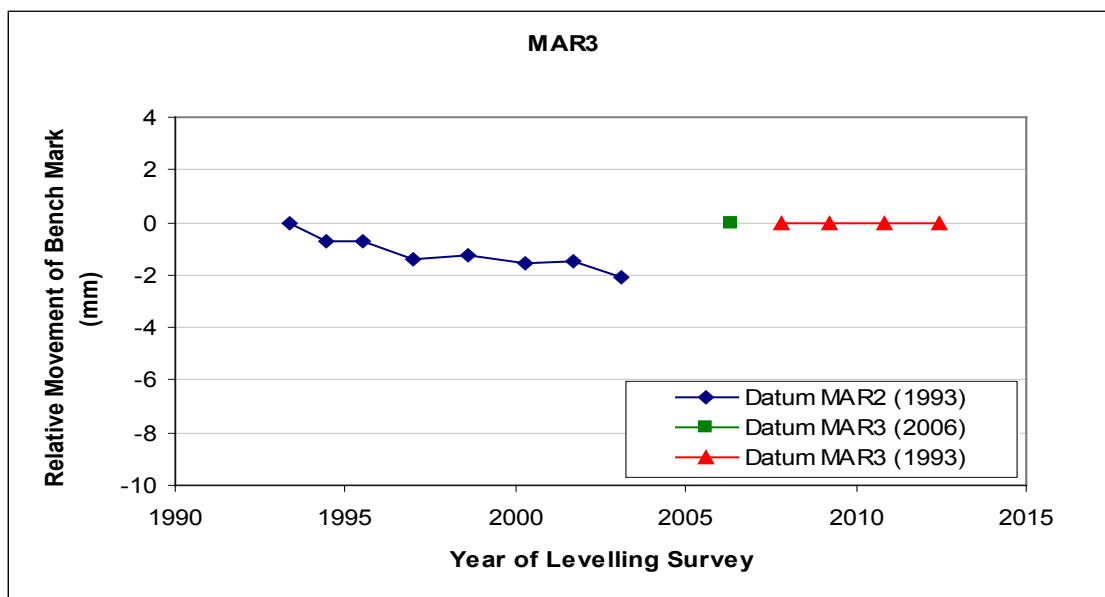
Datum	Year	MAR2	MAR3	MAR13	MAR14	MAR15	MAR50	MAR51	MAR52	MAJUBM	MAJU	MAR53
MAR2	1993.38	1.6025	1.6083	1.5923	2.7977							
MAR2	1994.46	1.6025	1.6076	1.5925	2.7983							
MAR2	1995.54	1.6025	1.6076	1.5919	2.7971	1.7510						
MAR2	1996.96	1.6025	1.6069	1.5915	2.7973	1.7498						
MAR2	1998.63	1.6025	1.6071	1.5912	2.7965	1.7495						
MAR2	2000.30	1.6025	1.6068	1.5907	2.7955	1.7486						
MAR2	2001.71	1.6025	1.6069	1.5909	2.7969	1.7483						
MAR2	2003.13	1.6025	1.6063	1.5908	2.7911	1.7433	1.5079	1.8211	1.3321			1.4826
MAR3 2006	2006.34		1.6063	1.5909	2.7894	1.7415	1.5076	1.8225	1.3350			1.4858
MAR3 2006	2006.34		1.6063	1.5899	2.7881	1.7415	1.5079	1.8217	1.3332			1.4838
MAR3 2007	2007.79		1.6083	1.5922	2.7936	1.7424	1.5091	1.8186	1.3341	3.1417	4.0860	
MAR3 2007	2009.20		1.6083	1.5919	2.7929	1.7436	1.5097	1.8210	1.3373	3.1420	4.0863	
MAR3 2007	2010.82		1.6083	1.5934	2.7934	1.7453	1.5115	1.8217	1.3378	3.1428	4.0873	
MAR3 2007	2012.45		1.6083	1.5938	2.7903	1.7443	1.5105	1.8203	1.3371	3.1422		

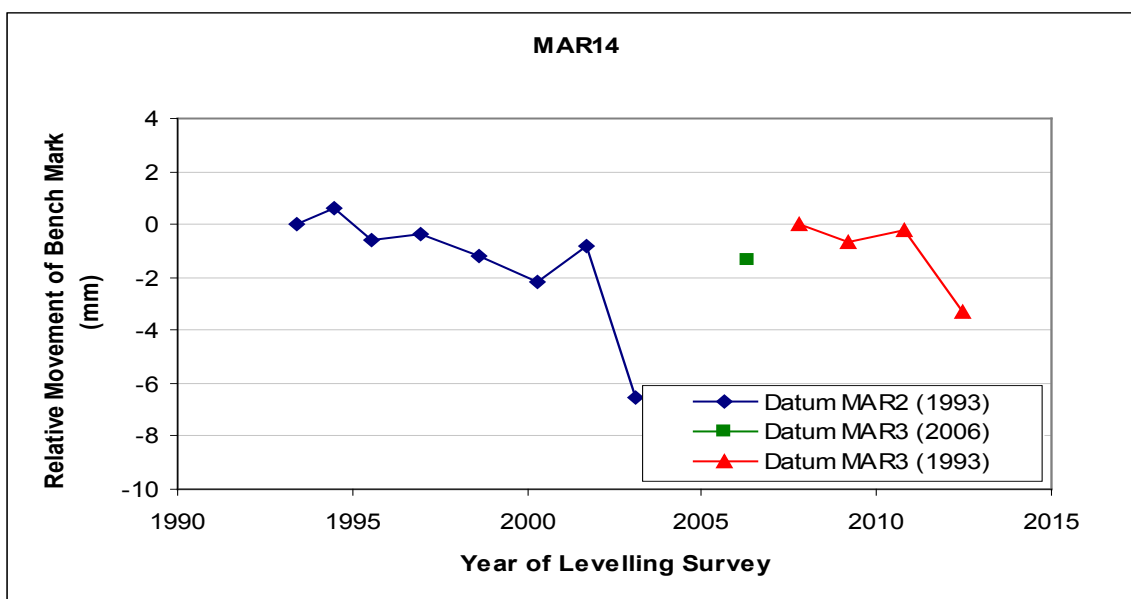
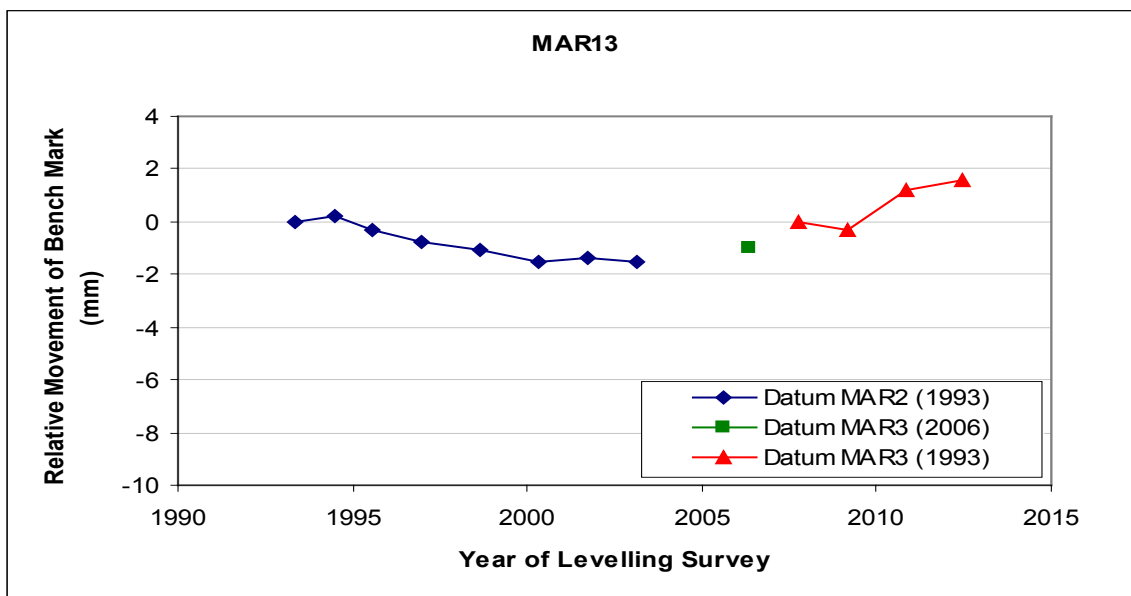
3.3 Time Series of Bench Mark Movement

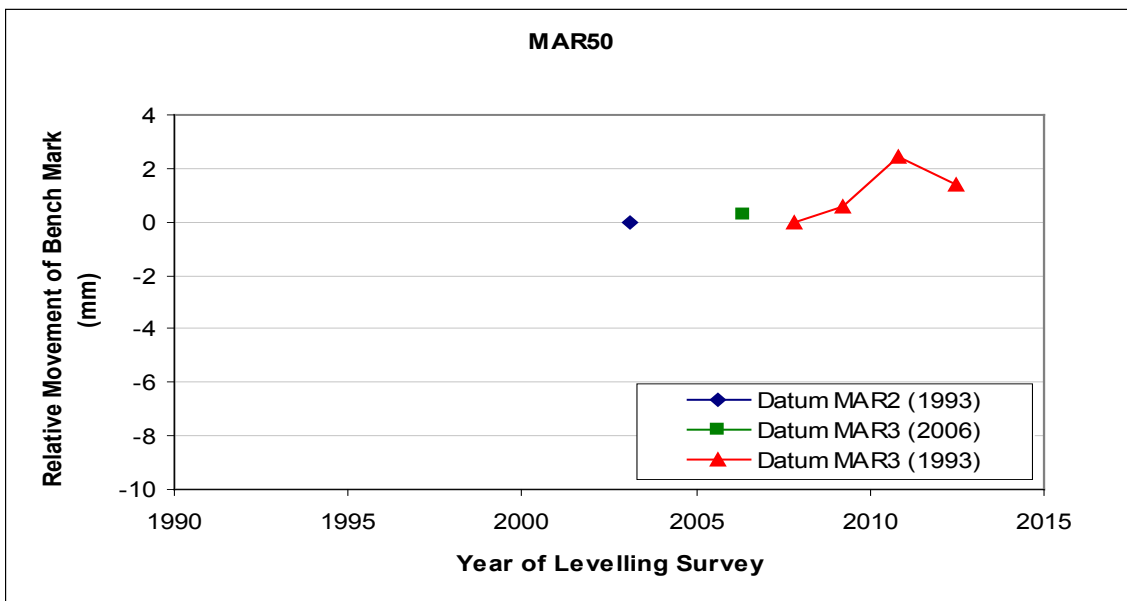
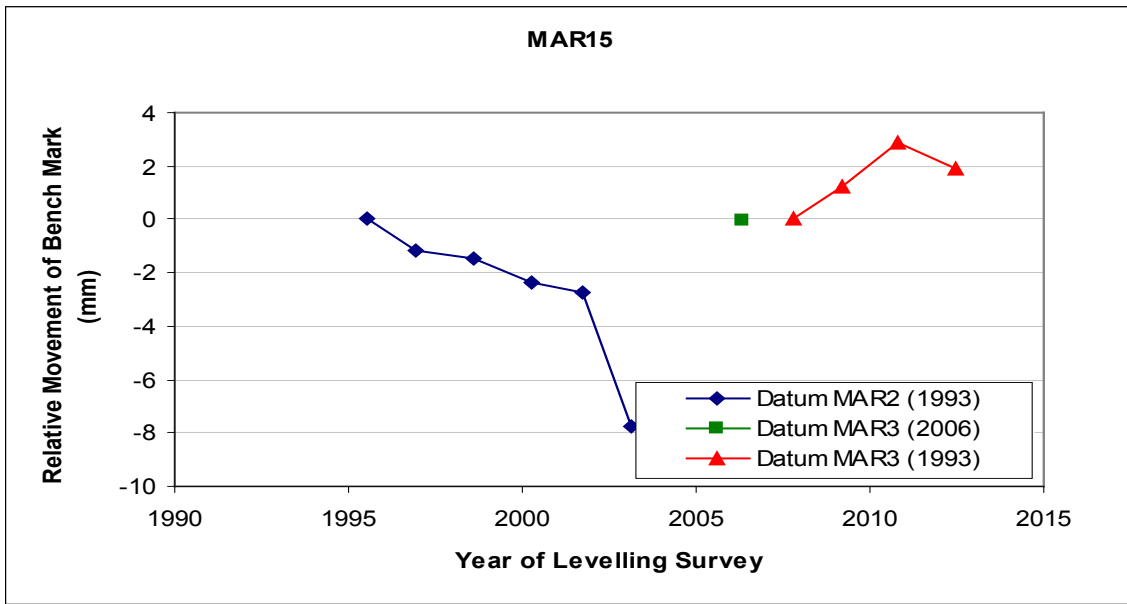
Precise Differential Levelling: 1993 - 2006 ◆ — ◆
EDM Height Traversing: 2006 onwards ◆ — ◆

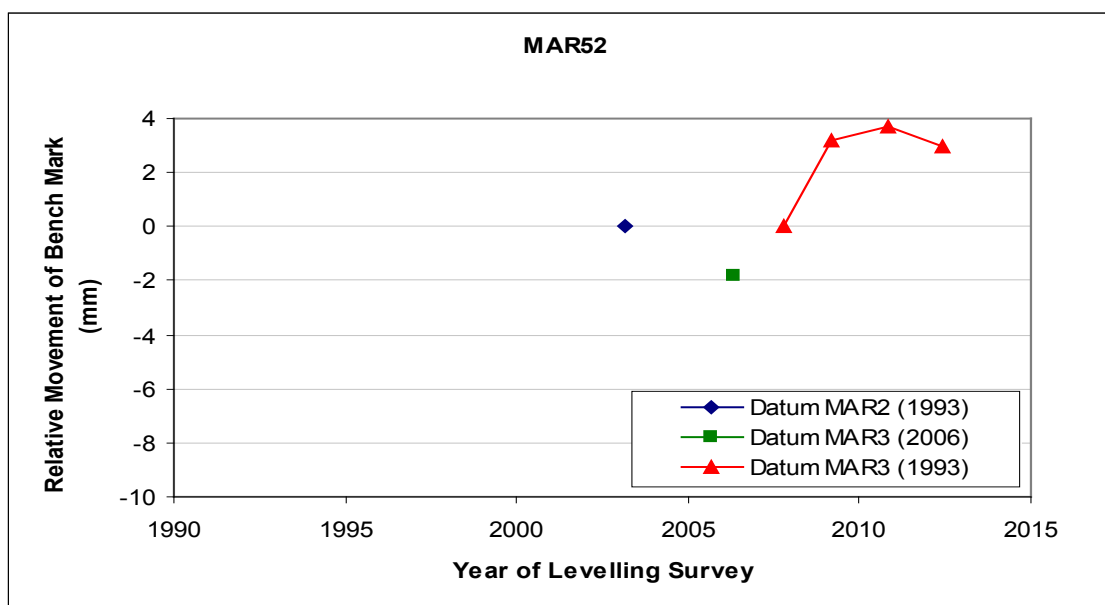
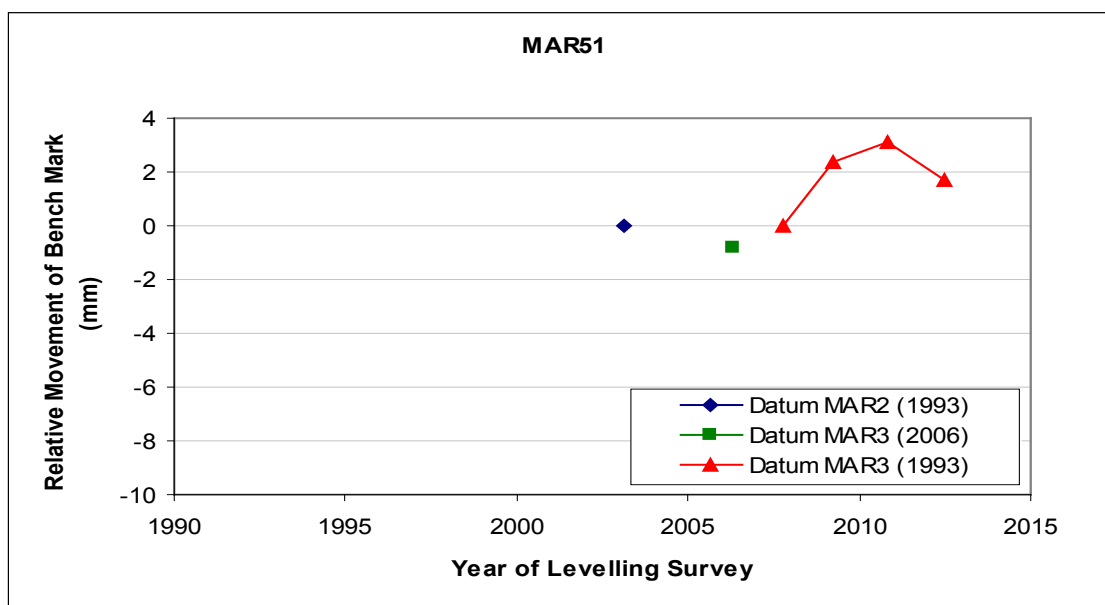
The purpose of this survey is in twofold: firstly, to provide accurate changes in land height to be used in computations of absolute sea level rise and secondly to provide accurate assessments of relative sea level changes due to localised deformation.

- There appears to be a few movements occurring:
- A possible drop in the reference point (MAR3) of ~1 mm over 3 years.
- A possible rise in the holding marks (e.g. MAR50-52) of ~4 mm over 3 years.
- A knock to the tide gauge (MAR14) could have occurred in 2003 and another smaller knock between the 2010 and 2012 surveys ~-3 mm.
- An incorrect point could have been observed at MAR15 in 2003.
- According to a localised analysis of MAJU and its RM's, it appears that the GPS site is quite stable.









4 Deep Bench Mark Locality Diagrams



SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT



Survey Bench Mark Record

Bench Mark Number: MAR15

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA. *Date:* 30-06-95

Existing Bench Mark Established by: *Date:*

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

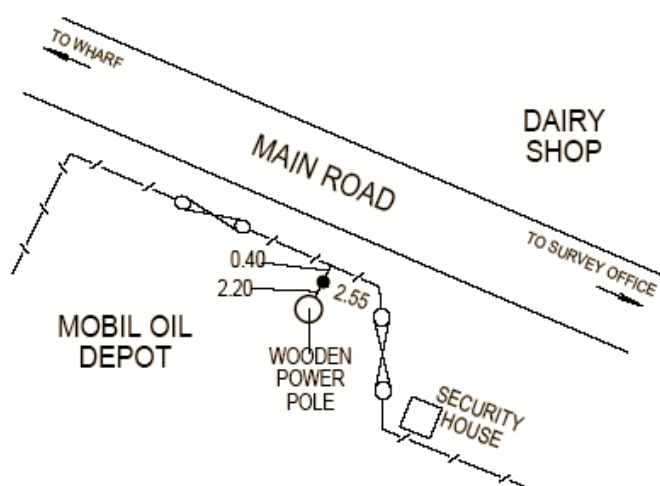
Country: Republic of Marshall Islands
Atoll: Majuro

City: Uliga

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 1.0m. Top of mark 0.2m below ground level.

Locality sketch: Mark approximately 750m from the tide gauge station.



Not to scale

Distances in Metres

Magnetic bearings

Approved by: Geoscience Australia / SOPAC

Date: Nov 2007



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



Survey Bench Mark Record

Bench Mark Number: MAR3

<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> 31-01-92
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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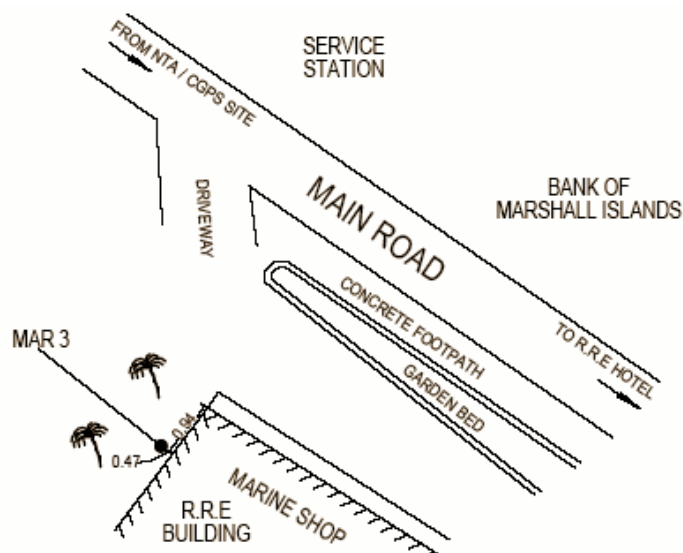
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.
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<i>Country:</i> Republic of Marshall Islands <i>Atoll:</i> Majuro	<i>City:</i> Uliga
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Marking 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 1.0m. 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: Nov 2007
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**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: MAR50

<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> 20-02-03
<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> Republic of Marshall Islands <i>Atoll:</i> Majuro	<i>City:</i> Uliga
<u>Marking and locality sketch</u> Bench Mark: 2.0m of 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 0.50m. Top of mark 0.1m below ground level. Locality sketch: Mark approximately 1050m from the tide gauge station.	
Not to scale Distances in Metres Magnetic bearings	
Approved by: Geoscience Australia / SOPAC	
Date: Nov 2007	



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



Survey Bench Mark Record

Bench Mark Number: MAR51

<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> 20-02-03
<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> Republic of Marshall Islands <i>Atoll:</i> Majuro	<i>City:</i> Uliga
<u>Marking and locality sketch</u> Bench Mark: 3.6m of 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 0.50m. Top of mark 0.1m 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: Nov 2007	



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



Survey Bench Mark Record

Bench Mark Number: MAR52

<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> 20-02-03
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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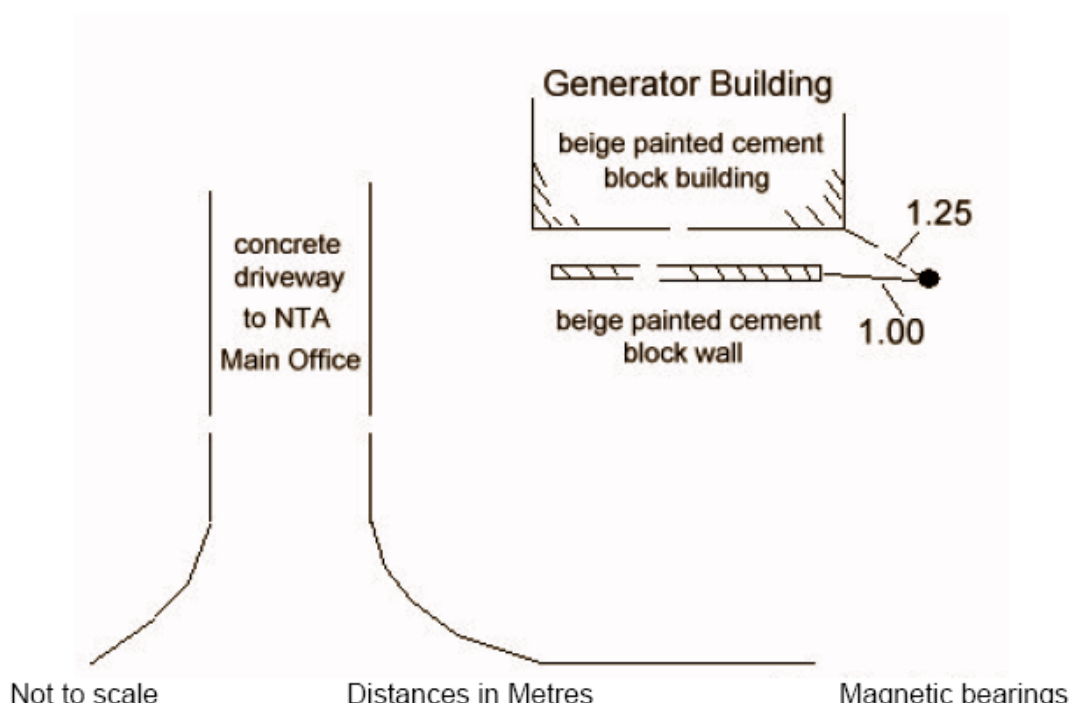
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.
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<i>Country:</i> Republic of Marshall Islands <i>Atoll:</i> Majuro	<i>City:</i> Uliga
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Marking 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 0.50m. Top of mark 0.3m below ground level.

Locality sketch: Mark approximately 2350m from the tide gauge station.



Approved by: Geoscience Australia / SOPAC	Date: Nov 2007
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**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: MAR100

<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> 29-09-07
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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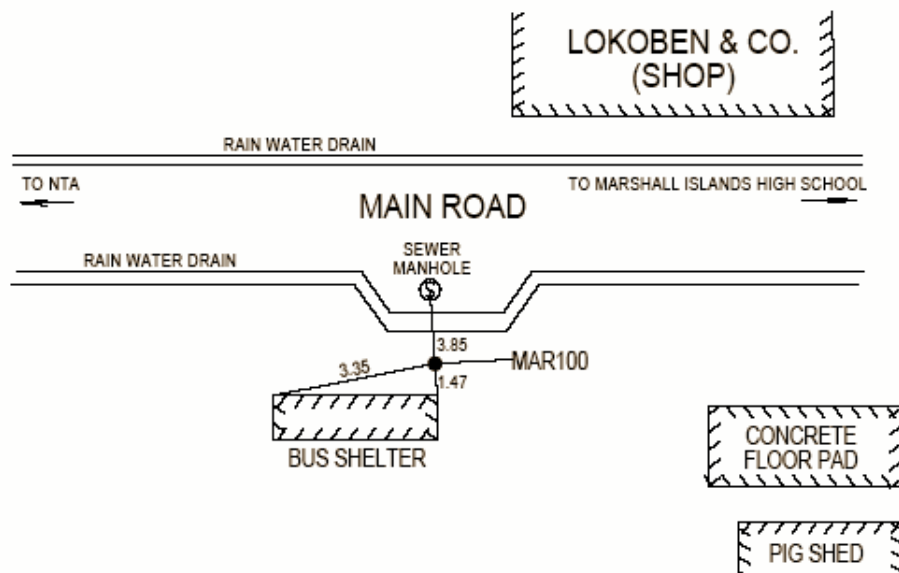
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.
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<i>Country:</i> Republic of Marshall Islands <i>Atoll:</i> Majuro	<i>City:</i> Uliga
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Marking and locality sketch

Bench Mark: 6.8m 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.

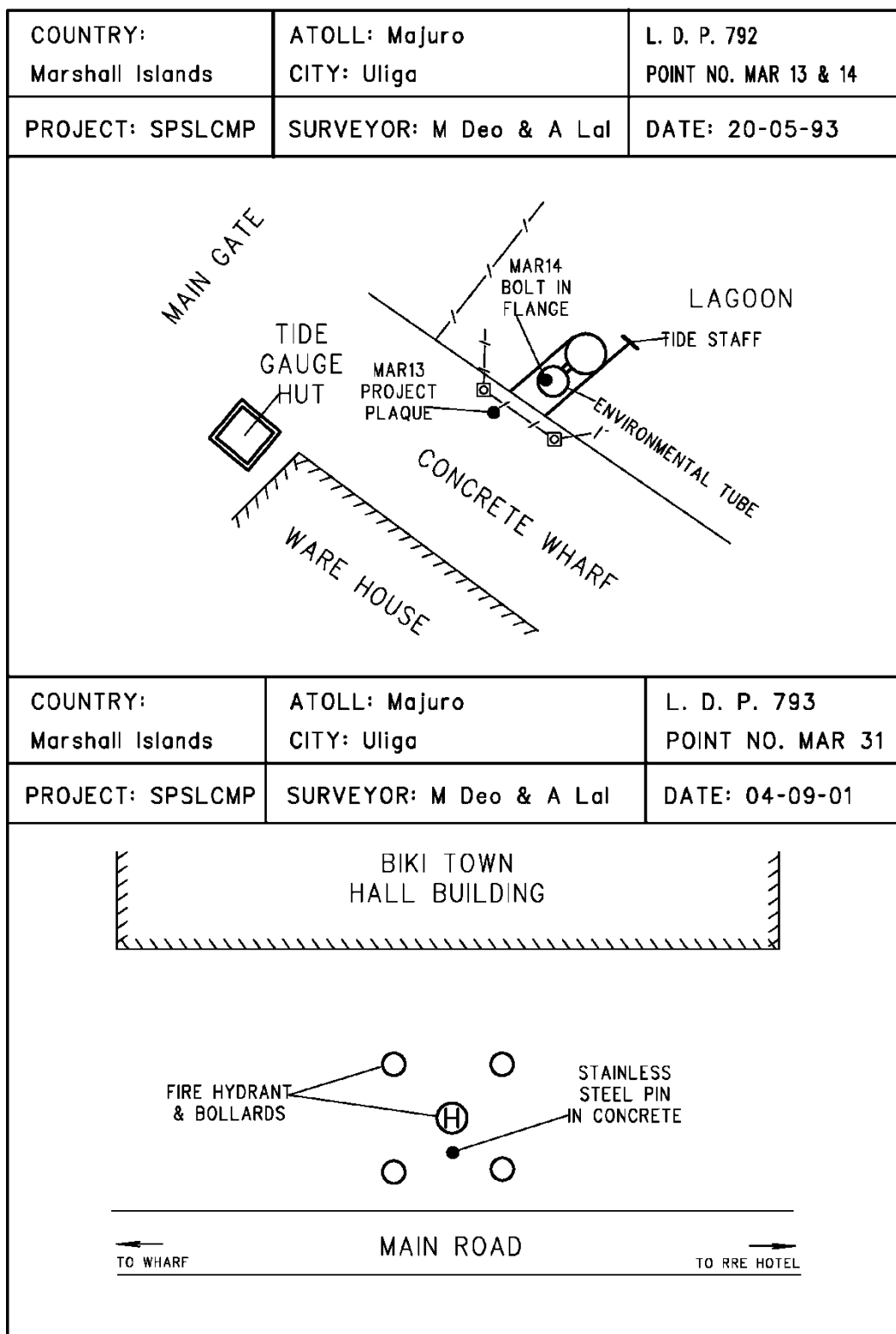
Locality sketch: Mark approximately 1140m from the tide gauge station.



Not to scale	Distances in Metres	Magnetic bearings
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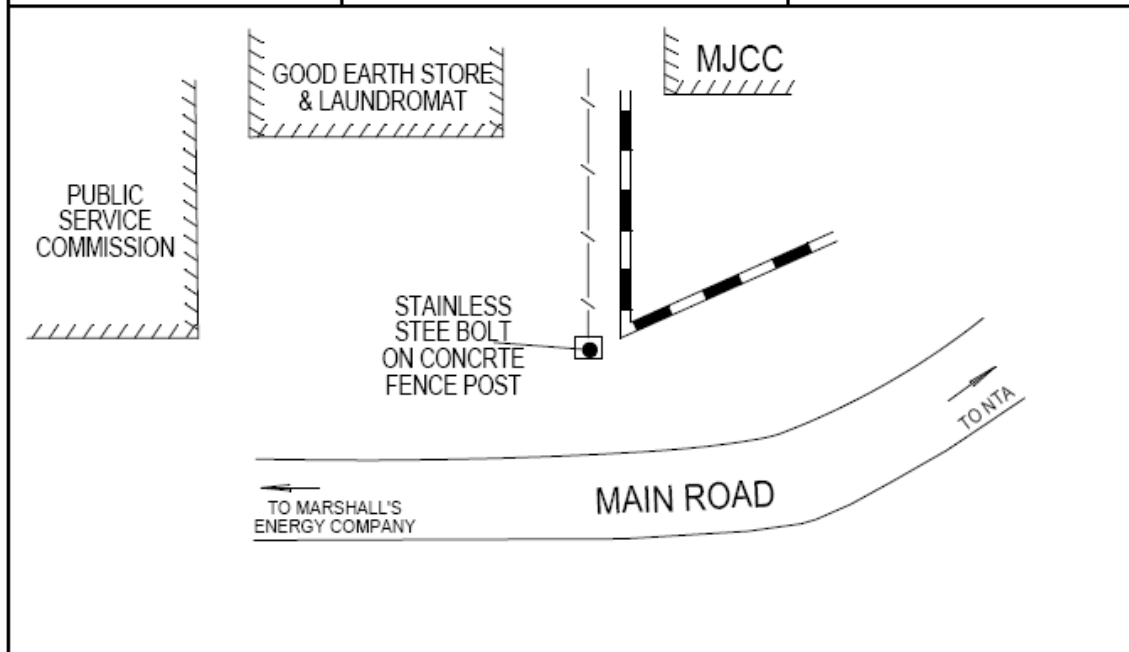
Approved by: Geoscience Australia / SOPAC	Date: Nov 2007
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5 Permanent Holding Mark Locality Diagrams

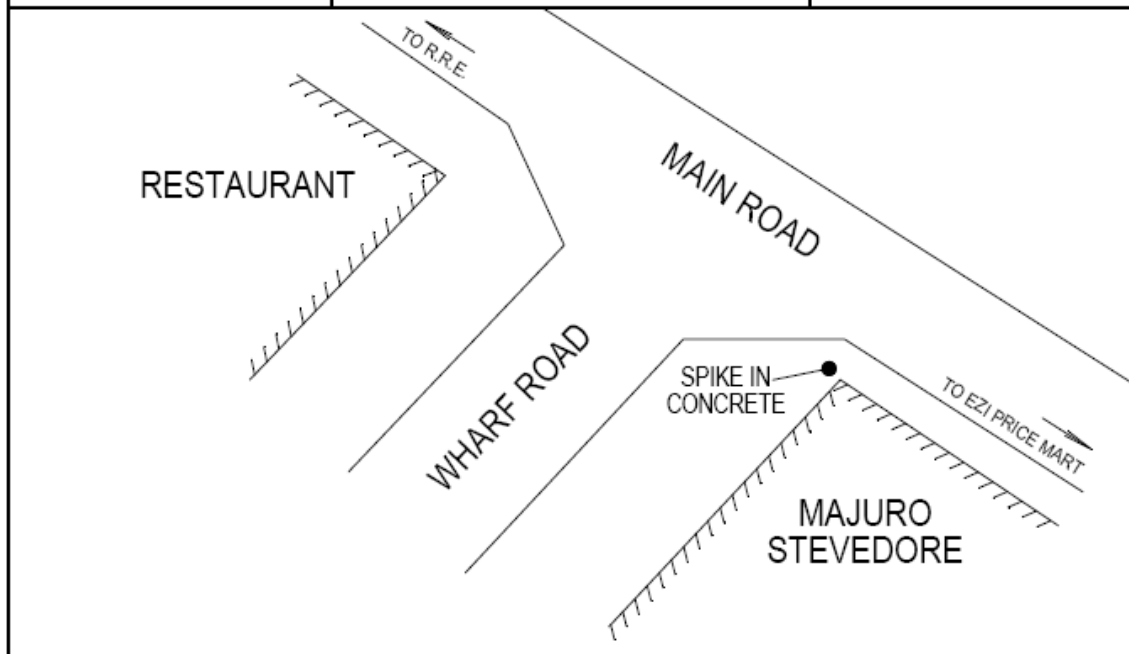


COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 794 POINT NO. MAR 36
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 17-02-03
The diagram for Point MAR 36 shows a plan view of a survey area. On the left is 'J's Discount Store' represented by a hatched L-shaped area. To its right is a 'STAINLESS STEE BOLT IN CONCRETE' marked with a black dot. Further right is the 'ELECTRICITY SUB-STATION', a square area with a hatched border. Below these features is a horizontal line representing the 'MAIN ROAD'. Arrows on the road point left towards 'TO STATIONERY SHOP' and right towards 'TO ASSUMPTION CHURCH'.		
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 795 POINT NO. MAR 40
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 18-02-03
The diagram for Point MAR 40 shows a plan view. It features a large square area labeled 'ELECTRICITY SUB-STATION WHITE PAINTED CEMENT RENDERED BUILDING' with a hatched border. At the bottom-left corner of this building is a 'STAINLESS STEE BOLT IN CONCRETE' marked with a black dot. Below the building is a horizontal line for the 'MAIN ROAD'. Arrows on the road point left towards 'TO MARSHALL'S ENERGY CO.' and right towards 'TO STATIONERY SHOP'.		

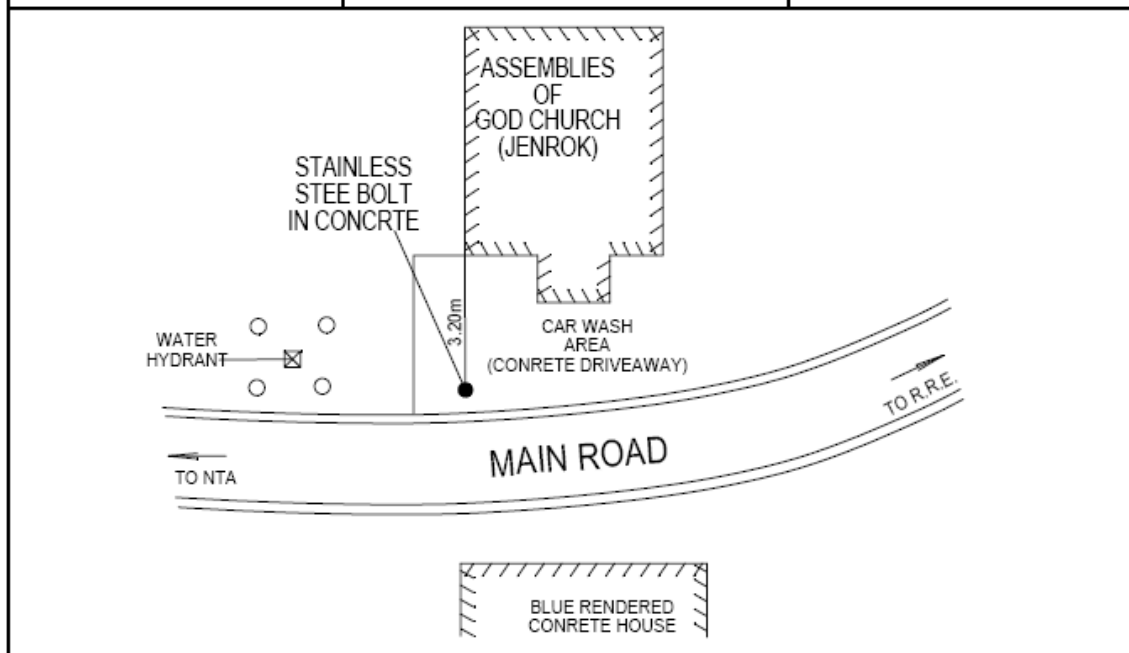
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 796 POINT NO. MAR 44
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 19-02-03



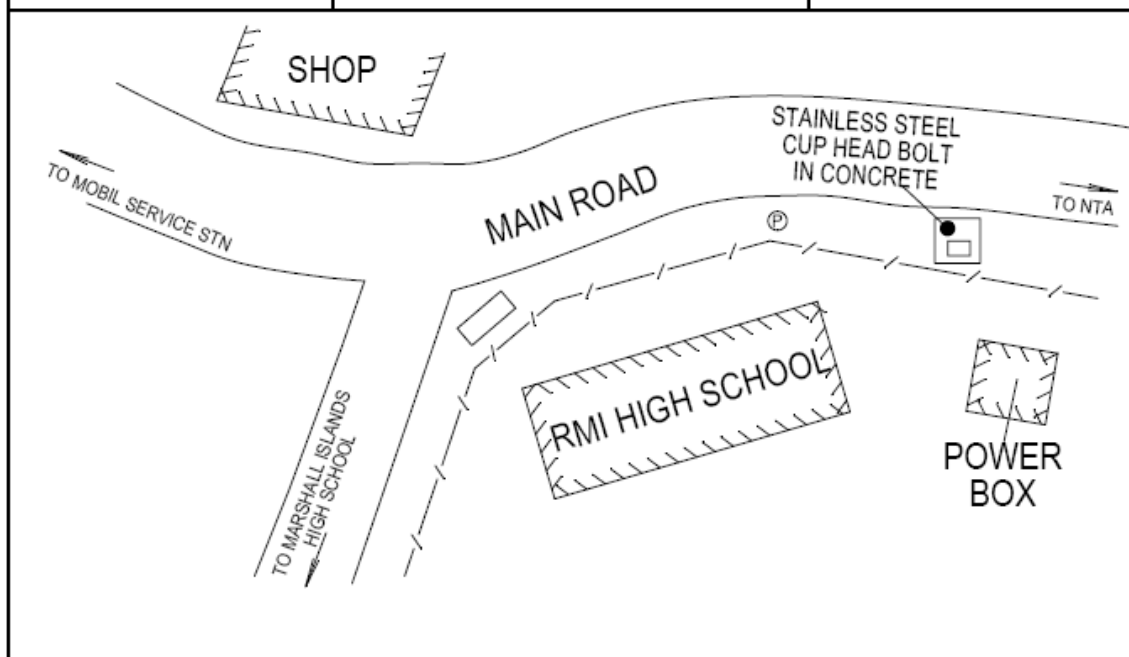
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 797 POINT NO. MAR 54
PROJECT: SPSLCMP	SURVEYOR: S Yates & A Lal	DATE: 28-04-06



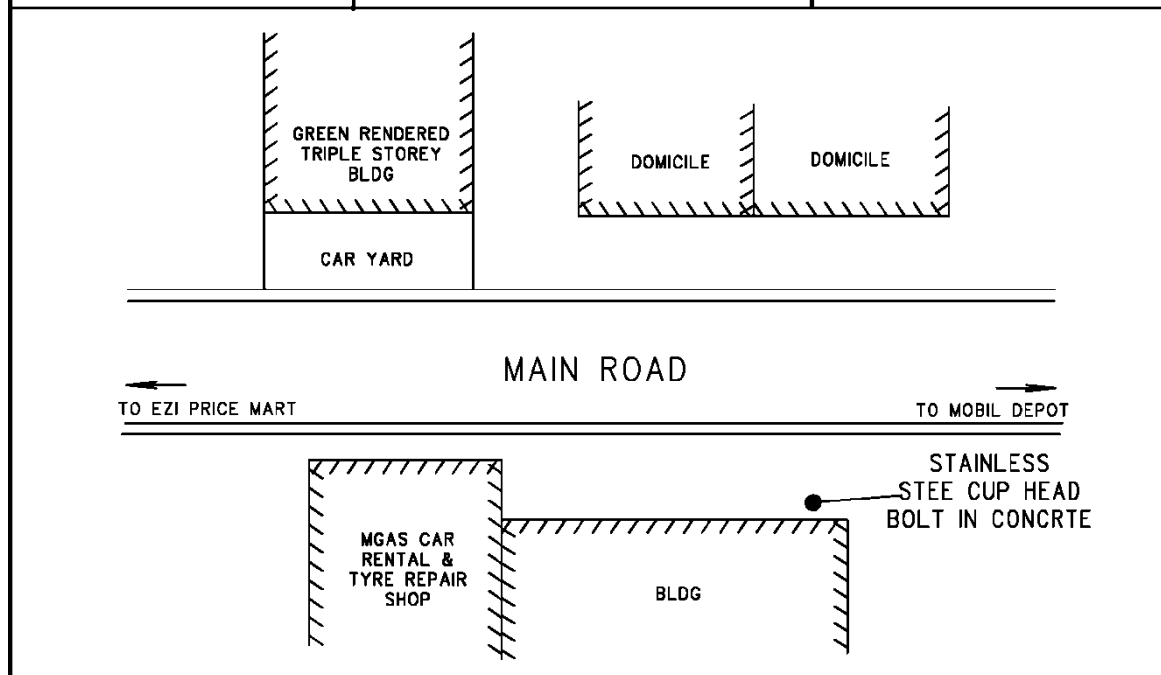
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 798 POINT NO. MAR 101
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 30-09-07



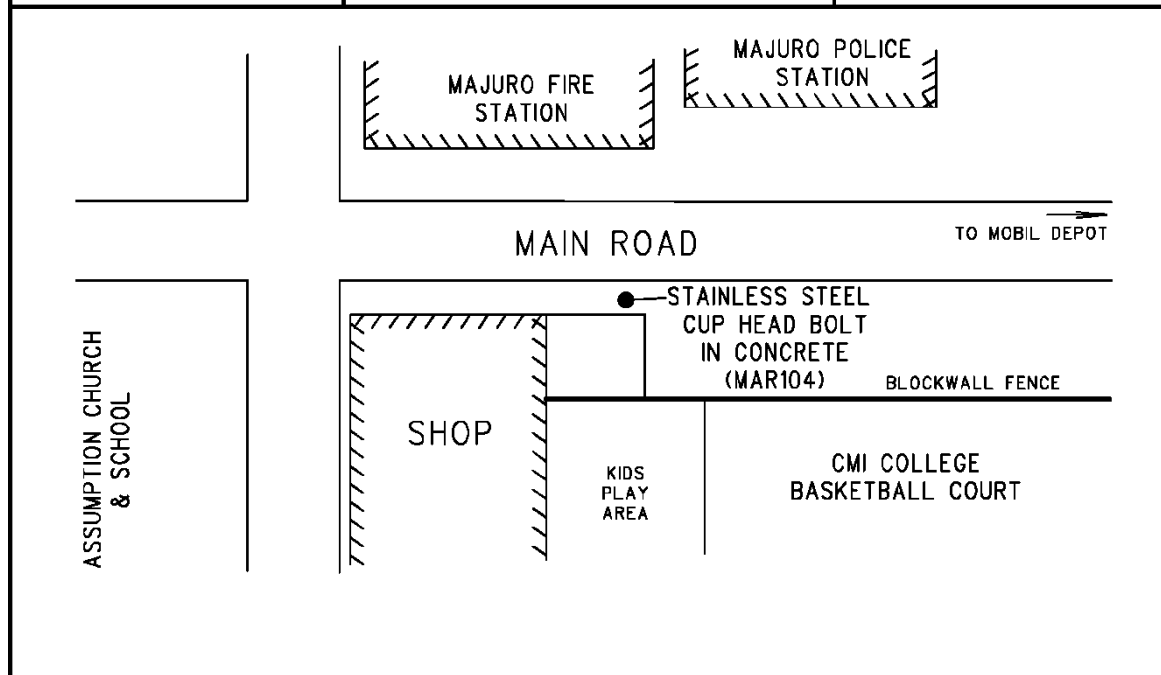
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 799 POINT NO. MAR 102
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 30-09-07



COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 800 POINT NO. MAR 103
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 19-02-03



COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 894 POINT NO. MAR 104
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09



COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 895 POINT NO. MAR 105
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09

LAGOON

GREEN HOUSE

MAIN ROAD

TO MARSHALLS ENERGY COMPANY TO MARSHALL AIRLINES

1.0m

STAINLESS
STEEL CUP HEAD
BOLT IN CONCRETE
(MAR105)

MOBIL
SERVICE
STN

FUEL TANK
BLDG

COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 896 POINT NO. MAR 106
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09

MAIN ROAD

STAINLESS
STEEL BOLT
IN CONCRETE
(MAR106)

CAR PARK

EZI PRICE MART
STORE

EZI PRICE MART
HOMEWARE STORE

DRIVE WAY



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



Survey Bench Mark Record

Bench Mark Number: MAR107

<i>Original Bench Mark Established by:</i> Geodetic Operations, National Geospatial Reference Systems (NGRS) Geoscience Australia Earth Monitoring Division (GEMD), Geoscience Australia.	<i>Date:</i> 04-04-09
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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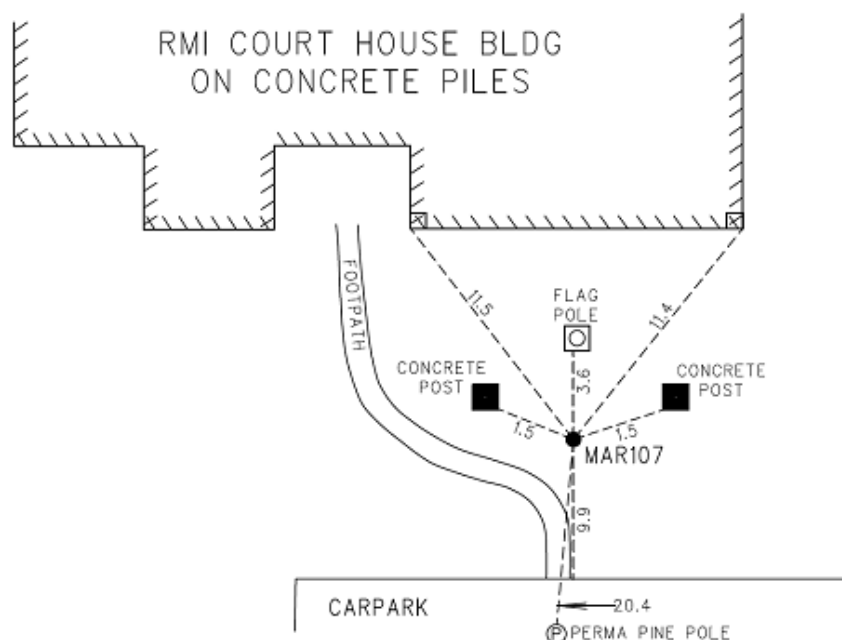
Notes / References: Deep Survey Benchmark
 This survey mark is not in a good locality for GPS occupation.

<i>Country:</i> Republic of Marshall Islands <i>Atoll:</i> Majuro	<i>City:</i> <u>Ulige</u>
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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, for 0.5m. Top of mark
 0.05m below ground level.

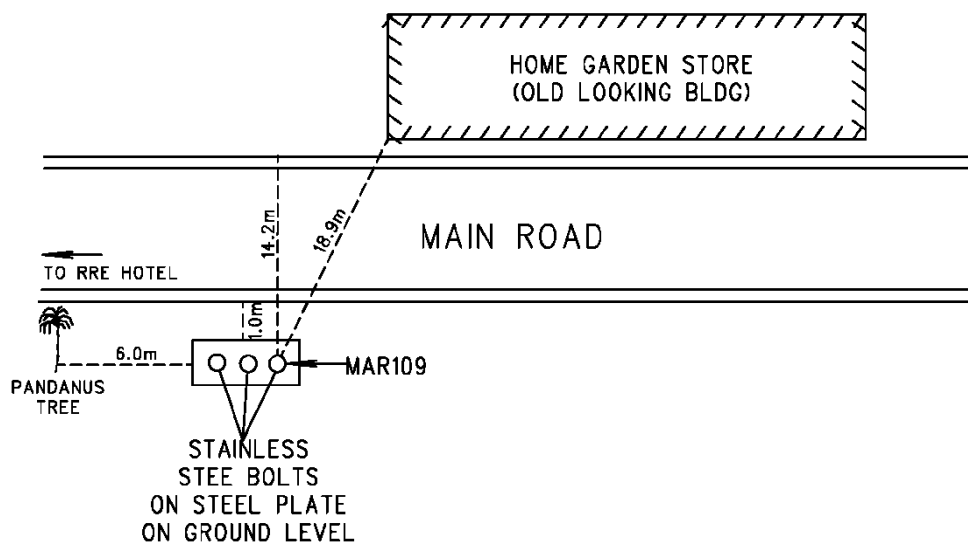
Locality sketch: Mark approximately 160m from the tide gauge station.



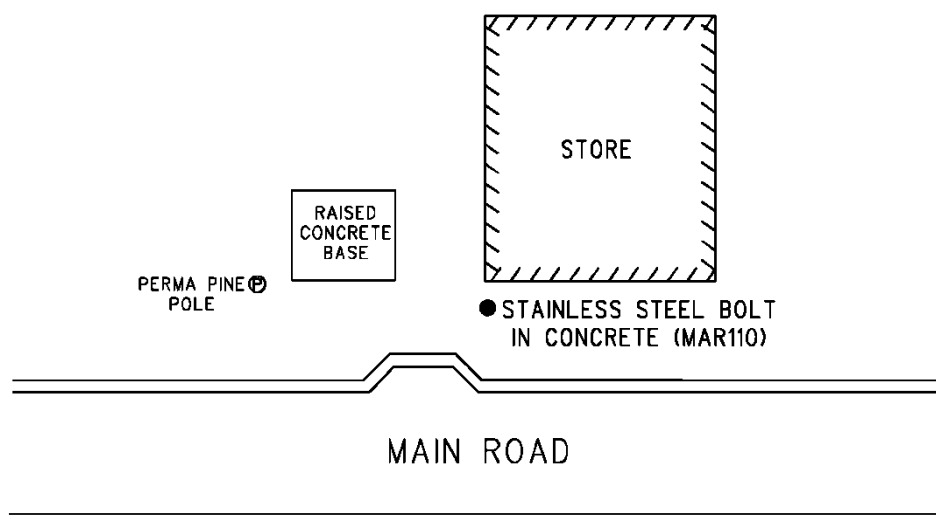
Not to scale	Distances in Metres	Magnetic bearings
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Approved by: Geoscience Australia / SOPAC	Date: April 2009
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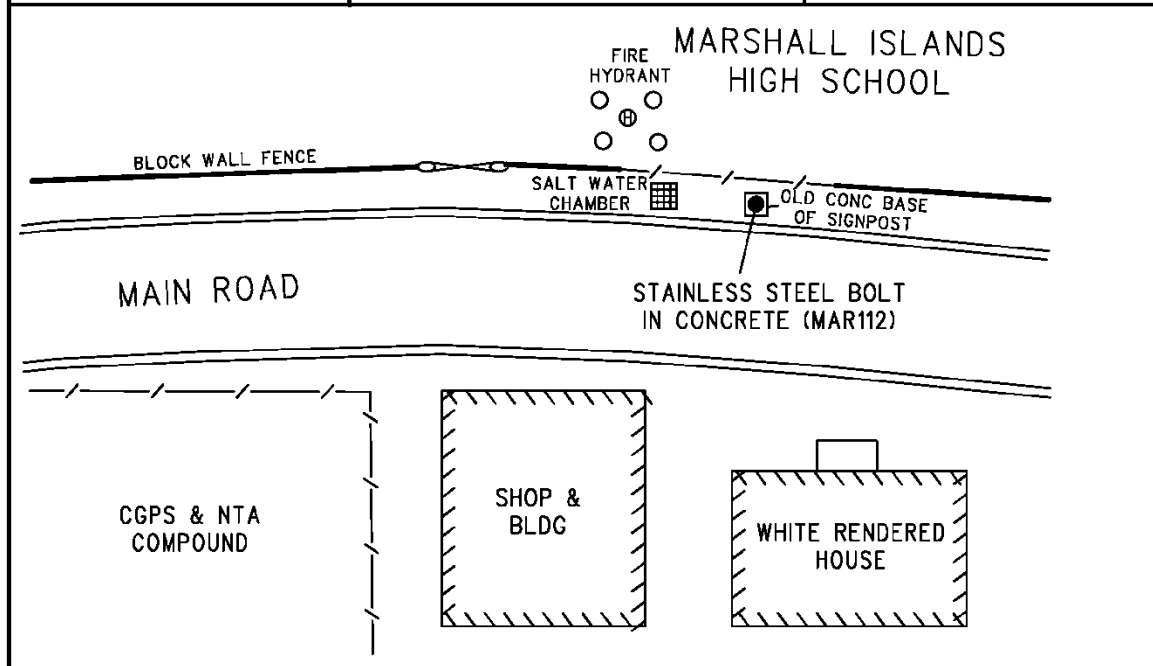
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 897 POINT NO. MAR 109
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09



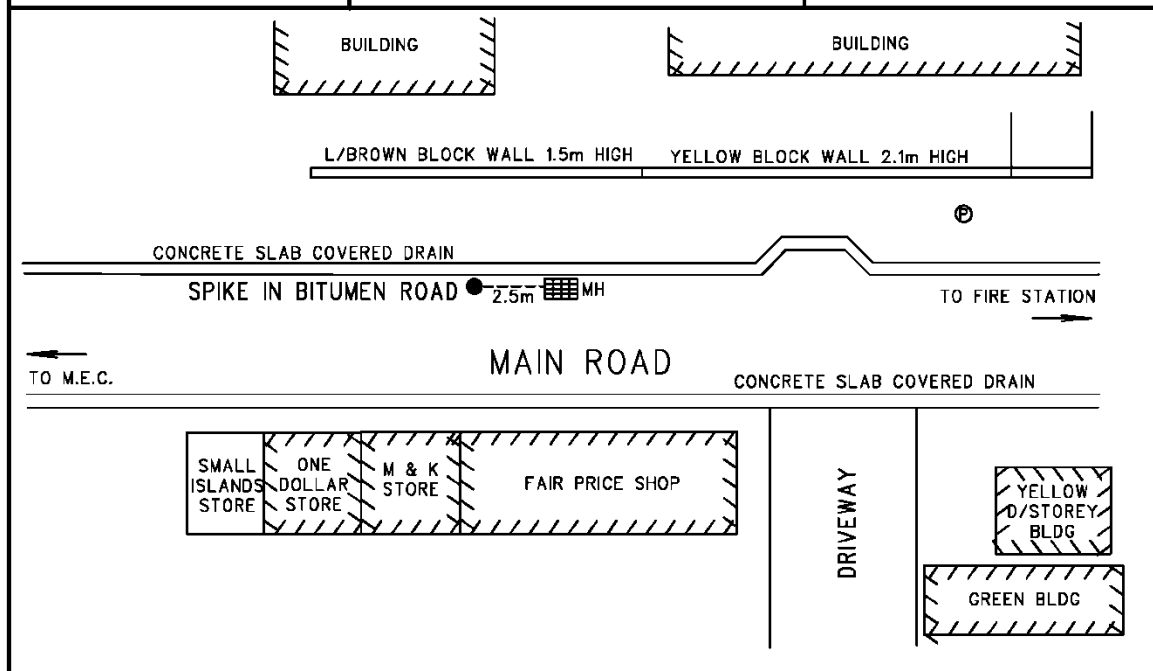
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 898 POINT NO. MAR 110
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09



COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 899 POINT NO. MAR 112
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09



COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 900 POINT NO. MAR 113
PROJECT: SPSLCMP	SURVEYOR: N Brown & A Lal	DATE: 24-10-10

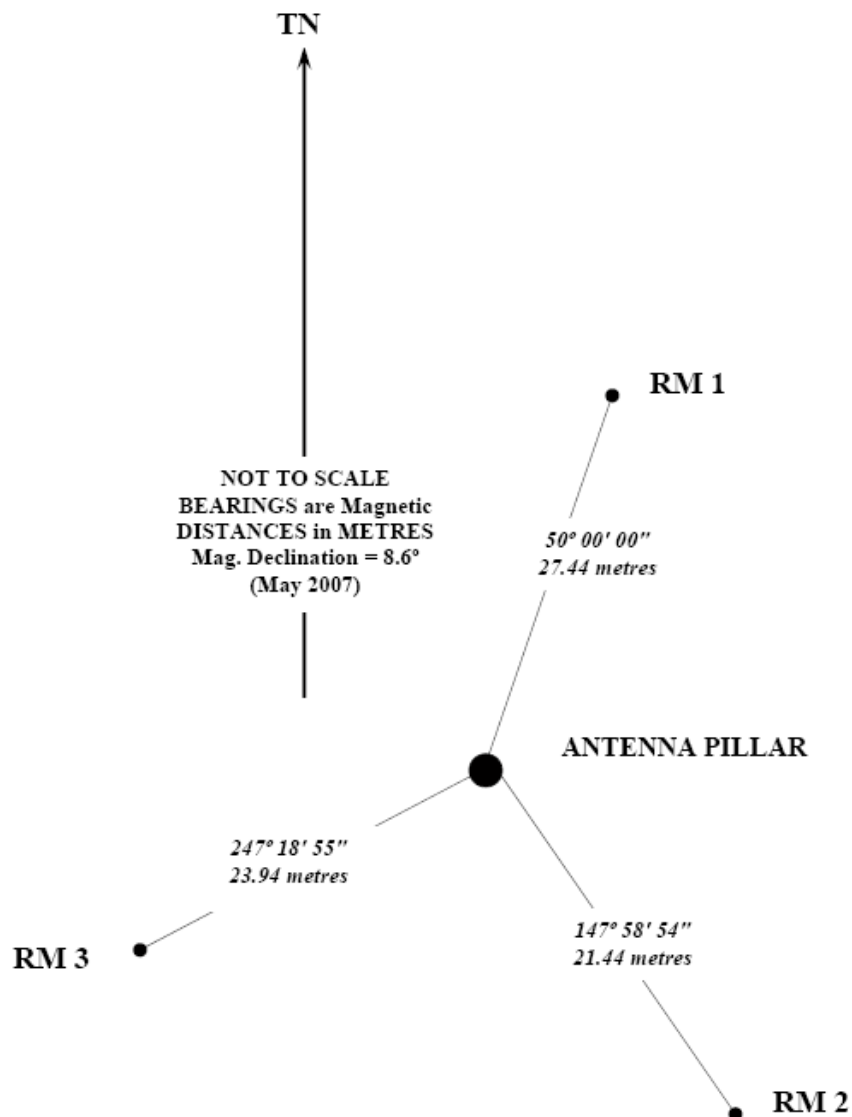


6 MAJUBM and MAJU Reference Mark Locality Diagrams

Marshall Islands CGPS Station, Rita, Majuro – Reference Marks

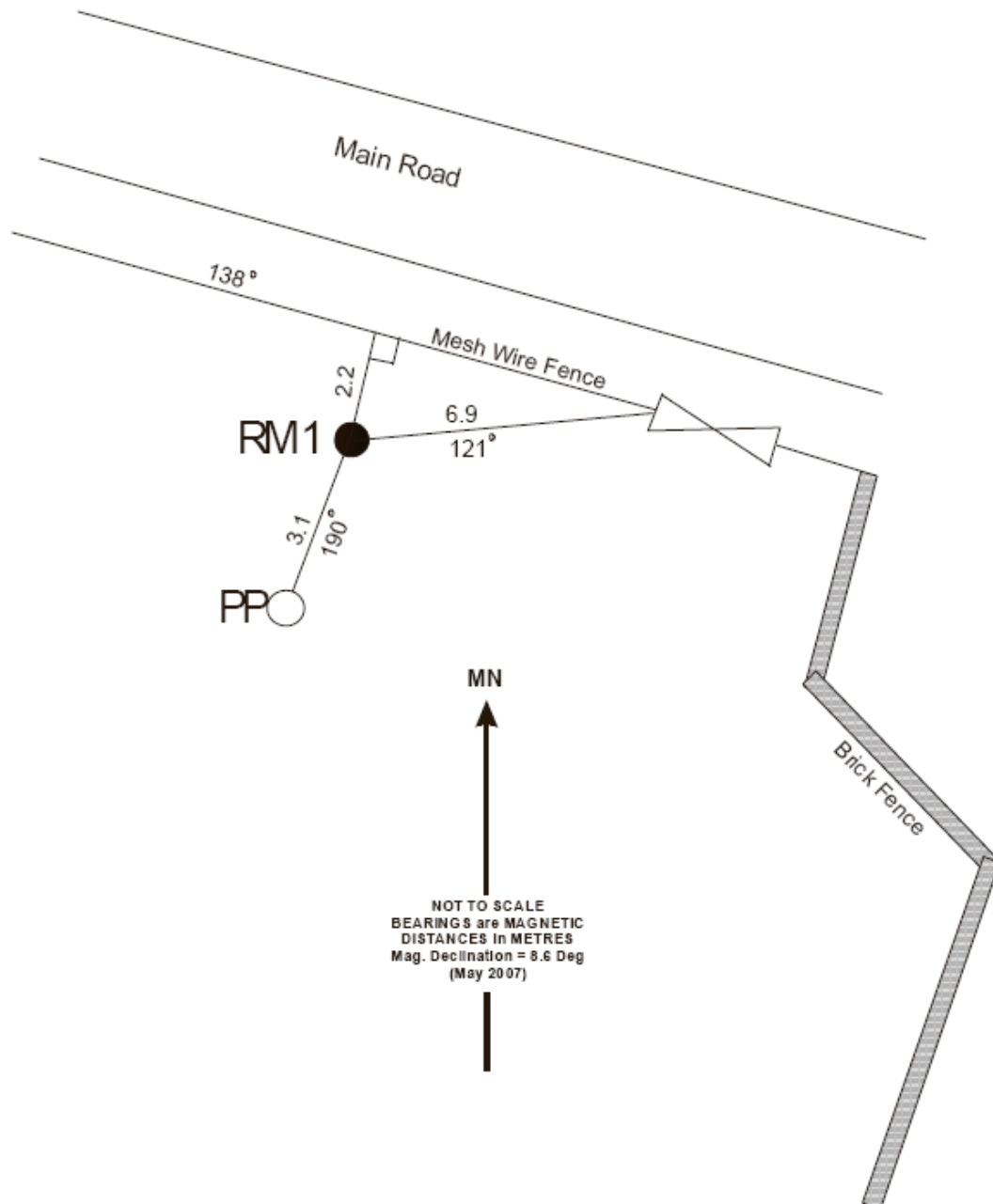
REFERENCE MARKS

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 150 mm below ground level.



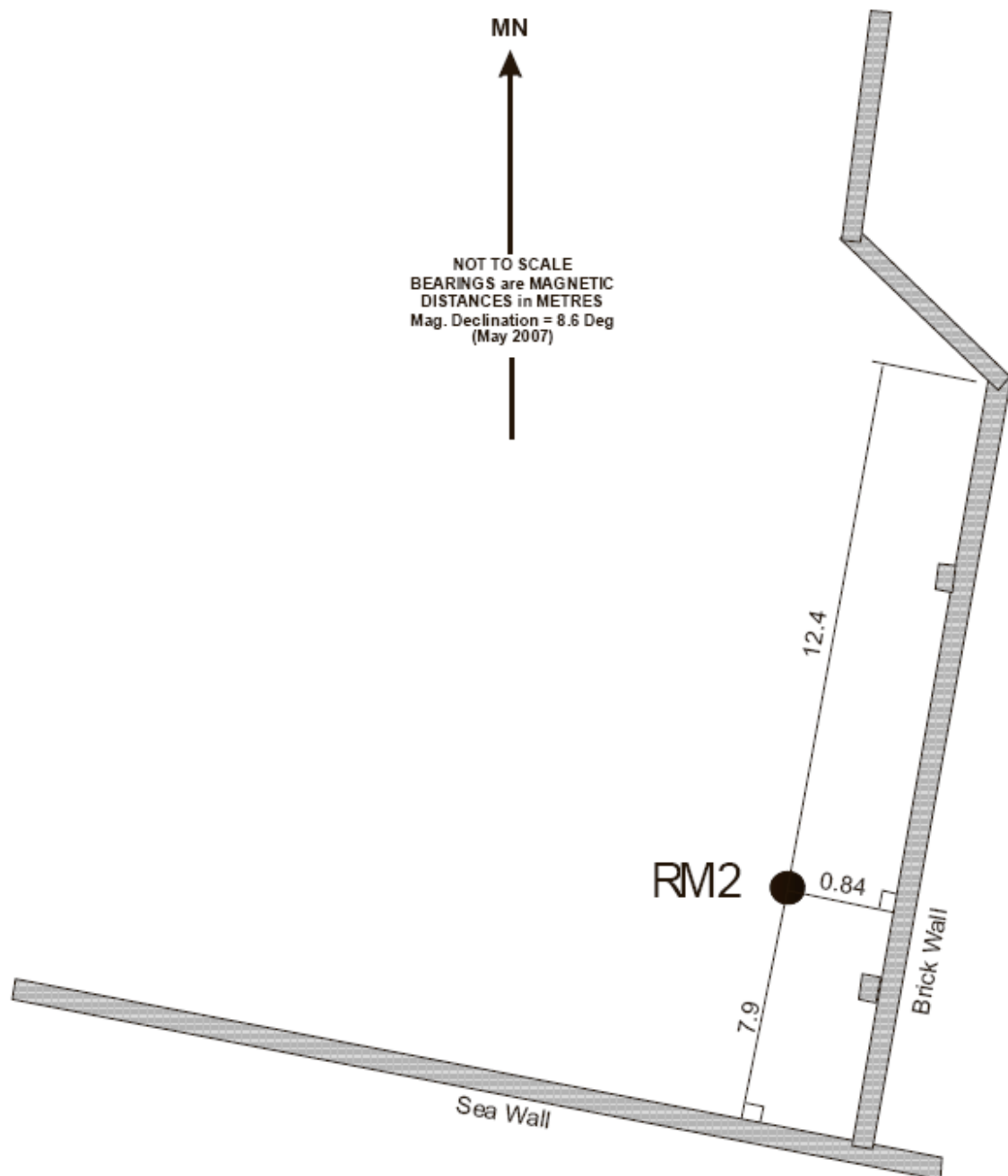
Marshall Islands CGPS Station, Rita, Majuro – RM 1 Location Diagram

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 150 mm below ground level.



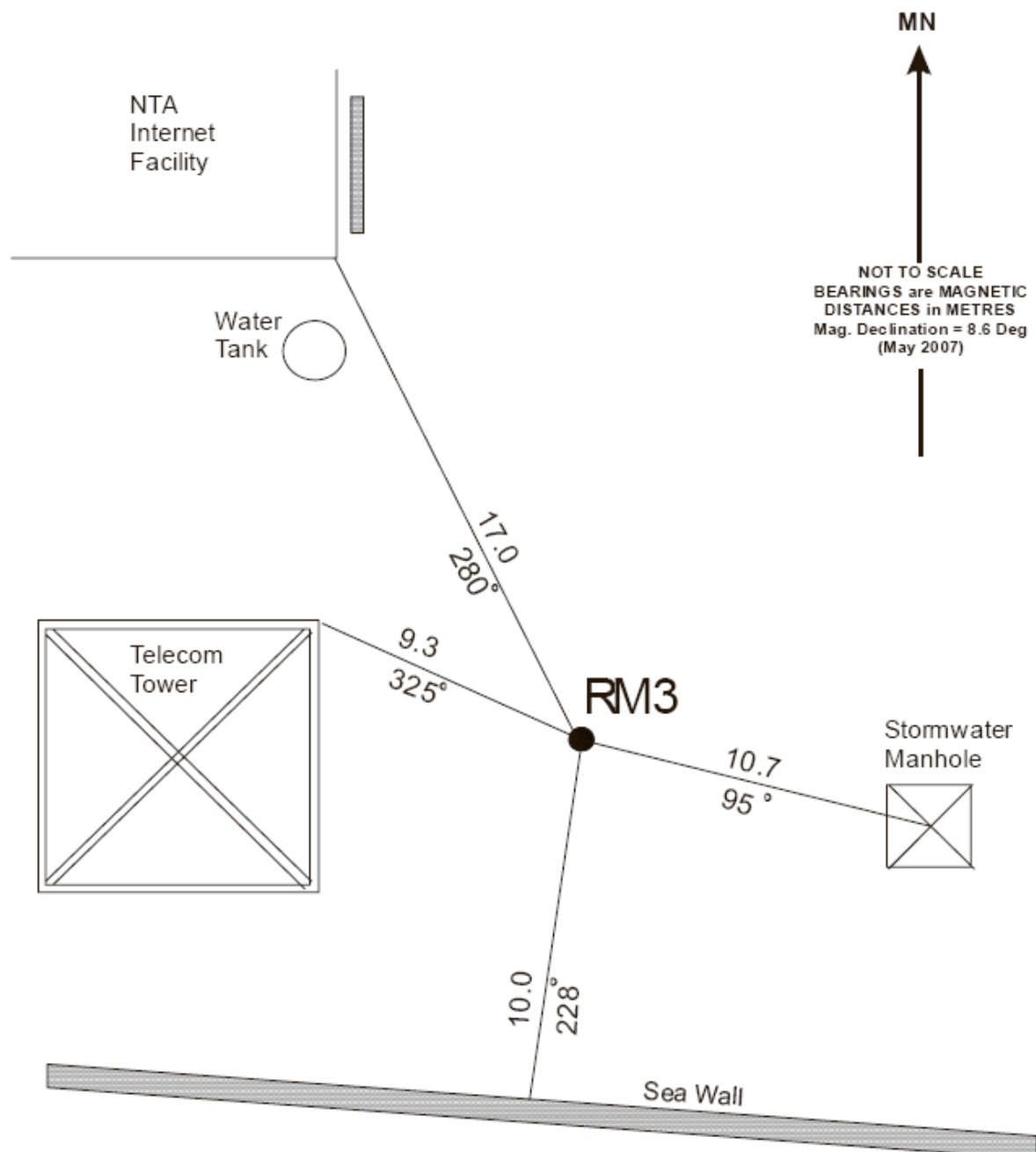
Marshall Islands CGPS Station, Rita, Majuro – RM 2 Location Diagram

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 150 mm below ground level.



Marshall Islands CGPS Station, Rita, Majuro – RM 3 Location Diagram

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 150 mm 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.