Australian Government

Geoscience Australia

South Pacific Sea Level and Climate Monitoring Project (SPSLCMP)

Survey Report

EDM Height Traversing
Levelling Survey

Majuro, Marshall Islands

April 2009

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 # 69400

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Introduction

This report outlines the level survey completed during the visit to Majuro Atoll, Marshall Islands during 27 March to 4 April, 2009.

Personnel: Manoj Deo – Surveyor - **GEOSCIENCE AUSTRALIA**
Andrick Lal – Surveyor - **SOPAC**

This is the third EDM Height Traversing levelling survey of the deep driven bench mark array in Majuro Atoll, Marshall Islands. These surveys follow the eight previous surveys from 1993 to February 2003, undertaken by the National Tidal Centre (NTC) using the Precise Differential Levelling technique.

The Survey

The EDM Height Traversing level survey was carried out between the 6 deep driven bench marks:

MAR3
MAR15
MAR50
MAR51
MAR52
MAR100
MAR107 (new)

Included in the survey was the newly established CGPS Station bench mark, **MAJUBM**, a new deep driven bench mark **MAR107** and the SEAFRAME Sensor Bench Mark **MAR14** at the Tide Gauge.

All the deep driven bench marks were located and found in good order and undisturbed, except **MAR3**, which is now inside a building owned by Robert Reimers Enterprise. After persistent lobbying with the owner, permission was granted to excavate part of the floor to uncover the benchmark. Fortunately, the benchmark was found and a levelling connection was made successfully.

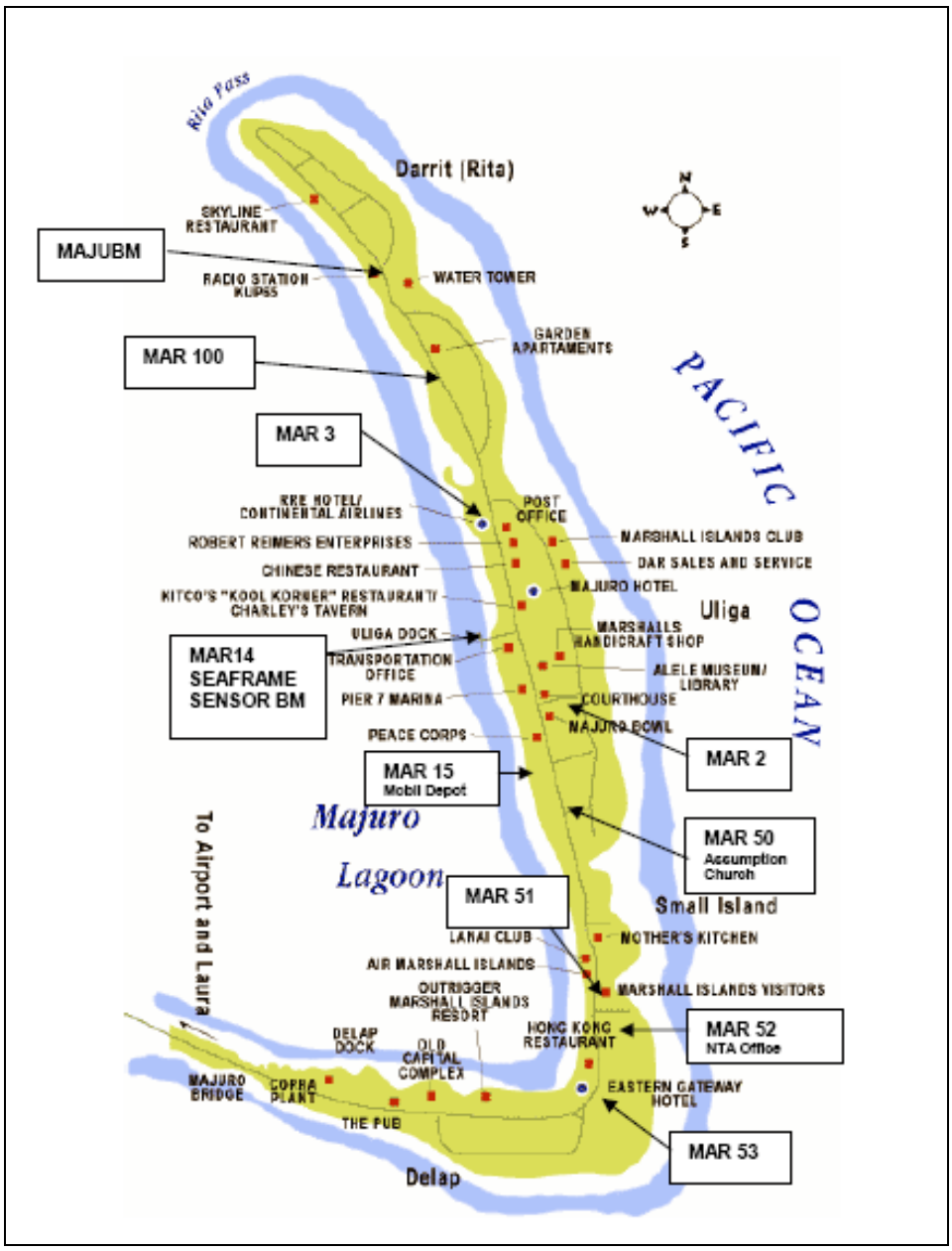
***Figure 1**: Location of MAR3 inside the Robert Reimers Building*

Temporary holding marks **MAR104, MAR105, MAR106, MAR108 – MAR111** were placed during this survey, which consists of stainless steel bolt 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 **1mm** $\sqrt{\mathbf{K}}$ or better was achieved, where K is distance in kilometres. This is well within the Project Specification of **2mm** $\sqrt{\mathbf{K}}$

Bench Mark Locality Map



The Marshall Islands Datum

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

MAR3 is the adopted reference point for the survey with **RL = 1.6083385**.

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.

Equipment

LEICA Total Station Model TCA2003 (S/N 440883).
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 Marshall 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 Meteorological Office and Marshall Islands National Telecommunications Authority (NTA).
Personnel consulted during the visit were:
Mr. Lee Jacklick – Meteorological Office
Mr. Reginald White – Meteorological Office
Mr. Melvin Aliven – NTA

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

Issues

MAR3 is now inside a building and permission for occupying the benchmark can be obtained from Mr. Rod Reimers, email: rod.reimers@rreinc.com. 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.

Description of Marks - Majuro, Marshall Islands

MAR3 is the bench mark held fixed with **RL = 1.6083385 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.

MAR15, MAR50, MAR51, MAR52, MAR100, MAR107 are all Deep driven BM's

MAR14 is the SEAFRAME Sensor Bench Mark

MAR13 is the Project Plaque point or Tide Sensor Bench Mark

MAJUBM is the Reference Bench Mark for the CGPS Pillar.

MAJU is the CGPS mark.

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

Points MAR101-MAR106, MAR108-MAR111, MAR25, MAR31, MAR36, MAR40 and MAR44 are holding marks comprising of stainless steel screw in concrete.

Table of Results for 2009 and Comparisons between 2007 and 2009

Marshall Islands 2009 EDM Height Traversing Levelling Comparison 2009 - 2007 and Table of Results								
MAR3 - Adopted fixed height (MSL) = 1.6083385m								
Backsight	Foresight	Levelled Height Difference	Reduced Level 2009	Misclose (mm)	Distance (km)	1mm√K	Reduced Level 2007	Difference (mm) 2009 - 2007
MAR3			1.60834				1.6083	0.0000
MAR108	MAR108	0.1347	1.74305	0.081	0.025	0.157		
MAR109	MAR109	0.0055	1.74859	0.449	0.199	0.446		
MAR101	MAR101	0.0400	1.78858	-0.183	0.207	0.455	1.7891	-0.0005
MAR100	MAR100	-0.3064	1.48222	0.265	0.242	0.492	1.4826	-0.0004
MAR110	MAR110	0.4535	1.93570	-0.182	0.208	0.456		
MAR102	MAR102	-0.1486	1.78707	-0.075	0.175	0.419	1.7904	-0.0034
MAR111	MAR111	-0.0792	1.70784	0.322	0.238	0.487		
MAJUBM	MAJUBM	1.4342	3.14204	-0.199	0.084	0.291	3.1417	0.0003
	MAJU	0.9443	4.08633	-0.025	0.020	0.140	4.0860	0.0003
MAR54			1.88858				1.8883	0.0003
MAR31	MAR31	-0.0887	1.79987	0.278	0.217	0.466		
	MAR108	-0.0568	1.74305	0.029	0.182	0.426		
MAR54			1.88858				1.8883	0.0003
	MAR107	-0.2237	1.66485	-0.139	0.048	0.219		

MAR54			1.88858				1.8883	0.0003
MAR13	MAR13	-0.2967	1.59192	0.291	0.168	0.410	1.5922	-0.0003
	MAR14	1.2009	2.79287				2.7936	-0.0008
MAR15			1.74360				1.7424	0.0012
MAR25	MAR25	0.1641	1.90770	-0.045	0.012	0.111		
MAR103	MAR103	0.0885	1.99623	-0.173	0.153	0.391	1.9954	0.0009
MAR106	MAR106	-0.0642	1.93206	-0.121	0.215	0.463		
	MAR54	-0.0435	1.88858	0.050	0.194	0.441	1.8883	0.0003
MAR25			1.90770					
MAR104	MAR104	0.0366	1.94434	0.448	0.209	0.458		
MAR50	MAR50	-0.4346	1.50974	0.035	0.045	0.213	1.5091	0.0006
MAR36	MAR36	0.1508	1.66054	0.123	0.114	0.337	1.6660	-0.0055
MAR40	MAR40	0.1080	1.76854	0.559	0.413	0.642	1.7668	0.0018
MAR105	MAR105	0.0636	1.83211	0.125	0.197	0.444		
MAR51	MAR51	-0.0111	1.82103	0.156	0.107	0.327	1.8186	0.0024
MAR44	MAR44	0.2191	2.04017	0.119	0.147	0.384	2.0390	0.0012
	MAR52	-0.7029	1.33728	-0.090	0.189	0.435	1.3341	0.0032
MAJUBM			3.1420				3.1417	0.0003
	RM1	-1.8151	1.3269				1.3265	0.0004
	RM2	-0.1462	1.1807				1.1805	0.0003
	RM3	-0.1843	0.9964	0.003	0.1076	0.328	0.9962	0.0003
Misclose for all bays levelled =				2.098	4.008	2.002	*Allowable miclose is 2√K = 4.004mm*	
An internal precision of 1mm√K was achieved for all bays levelled. This is within the project specification of 2mm√K								

Combined Comparisons 1993 to 2009

MARSHALL ISLANDS - Comparison of the RL's for Precise Differential Levelling (1993 to 2006) and EDM Height Traversing (2006 to 2009)

YEAR	MARK													
	MAR2	MAR3	MAR13	MAR14	MAR15	MAR50	MAR51	MAR52	MAJUBM	MAJU	RM1	RM2	RM3	MAR53
1993.4	1.6025	1.6083	1.5923	2.7977										
1994.5	1.6032	1.6083	1.5932	2.7990										
1995.5	1.6032	1.6083	1.5926	2.7978	1.7517									
1997.0	1.6039	1.6083	1.5930	2.7987	1.7512									
1998.6	1.6037	1.6083	1.5924	2.7977	1.7507									
2000.3	1.6040	1.6083	1.5923	2.7970	1.7501									
2001.7	1.6040	1.6083	1.5923	2.7984	1.7497									
2003.1	1.6046	1.6083	1.5928	2.7932	1.7453	1.5100	1.8232	1.3342						1.4846
2006.3		1.6083	1.5930	2.7915	1.7436	1.5097	1.8246	1.3371						1.4879
2006.3 EDM		1.6083	1.5919	2.7901	1.7435	1.5099	1.8237	1.3352						1.4859
2007.8 EDM		1.6083	1.5922	2.7936	1.7424	1.5091	1.8186	1.3341	3.1417	4.0860	1.3265	1.1805	0.9962	
2009.2 EDM		1.6083	1.5919	2.7929	1.7436	1.5097	1.8210	1.3373	3.1420	4.0863	1.3269	1.1807	0.9964	

Marshall Islands – 2009 Reduced Levels

Date: 26 March – 4 April 2009

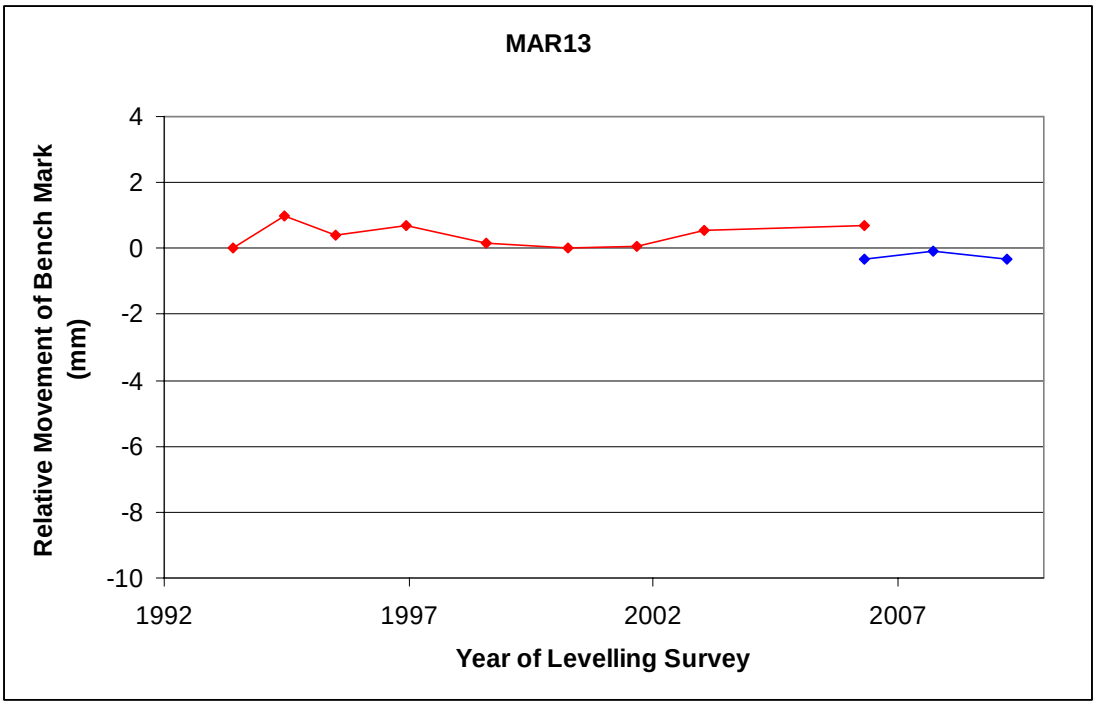
Datum: Mean Sea Level

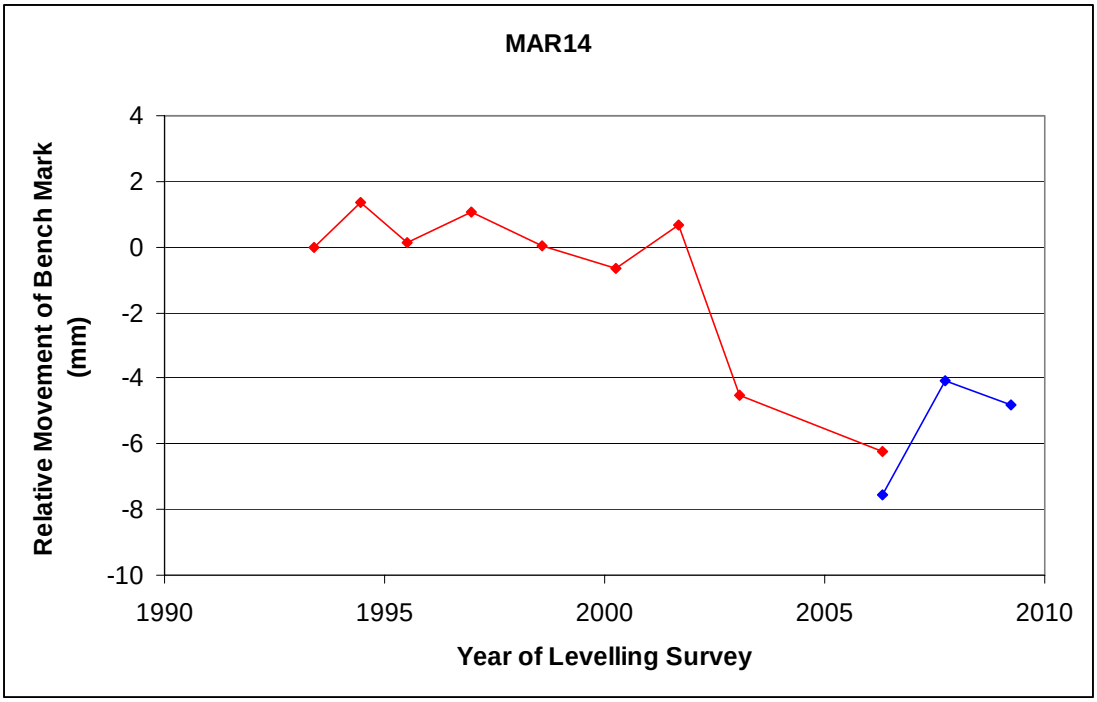
POINT#	2009 levelled diff. ht.	2009 RL	POINT#	2009 levelled diff. ht.	2009 RL
MAR3	0.0000	1.6083 (fixed)	MAR15	+0.1353	1.7436
MAR108	+0.1347	1.7430	MAR103	+0.3879	1.9962
MAR109	+0.1403	1.7486	MAR106	+0.3237	1.9321
MAR101	+0.1802	1.7886	MAR25	+0.2994	1.9077
MAR100	-0.1261	1.4822	MAR104	+0.3360	1.9443
MAR110	+0.3274	1.9357	MAR50	-0.0986	1.5097
MAR102	+0.1787	1.7871	MAR36	+0.0522	1.6605
MAR111	+0.0995	1.7078	MAR40	+0.1602	1.7685
MAJUBM	+1.5337	3.1420	MAR105	+0.2238	1.8321
MAJU	+2.4780	4.0863	MAR51	+0.2127	1.8210
MAR54	+0.2802	1.8886	MAR44	+0.4318	2.0402
MAR31	+0.1915	1.7999	MAR52	-0.2711	1.3373
MAR107	+0.0565	1.6648	RM1	-0.2814	1.3269
MAR13	-0.0164	1.5919	RM2	-0.4276	1.1807
MAR14	+1.1845	2.7929	RM3	-0.6119	0.9964

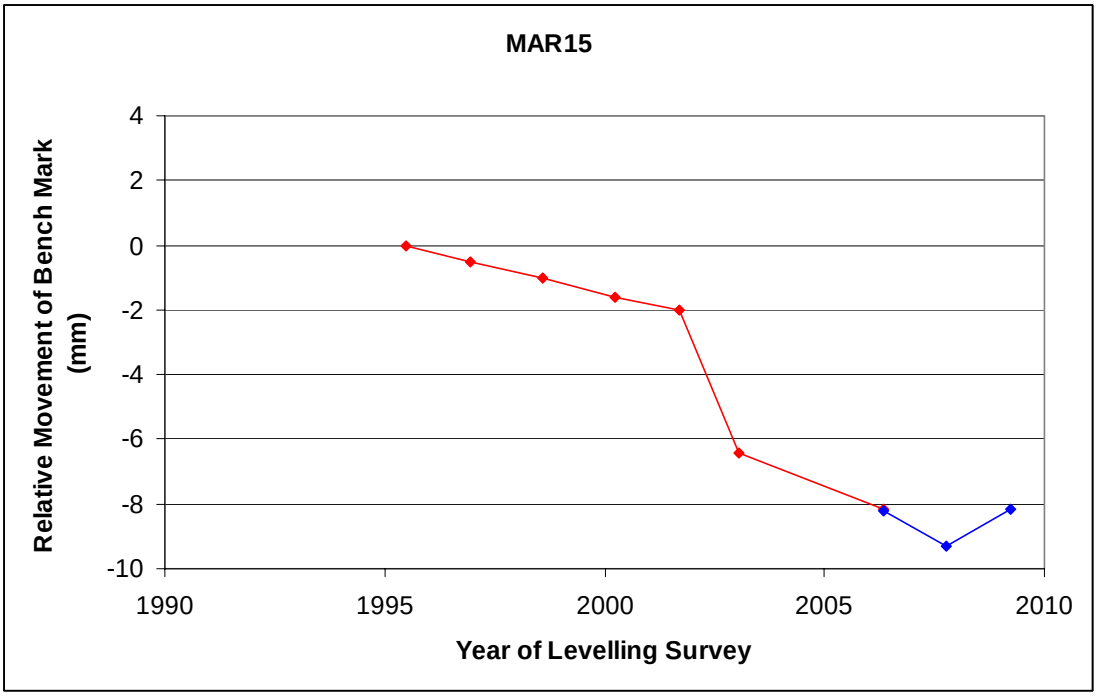
Time Series of Bench Mark Movement relative to the Fixed Deep driven Bench Mark – MAR3

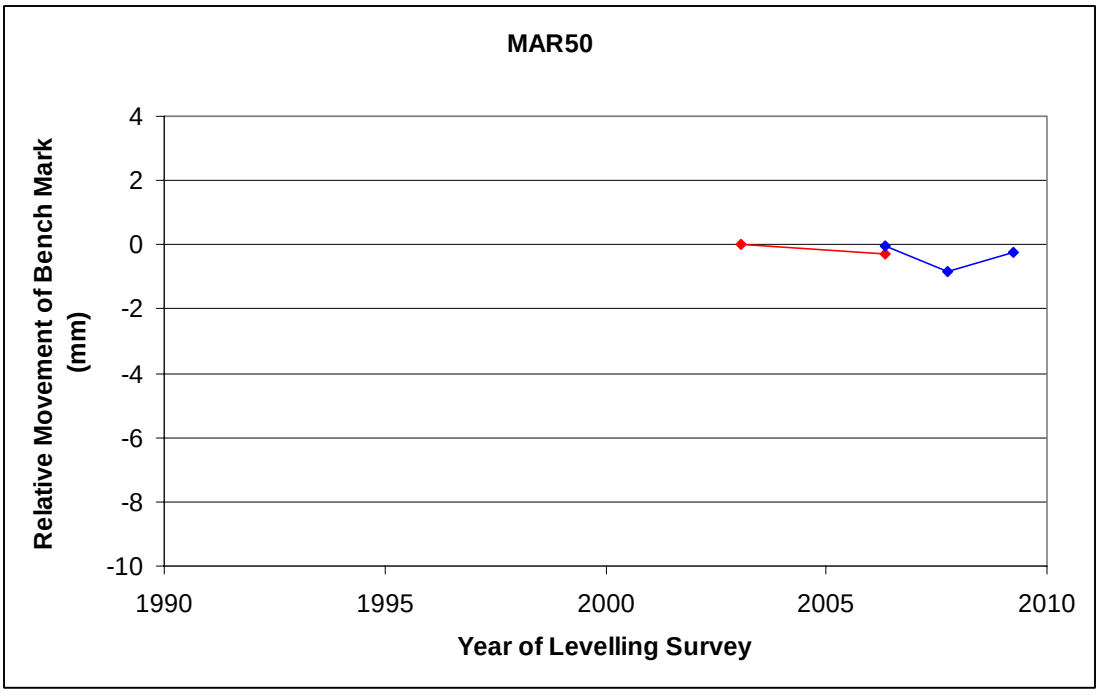
Precise Differential Levelling - 1993 to 2006

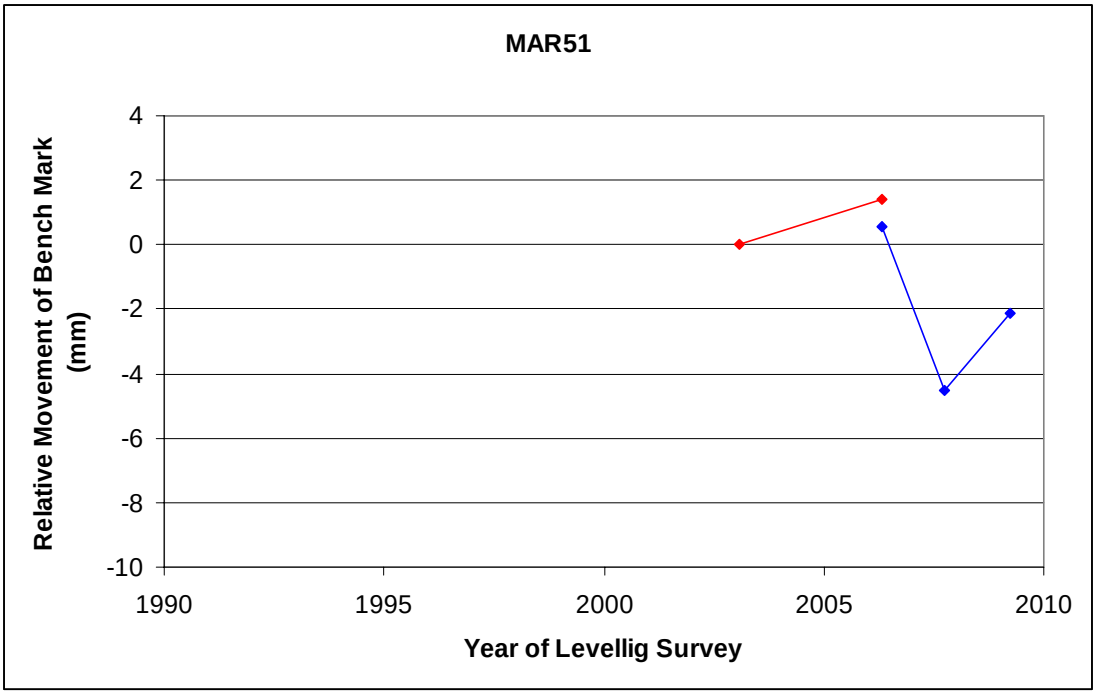
EDM Height Traversing - commenced 2006

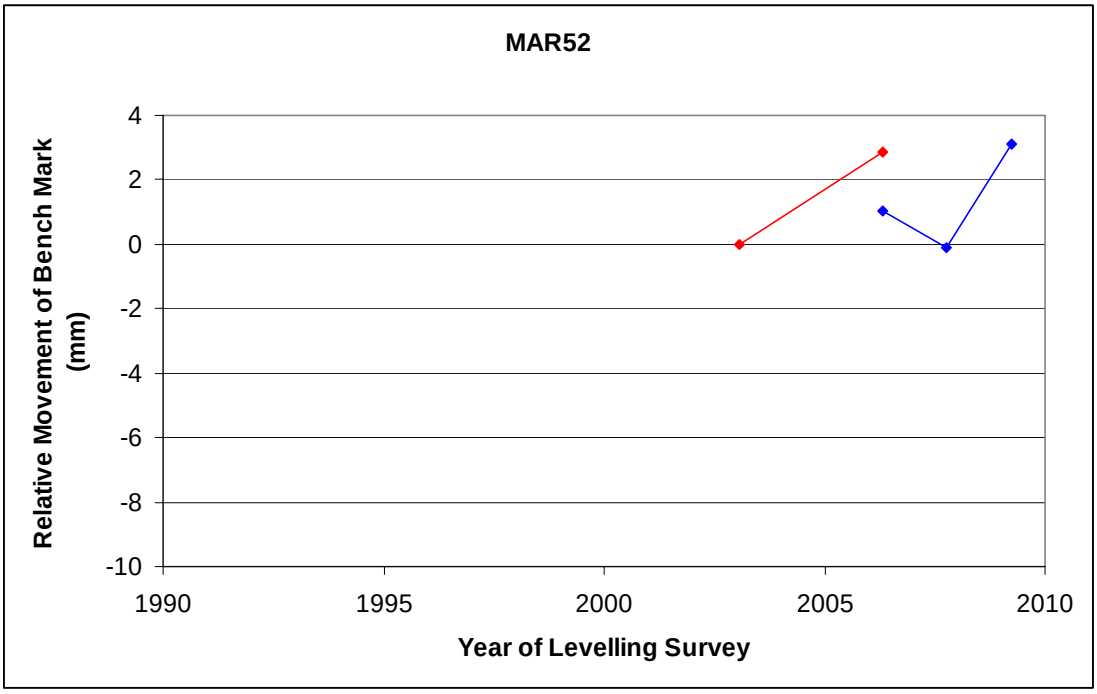


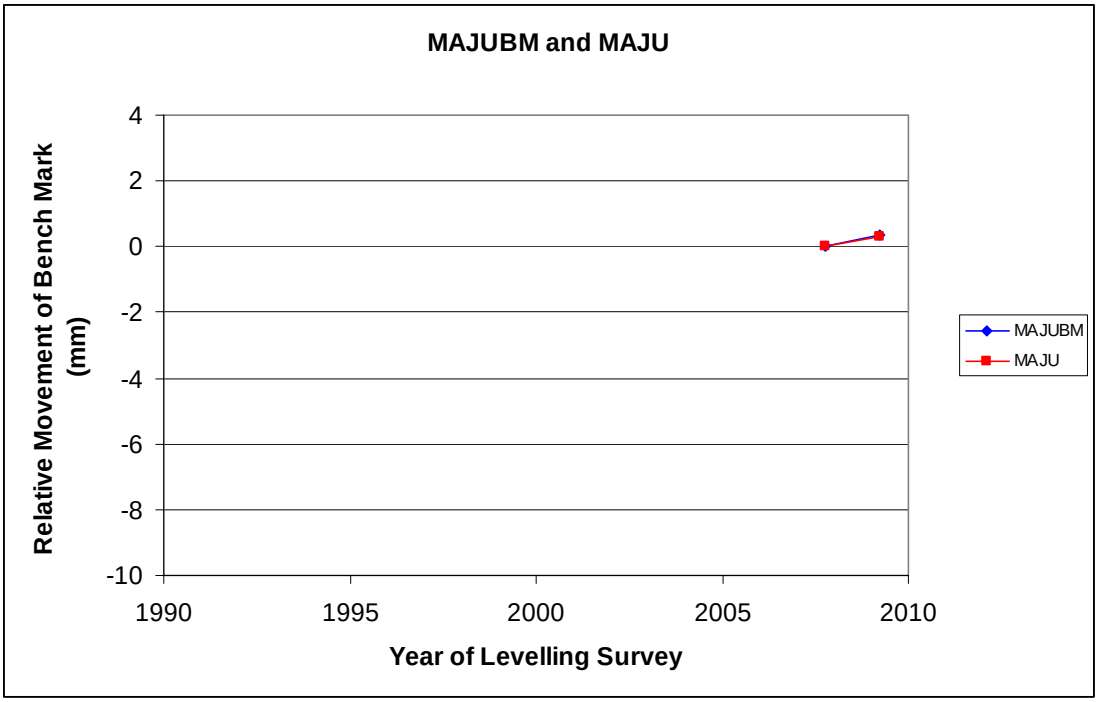


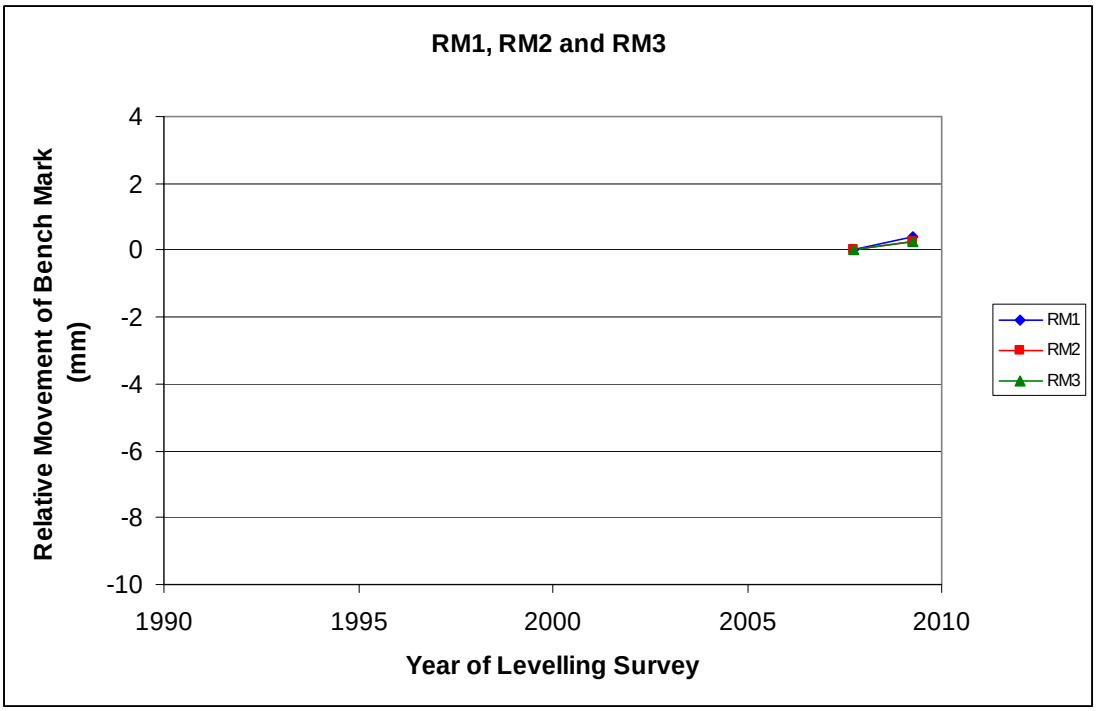












SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

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:

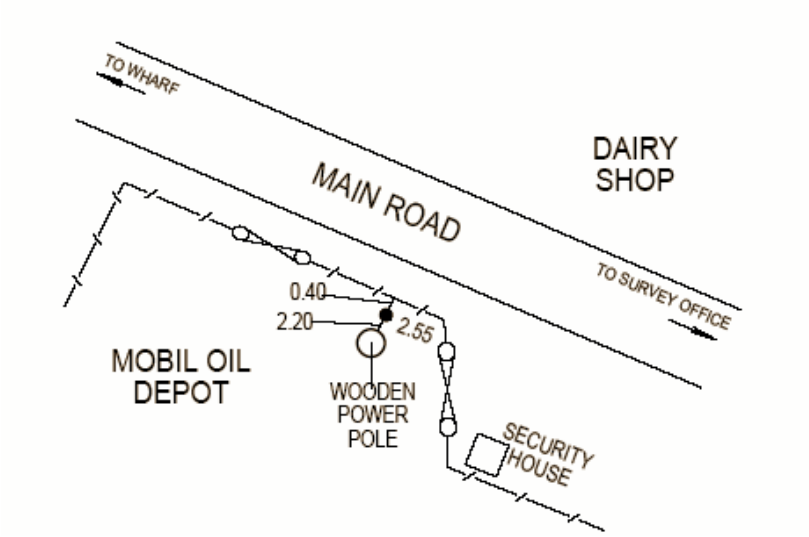
Notes / References: Deep Survey Benchmark
This survey mark is good for GPS occupation.

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

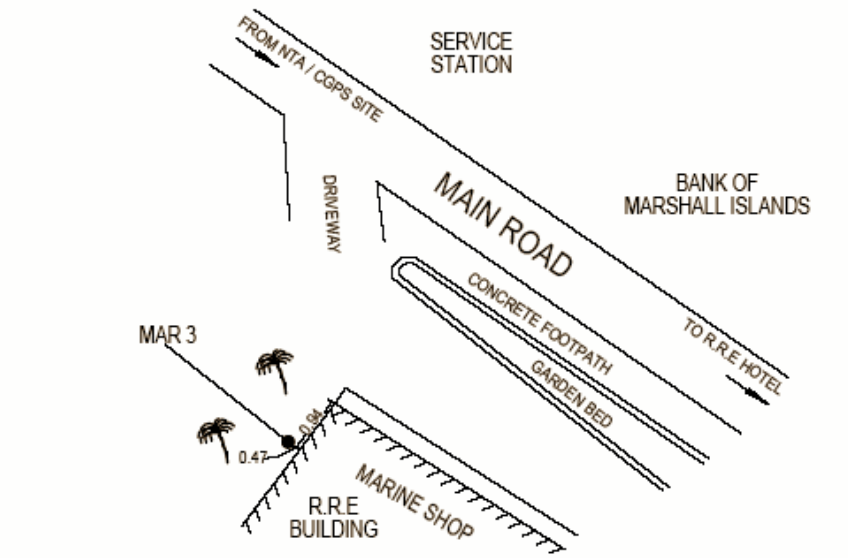
Bench Mark Number: MAR3

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	*Date*: 31-01-92
Existing Bench Mark Established by:	*Date*:
Notes / References: Deep Survey Benchmark This survey mark is not in a good locality 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 500m 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: MAR50

Original Bench Mark Established by:
National Tidal Centre Australia, Oceanographic Services,
Bureau of Meteorology, 25 College Rd, Kent Town, SA.
Date: 20-02-03

Existing Bench Mark Established by:
Date:

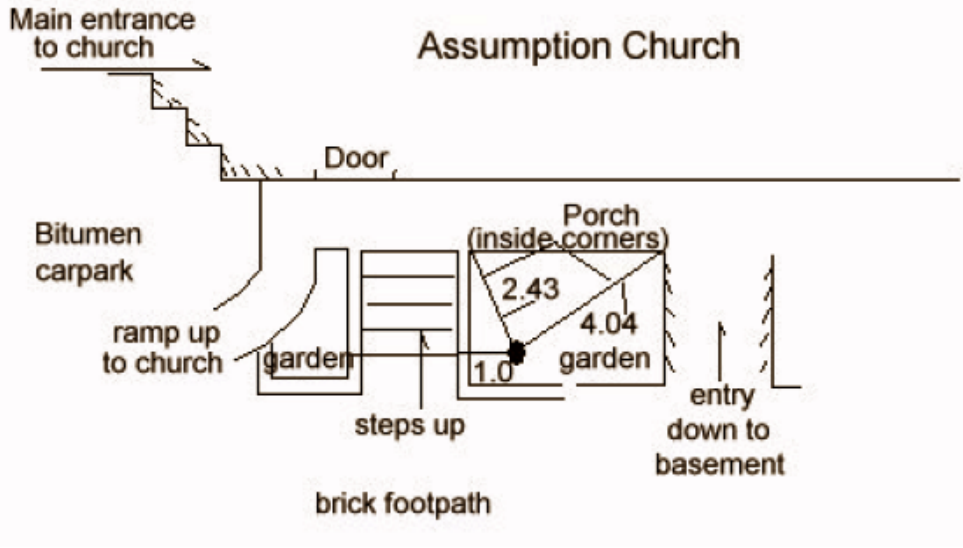
Notes / References: Deep Survey Benchmark
This survey mark is not in a good locality for GPS occupation.

Country: Republic of Marshall Islands
Atoll: Majuro
City: Uliga

Marking and locality sketch

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

Original Bench Mark Established by:
National Tidal Centre Australia, Oceanographic Services,
Bureau of Meteorology, 25 College Rd, Kent Town, SA.
Date: 20-02-03

Existing Bench Mark Established by:
Date:

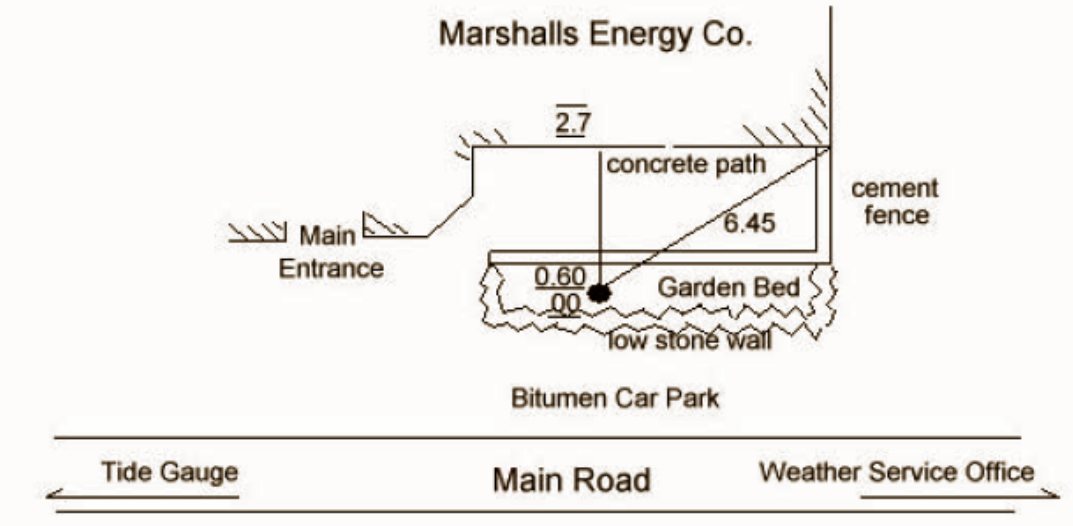
Notes / References: Deep Survey Benchmark
This survey mark is not in a good locality for GPS occupation.

Country: Republic of Marshall Islands
Atoll: Majuro
City: Uliga

Marking and locality sketch

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

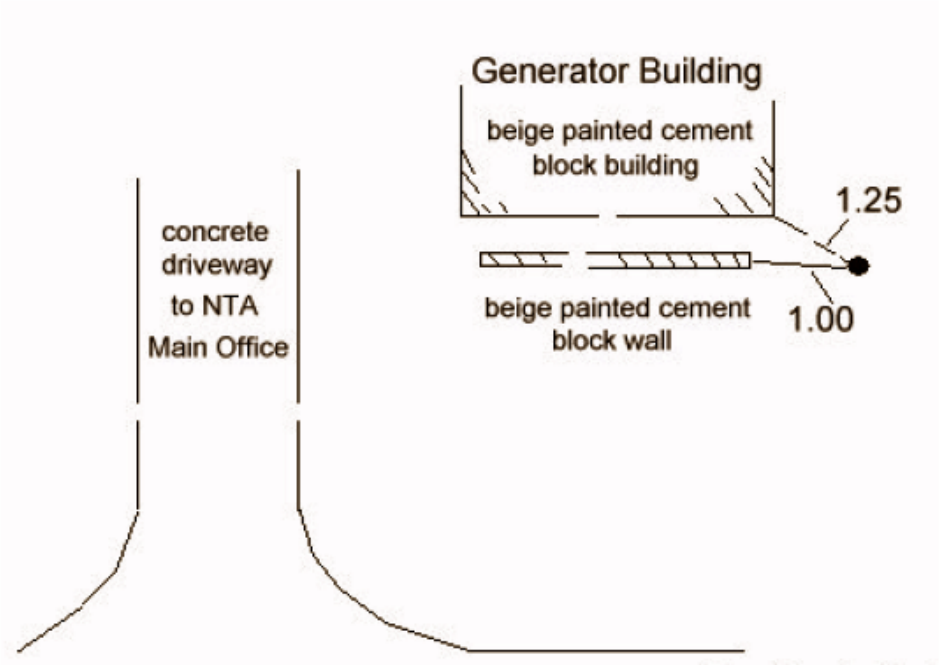
Bench Mark Number: MAR52

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	*Date*: 20-02-03
Existing Bench Mark Established by:	*Date*:
Notes / References: Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.	
Country: Republic of Marshall Islands *Atoll*: Majuro	*City: Uliga*

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.



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: MAR100

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

Date: 29-09-07

Existing Bench Mark Established by:

Date:

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

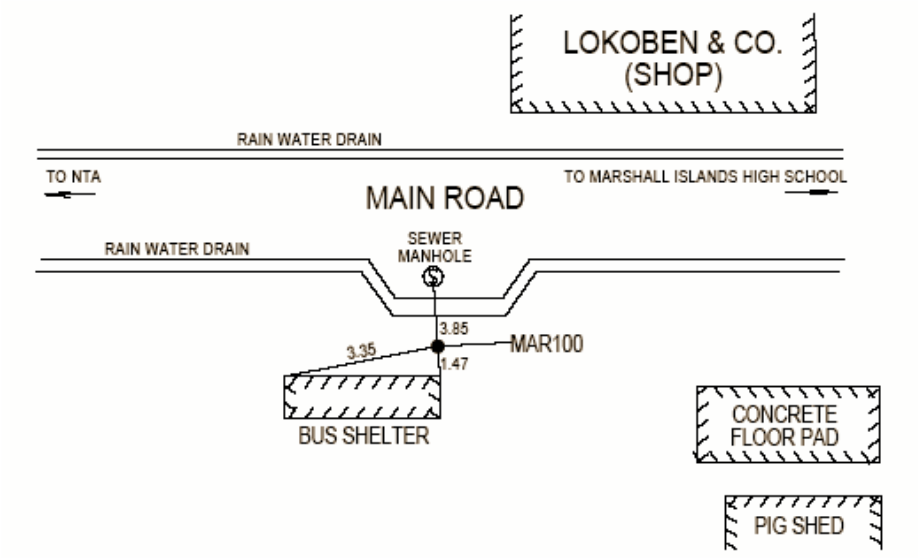
Country: Republic of Marshall Islands
Atoll: Majuro

City: Uliga

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

Approved by: Geoscience Australia / SOPAC

Date: Nov 2007

SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

Bench Mark Number: MAR107

Original Bench Mark Established by: *Date*: 04-04-09
Geodetic Operations, National Geospatial Reference Systems (NGRS)
Geoscience Australia Earth Monitoring Division (GEMD), Geoscience Australia.

Existing Bench Mark Established by: *Date*:

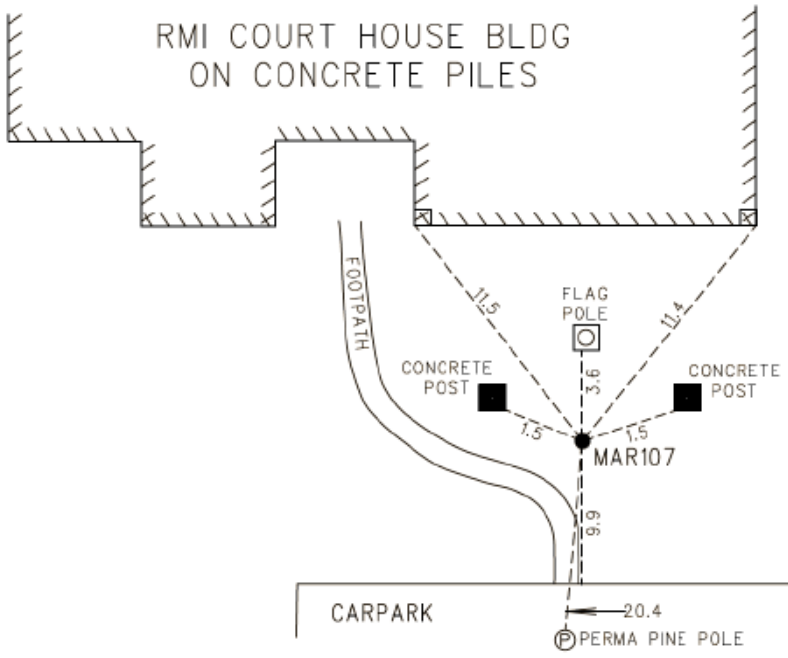
Notes / References: Deep Survey Benchmark
This survey mark is not in a good locality for GPS occupation.

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, for 0.5m. Top of mark 0.05m below ground level.

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

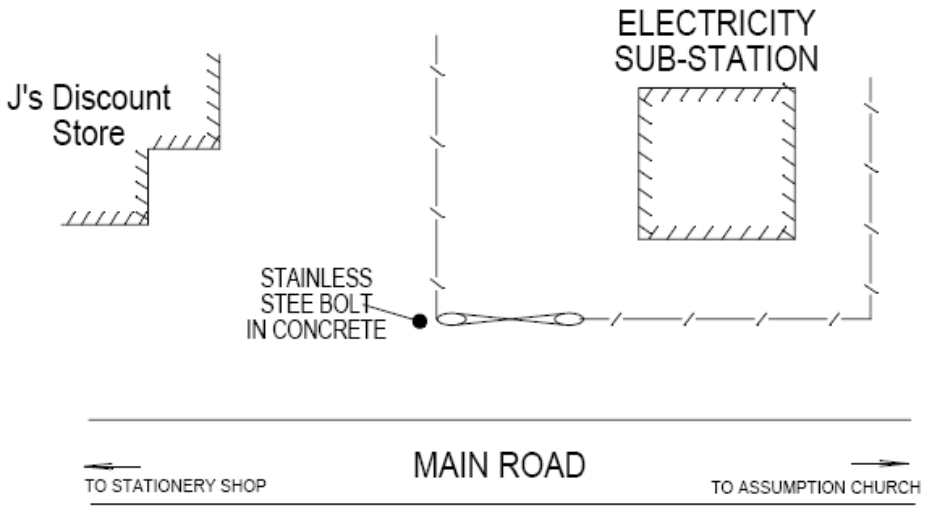


Not to scale Distances in Metres Magnetic bearings

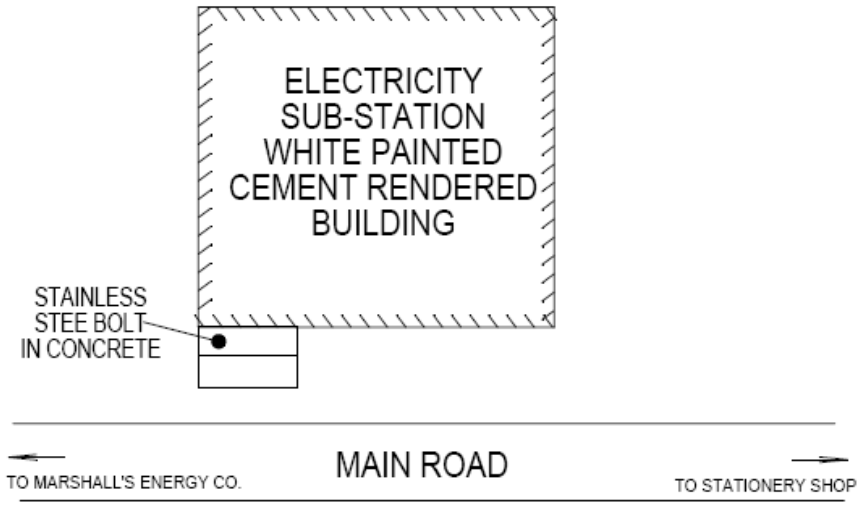
Approved by: Geoscience Australia / SOPAC Date: April 2009

Temporary Holding Marks Locality Diagrams

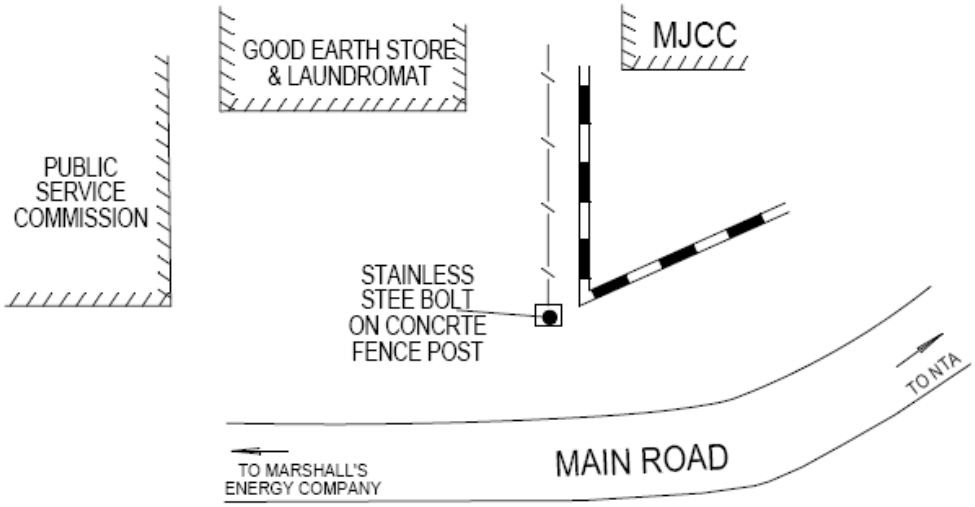
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 794 POINT NO. MAR 36
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 17-02-03



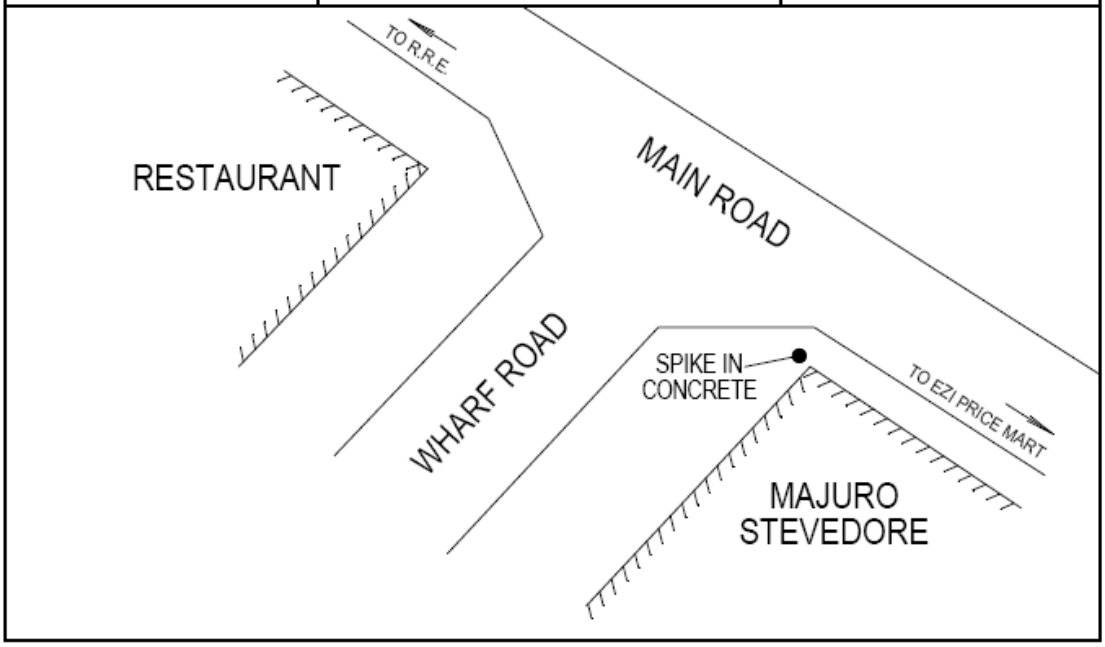
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 795 POINT NO. MAR 40
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 18-02-03



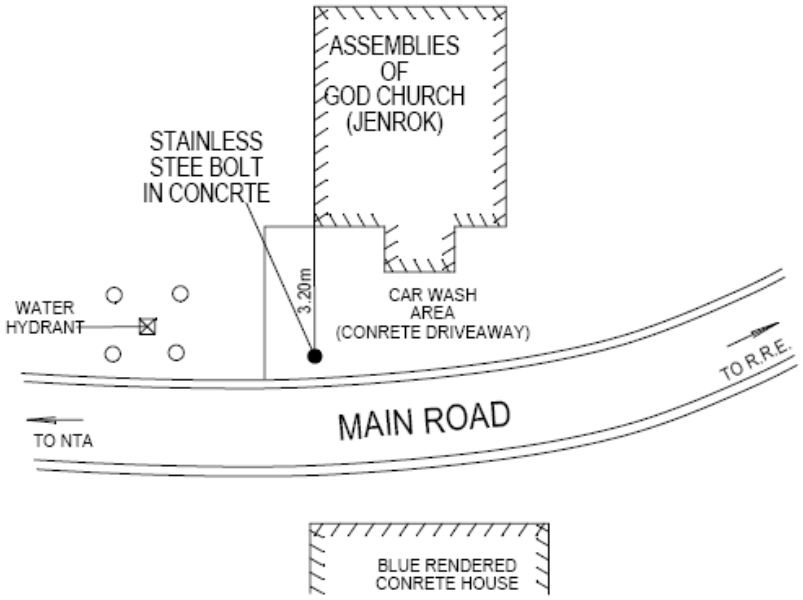
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 796 POINT NO. MAR 44
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 19-02-03



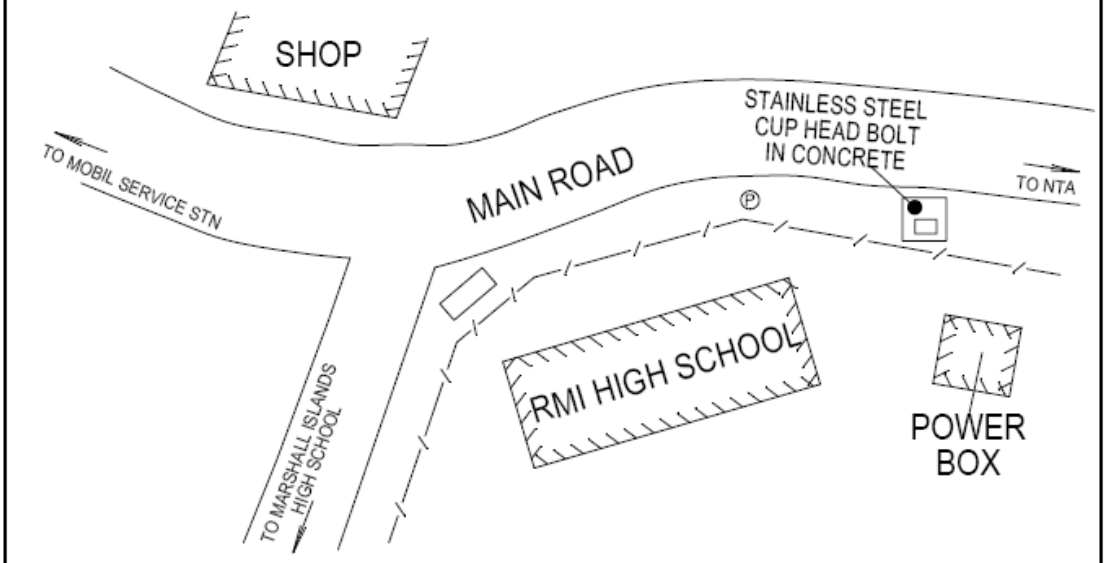
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 797 POINT NO. MAR 54
PROJECT: SPSLCMP	SURVEYOR: S Yates & A Lal	DATE: 28-04-06



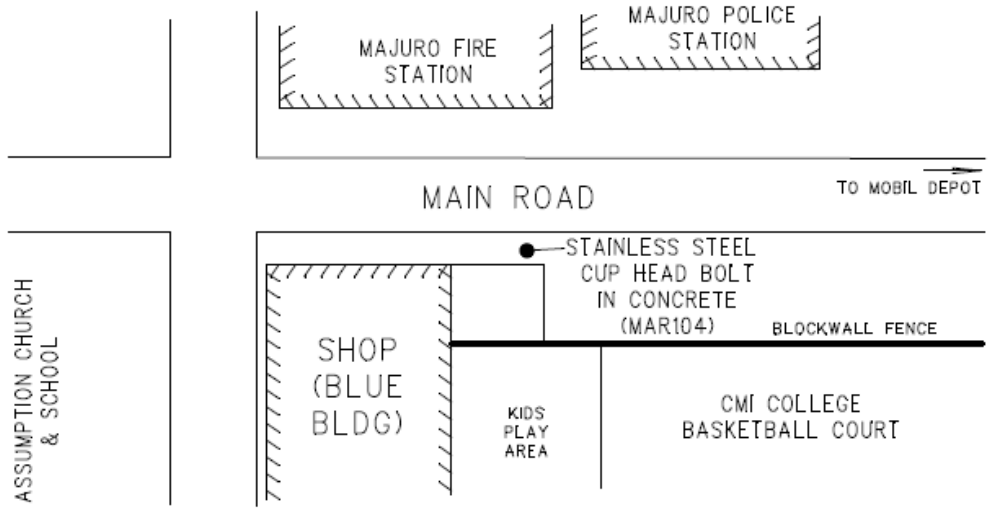
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 798 POINT NO. MAR 101
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 30-09-07



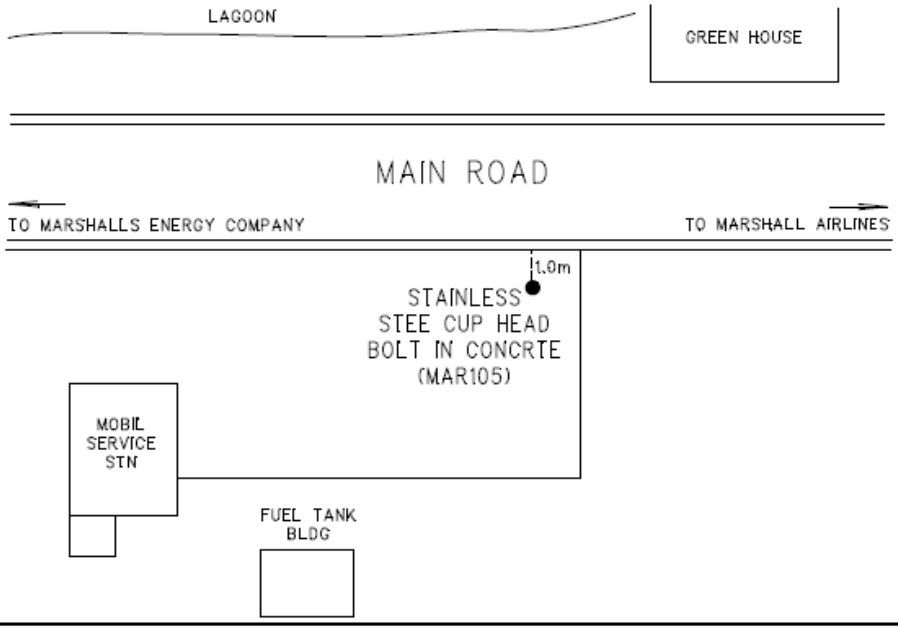
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 799 POINT NO. MAR 102
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 30-09-07



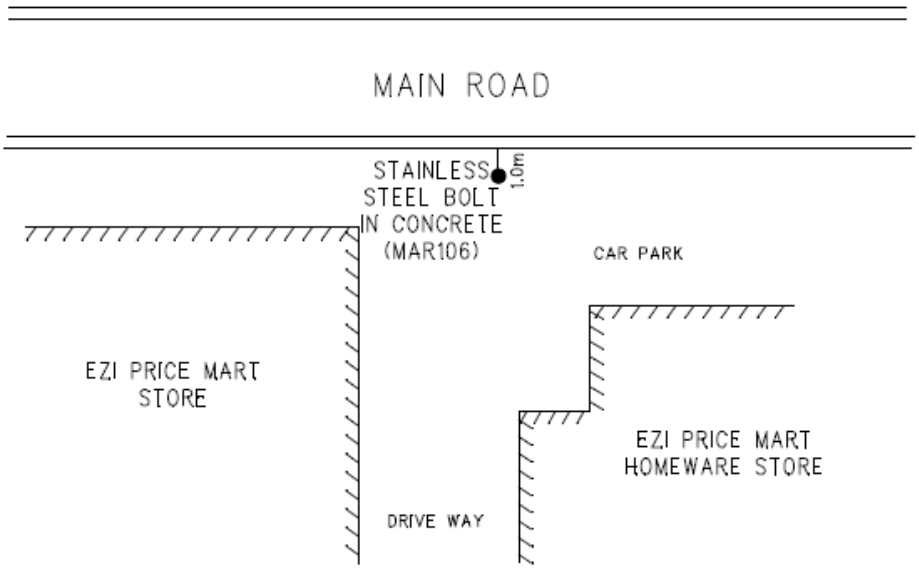
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 894 POINT NO. MAR 104
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09



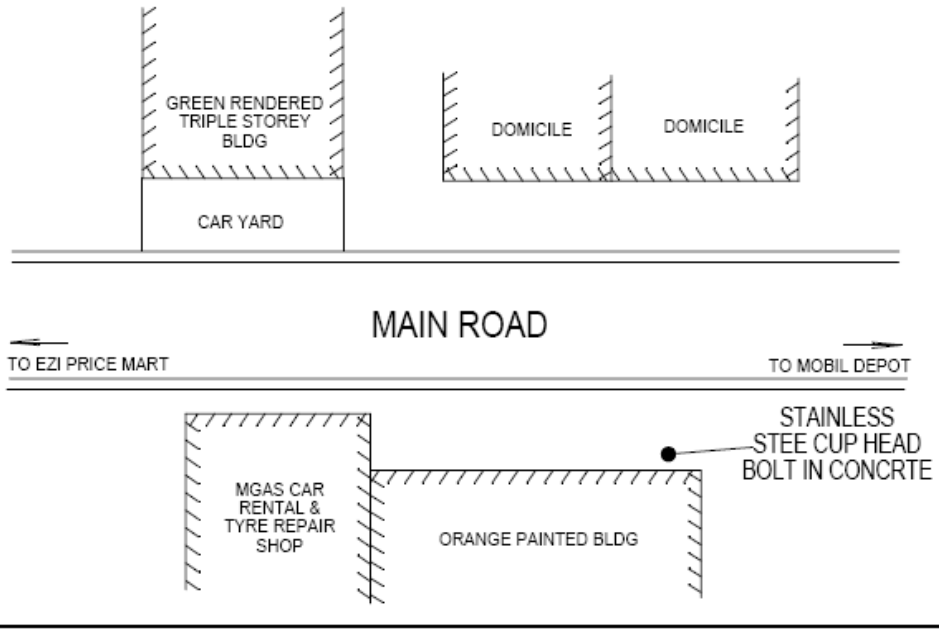
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 895 POINT NO. MAR 105
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09



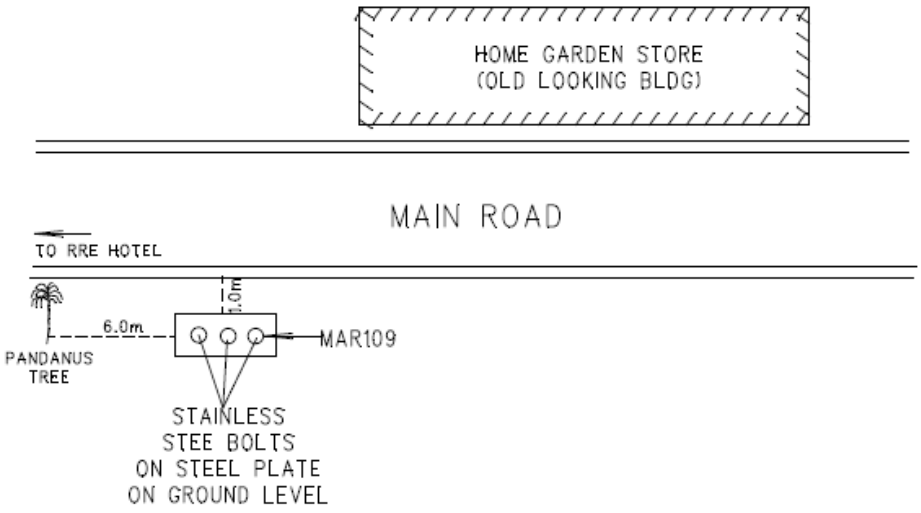
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 896 POINT NO. MAR 106
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09



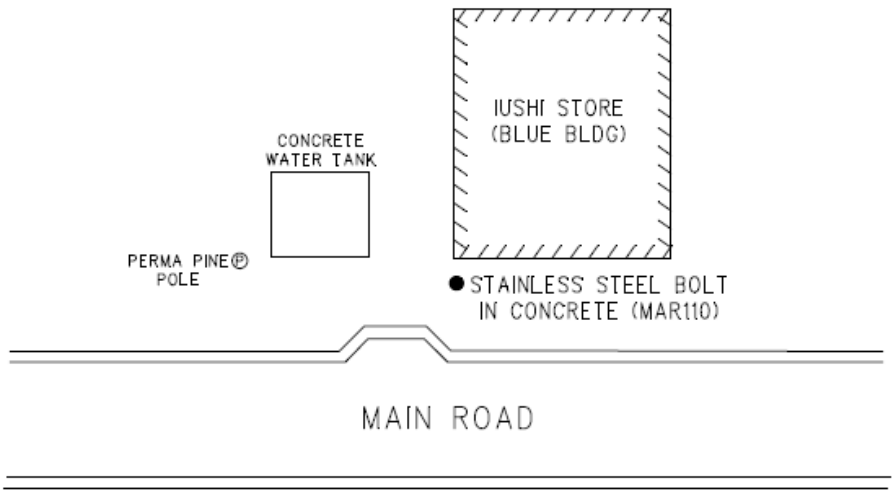
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 800 POINT NO. MAR 103
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 19-02-03



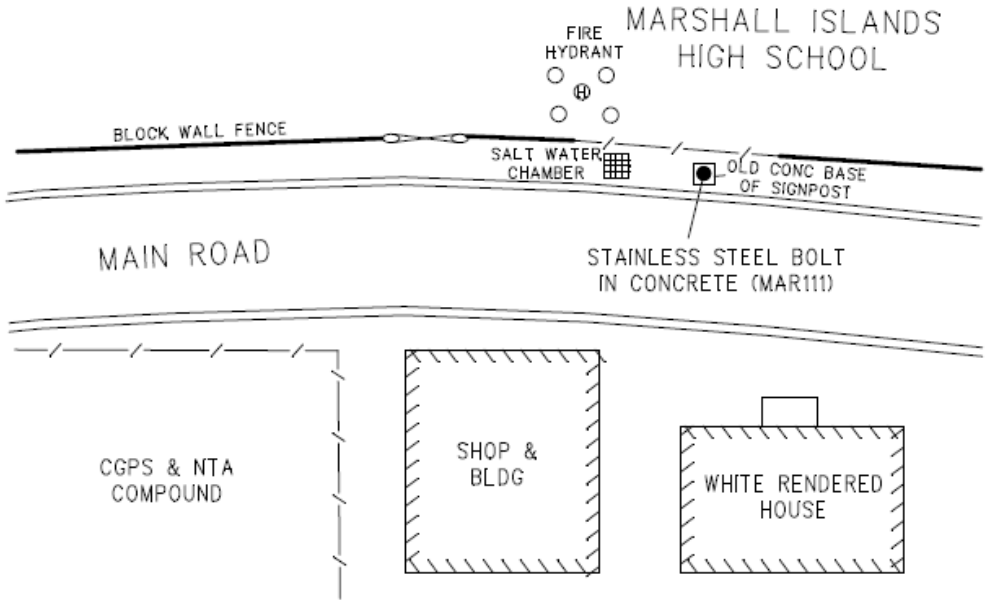
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 897 POINT NO. MAR 109
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09



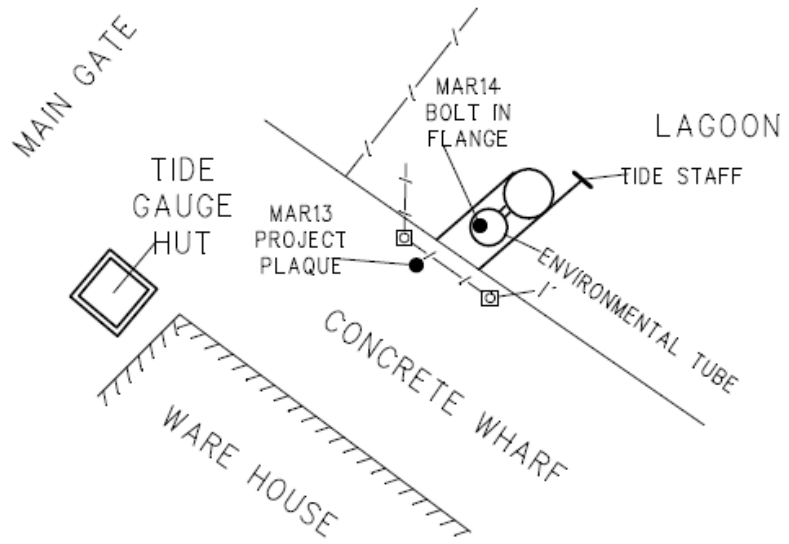
COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 898 POINT NO. MAR 110
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09



COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 899 POINT NO. MAR 111
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 04-04-09



COUNTRY: Marshall Islands	ATOLL: Majuro CITY: Uliga	L. D. P. 792 POINT NO. MAR 13 & 14
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 20-05-93

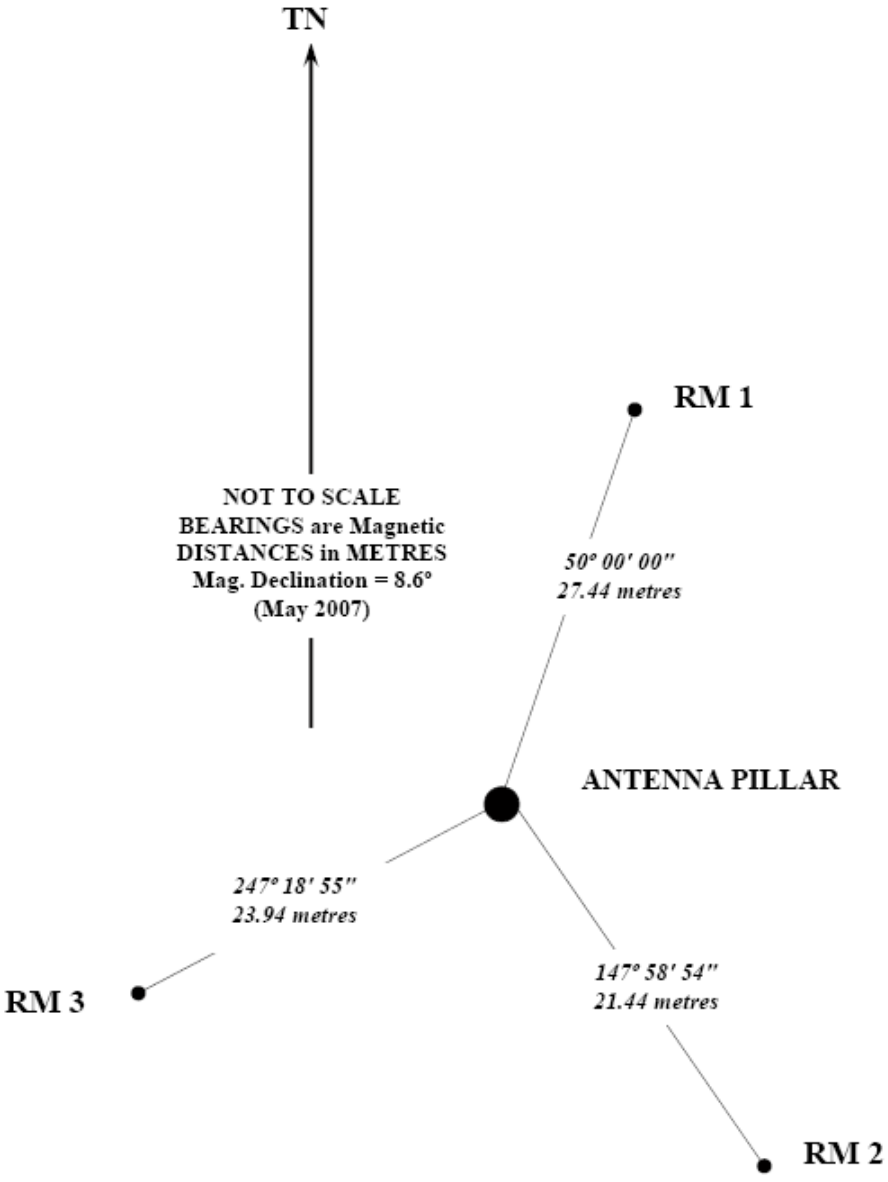


MAJUBM and MAJU Reference Mark Locality Diagrams

Marshall Islands CGPS Station, Rita, Majuro – Reference Marks

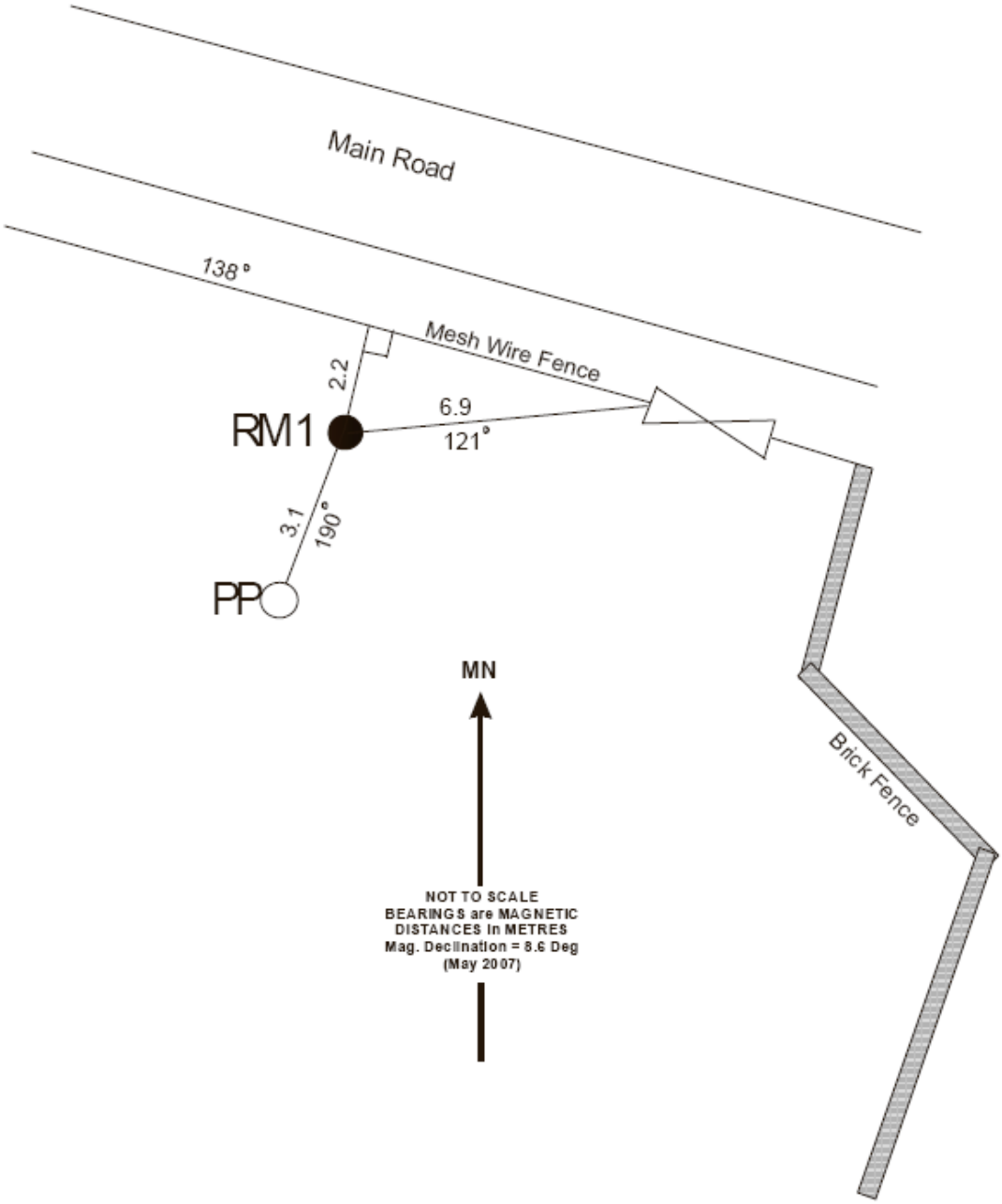
REFERENCE MARKS

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.



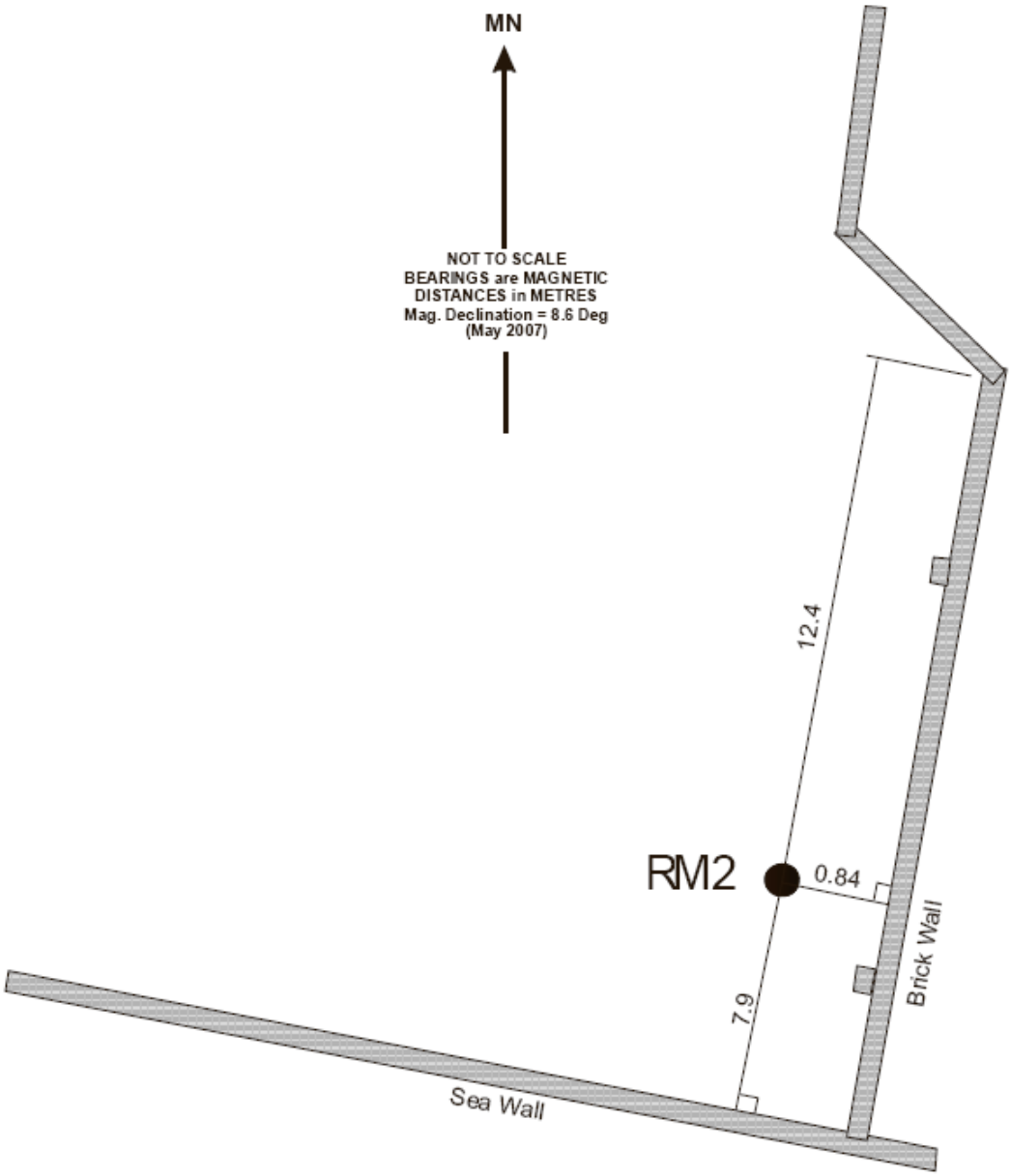
Marshall Islands CGPS Station, Rita, Majuro – RM 1 Location Diagram

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.