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EDM Height Traversing Levelling Survey Report

Honiara, Solomon Islands, June 2013

S. J. K. Yates, A. Lal

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GEOSCIENCE AUSTRALIA
RECORD 2014/27

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Australian Government
Geoscience Australia

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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 Station and the Continuous Global Navigation Satellite Systems (CGNSS) Station in Honiara, Solomon Islands from 22nd to 27th June 2013.

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

The Electronic Distance Measuring (EDM) height traversing levelling technique was employed to observe differences in height between the deep bench mark survey arrays in Honiara, which runs approximately 1.2 km from the tide gauge sensor benchmark to the CGNSS Pillar Benchmark. Previous levelling surveys have been conducted along the route using this technique in 2007, 2009, 2010 and 2012.

In addition, precise differential levelling surveys were performed along the deep bench mark (BM) array from 1994 to 1999 by the National Tidal Centre Australia (NTCA). 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 in 1994.

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 marks:

SOLOBM	– Level reference bench mark for the CGNSS pillar
SOL103	– SEAFRAME Project Bench Mark
SOL18	– SEAFRAME Project Sensor Bench Mark
FBM1	– Local Bench Mark
FBM3	– Deep Driven Bench Mark
FBM4	– Deep Driven Bench Mark
FBM8	– Deep Driven Bench Mark
FBM9	– Deep Driven Bench Mark
SOLO	– CGNSS reference point
SOLO RM1	– CGNSS reference mark
SOLO RM2	– CGNSS reference mark
SOLO RM3	– CGNSS reference mark

Most of the deep bench marks were located and found in good order and undisturbed. FBM2 (Deep Driven Bench Mark) was found destroyed in 2012 and therefore was not levelled to. Also included in the survey were temporary holding marks SOL103, SOL106, SOL107, SOL108, SOL110, SOL111, SOL112, SOL113 and SOL114. FBM1 (a local Lands and Survey Bench Mark) was found to be inaccessible.

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 with the 2013 reduced levels are detailed later in this report.

2.1 Bench Mark Locality Diagram



2.2 The Solomon Islands Datum

The Datum for the survey is Mean Sea Level.

Reduction of the data has been calculated holding FBM4 fixed at 3.61966 metres, this value was determined by the National Tidal Centre Australia in July 1994.

The reference point for this survey is FBM4 derived in 1994 by adopting the height of FBM1 (local Bench Mark) RL = 6.386 metres (MSL)

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 Honiara 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 Solomon Islands 2013 Reduced Levels

Table 2.1 Honiara, Solomon Islands – Reduced levels and heights difference relative to FBM4.

Date: 22 to 29 June 2013

Datum: Mean Sea Level

Point ID	Reduced Level 2013	Type
FBM4	3.6197	Stainless Steel Rod in Ground
SOL106	3.2065	Stainless Steel Pin in Concrete
FBM8	1.9616	Stainless Steel Rod in Ground
SOL103	2.3065	Stainless Steel Pin in Concrete
SOL18	3.5697	Stainless Steel Pin
SOL107	4.9987	Stainless Steel Pin in Concrete
FBM9	4.7507	Stainless Steel Rod in Ground
SOL112	6.2180	Stainless Steel Pin in Concrete
SOL113	31.3015	Stainless Steel Pin in Concrete
SOL114	45.6951	Stainless Steel Pin in Concrete
SOL108	50.3082	Spike in Bitumen

Point ID	Reduced Level 2013	Type
FBM3	54.0469	Stainless Steel Rod in Ground
SOL110	54.0877	Stainless Steel Pin in Concrete
SOLOBM	54.3134	Stainless Steel Pillar Pin
SOLO RM1	54.2449	Stainless Steel Rod in Ground
SOLO RM2	53.0183	Stainless Steel Rod in Ground
SOLO RM3	53.7558	Stainless Steel Rod in Ground

2.6 Survey Support

The survey team very much appreciated the survey from the Solomon Islands Meteorological Service, especially field assistance from Mr. David Tapiei. All the staff from the Solomon Islands Meteorological Service has developed a keen interest in the PSLMP project and is always eager to provide assistance when required.

The Regional Office of the Secretariat of the Pacific Islands Community (SPC) in Honiara provide valuable logistics support for clearance of project survey equipment from the Customs Authority namely; Ms Mia Ramon, Coordinator and Ms Naomi Tagi, Office Assistant for the SPC Regional Office.

2.7 Issues

Prior approval needs to be taken to access the following survey benchmarks;

Tide Gauge Station and Deep Driven Bench Mark, FBM8 – Naval Patrol Base

The fixed deep driven benchmark, FBM4 is now within the locked compound of the National Museum and due to the heavy traffic, the level run to SOL106 across the road is best attempted early on a Sunday morning, a prior arrangement should be discussed with the National Museum's director to gain early morning access. It is also recommended the tide gauge half-metre pole should be setup on the FBM4 so that visibility through the galvanised iron fence can be attained.

CGNSS Station – Solomon Islands Meteorological Department

As a matter of courtesy, prior approval should be made for access to the survey array from deep driven bench mark FBM9 to FBM3. This survey array runs across the national parliament complex building compound.

3 Comparisons

3.1 Comparisons between 2013 and 2012 EDM Surveys

Table 3.1 Honiara, Solomon Islands 2013 EDM Height Traversing Levelling & Comparison 2013 - 2012. FBM4 - adopted fixed height of 3.61966m

From	To	Levelled Ht. Diff.	RL 2013	Misclose (mm)	Dist. (km)	1mm√k	RL 2012	Difference (mm) 2013 - 2012
FBM4			3.61966					
SOL106	SOL106	-0.41314	3.20653	-0.008	0.094	0.306	3.2058	0.73
FBM8	FBM8	-1.24493	1.96160	-0.258	0.136	0.368	1.9618	-0.20
SOL103	SOL103	0.34493	2.30653	-0.217	0.124	0.352	2.3062	0.33
	SOL18	1.26315	3.56968	0.020	0.014	0.120	3.5691	0.58
FBM4			3.61966					
SOL107	SOL107	1.37903	4.99869	-0.013	0.116	0.341	4.9991	-0.42
FBM9	FBM9	-0.24801	4.75068	0.380	0.149	0.387	4.7496	1.08
SOL112	SOL112	1.46736	6.21803	-0.033	0.046	0.214	6.2187	-0.67
SOL113	SOL113	25.08343	31.30146	0.144	0.100	0.315	31.3094	-7.94
SOL114	SOL114	14.39366	45.69512	0.025	0.087	0.295	45.7060	-10.88
SOL108	SOL108	4.61306	50.30818	0.063	0.059	0.243	50.3078	0.38
	FBM3	3.73872	54.04690	-0.169	0.070	0.264	54.0479	-1.00
SOL114			45.69512					
SOL110	SOL110	8.39260	54.08772	-0.395	0.159	0.399	54.0876	0.12
	SOLOBM	0.22567	54.31339	0.133	0.035	0.186	54.3113	2.09
			Misclose for all bays levelled =	-0.328	1.188	1.090		
SOLOBM			54.31339					
	RM1	-0.06852	54.24487	-0.025	0.027	0.164	54.2425	2.37
SOLOBM			54.31339					
	RM2	-1.29506	53.01833	-0.044	0.032	0.180	53.0162	2.13
SOLOBM			54.31339					
	RM3	-0.55761	53.75578	-0.031	0.028	0.166	53.7538	1.98

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

3.2 Combined Comparisons 1994 to 2013

Table 3.2 Honiara, Solomon Islands - Comparison of the RL's for Precise Differential Levelling (1994-1999) and EDM Height Traversing (2007 - 2013).

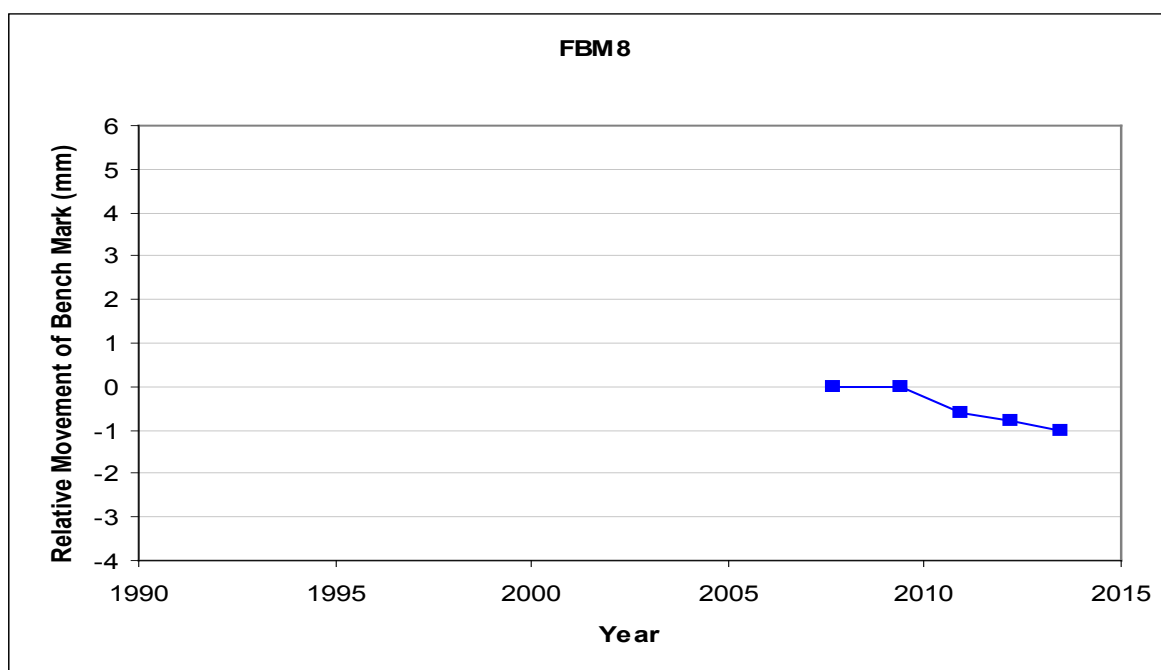
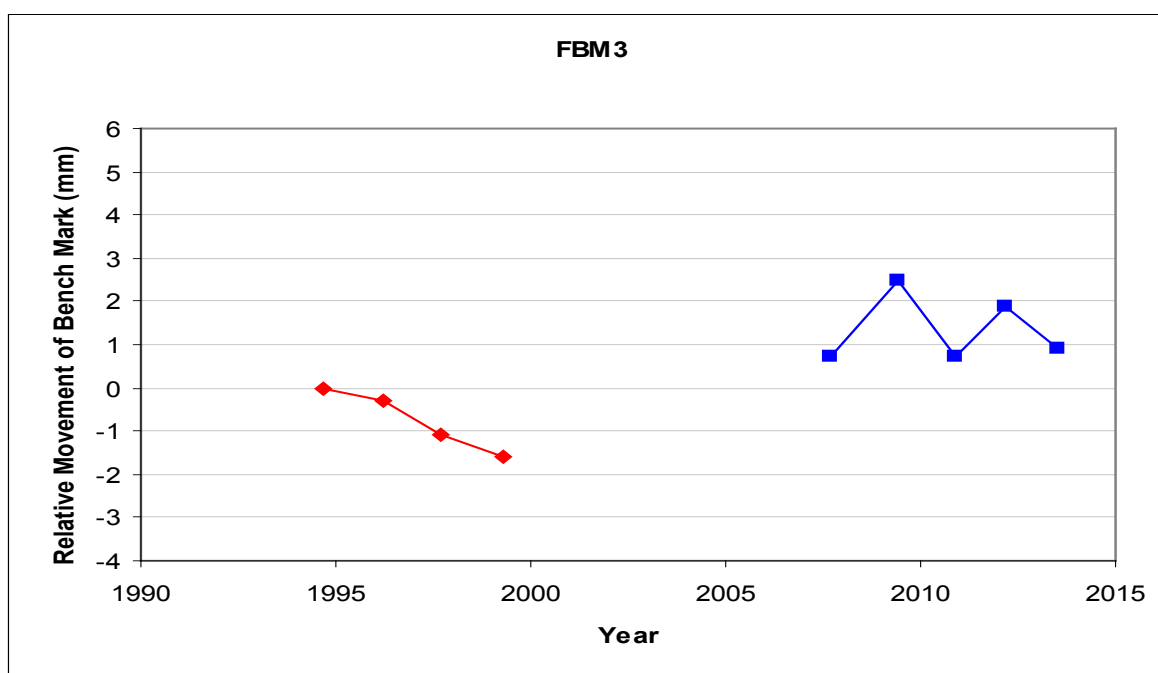
Year	FBM1	FBM2	FBM3	SOL18	SOL103	FBM8	FBM9	SOLOBM	*SOLO
1994.7	6.386	3.3171	54.046	3.5755					
1996.2	6.3848	3.3175	54.0457	3.5758					
1997.7	6.3857	3.3182	54.0449	3.5741					
1999.3	6.3856	3.3161	54.0444	3.5742					
2007.7	6.3866	3.3177	54.0467	3.572	2.3093	1.9626	4.75	54.3111	55.7756
2009.4	6.3863		54.0485	3.5718	2.3085	1.9626	4.7502	54.3134	55.7801
2010.9	6.3868		54.0467	3.5707	2.3078	1.962	4.75	54.3032	55.7678
2012.2			54.0479	3.5691	2.3062	1.9618	4.7496	54.3113	55.7759
2013.5			54.0469	3.5697	2.3065	1.9616	4.7507	54.3134	55.7780

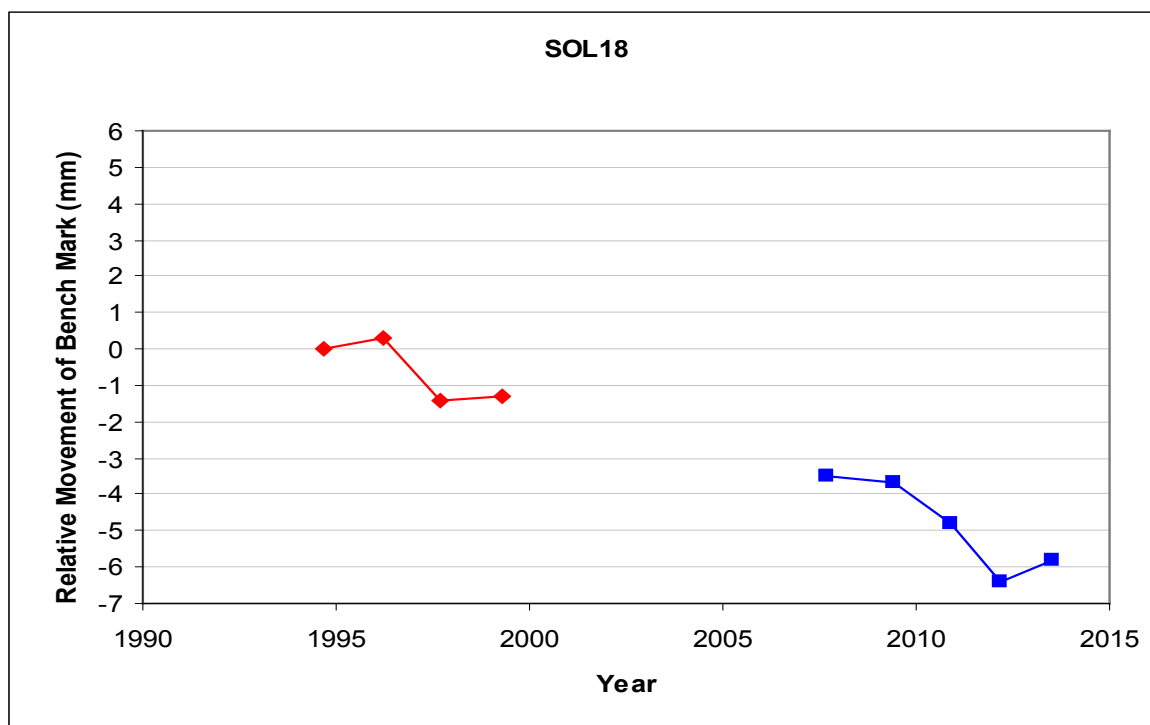
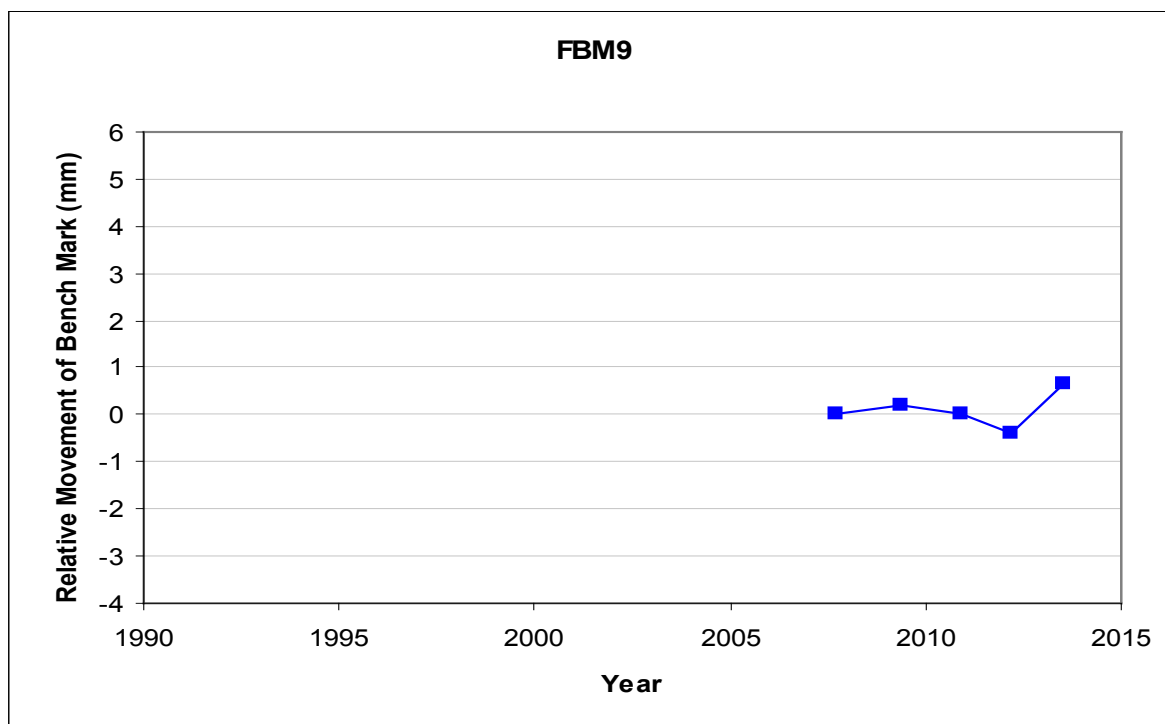
**The RL of the Reference Point SOLO (ARP) is derived from adding the static height difference from the levelled RL of SOLOBM.*

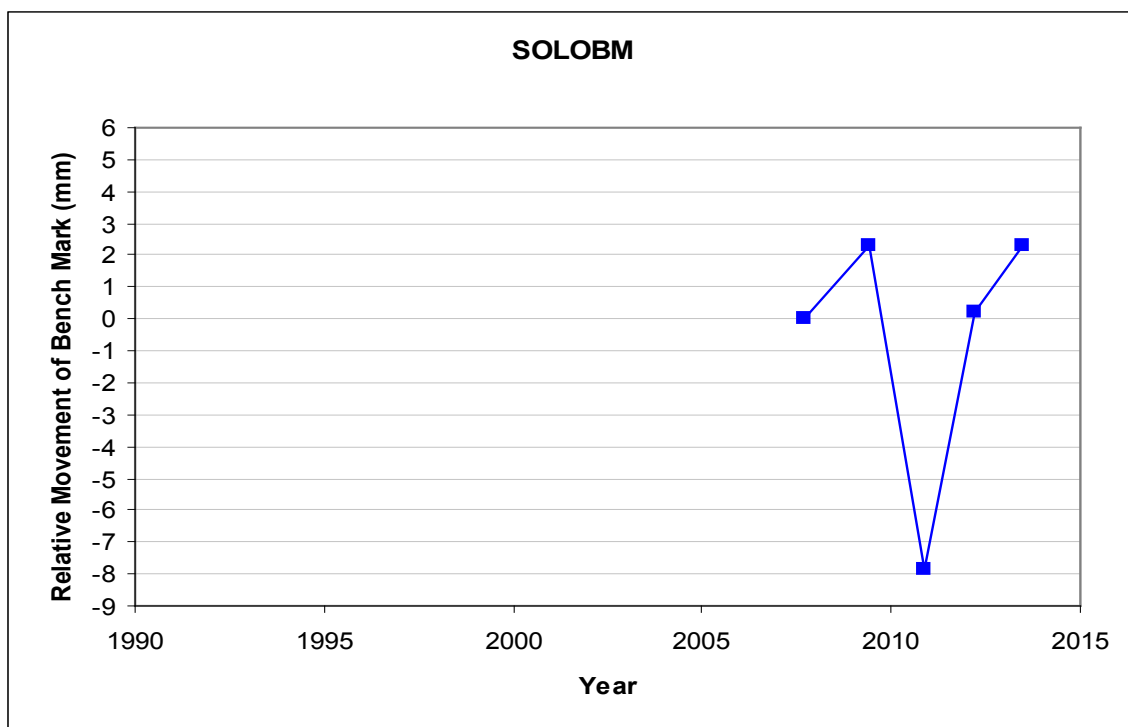
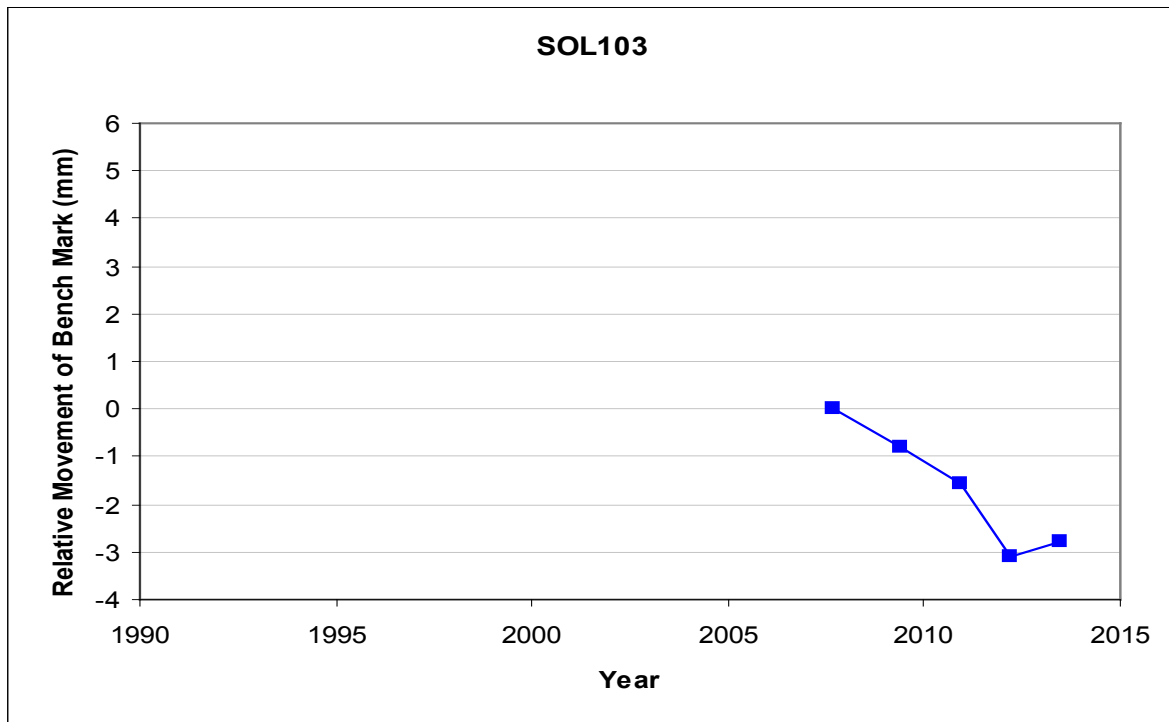
3.3 Time Series of Bench Mark Movement

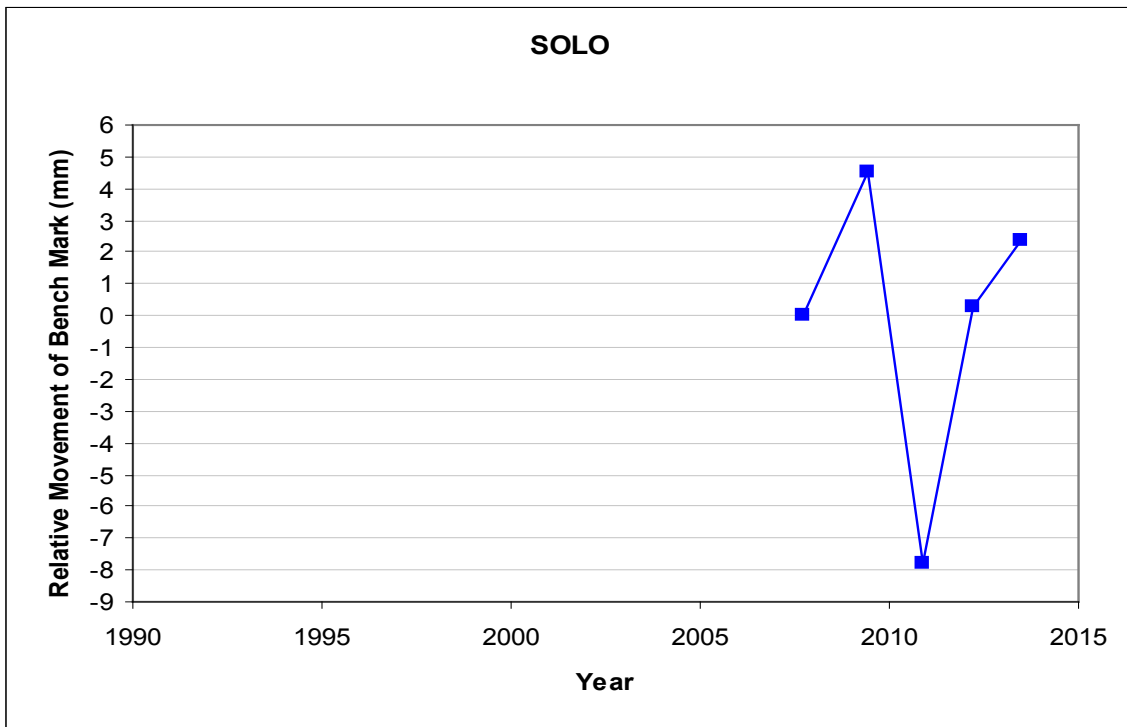
The purpose of this survey is in two folds: firstly, to provide accurate changes in land height to be used in computations of absolute sea level rise and secondly to provide accurate assessments of relative sea level changes due to localised deformation.

Precise Differential Levelling: 1994 - 1999 ◆ — ◆
EDM Height Traversing: 2007 onwards ◆ — ◆









4 Deep Bench Mark Locality Diagrams



SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT



Survey Bench Mark Record

Bench Mark Number: FBM1

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

Existing Bench Mark Established by: *Date:*

Notes / References: Department of Lands & Surveys BM register - FBM (Honiara)
This survey mark is not in a good locality for GPS occupation.

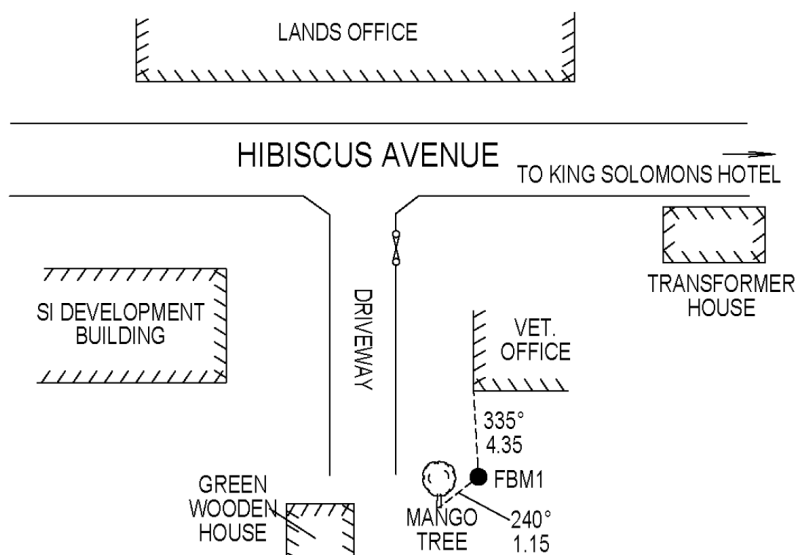
Country: Solomon Islands
Island: Guadalcanal

City: Honiara

Marking and locality sketch

Bench Mark: Brass bolt in the centre of a concrete pillar 35cm diameter and approx.
70cm above 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: Dec 2007

c:\users\andrick\ps\lcmp\localitydiagrams\solomons



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



Survey Bench Mark Record

Bench Mark Number: FBM3

<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> 28-10-91
<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
<i>Notes / References:</i> Deep Benchmark This survey mark is in a good locality for GPS occupation.	
<i>Country:</i> Solomon Islands <i>Island:</i> Guadalcanal	<i>City:</i> Honiara
<u>Marking and locality sketch</u> Bench Mark: 6.0m of 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC tube for top 2.0m. Top of mark 0.25m below ground level Locality sketch: Mark approximately 2200m from the tide gauge station. SOLOMON ISLANDS GOVERNMENT OPPOSITION OFFICE VAVAEA RIDGE ROAD TO WEATHER OFFICE POWER POLE 298° 14.5 6.70 105° 1.8 FBM3 GUY 39	
Not to scale Distances in Metres Magnetic bearings	
Approved by: Geoscience Australia / SOPAC	
Date: Dec 2007	

c:\users\andrick\spslcmp\localitydiagrams\solomons



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



Survey Bench Mark Record

Bench Mark Number: FBM4

<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> 30-07-94
<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
<i>Notes / References:</i> Deep Benchmark This survey mark is not in a good locality for GPS occupation.	
<i>Country:</i> Solomon Islands <i>Island:</i> Guadalcanal	<i>City:</i> Honiara
<u>Marking and locality sketch</u> Bench Mark: 1.8m of 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC tube for top 0.3m. Top of mark 0.3m below ground level Locality sketch: Mark approximately 370m from the tide gauge station. The diagram is a locality sketch. At the top, a horizontal line represents 'MENDANA AVENUE'. Below this line, on the left, is a hatched area labeled 'CONCRETE FENCE'. To the right of the fence, two points are marked: 'BM16' and 'FBM4'. A vertical line segment between the fence and 'BM16' is labeled '0.5'. A vertical line segment between 'BM16' and 'FBM4' is labeled '0.6'. Below 'FBM4' is another hatched area labeled 'CHAINWIRE FENCE'. To the left of the chainwire fence is the text 'SOLOMON ISLANDS NATIONAL MUSEUM (OPP. MENDANA HOTEL)'. To the right of the chainwire fence, a vertical line is labeled 'MANPROOF FENCE'. Further to the right, a vertical line leads to a circular shape representing a roundabout, with the text 'CORONTAION AVENUE' written vertically inside it. Two dashed vertical lines extend from Mendana Avenue down to the roundabout, with '0' marked at the intersection points.	
Not to scale Distances in Metres Magnetic bearings	
Approved by: Geoscience Australia / SOPAC	
Date: Dec 2007	

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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT



Survey Bench Mark Record

Bench Mark Number: FBM8

Original Bench Mark Established by: National Geospatial Reference Systems, Geospatial & Earth Monitoring Division (GEMD), Geoscience Australia. Date: 20-08-07

Existing Bench Mark Established by: Date:

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

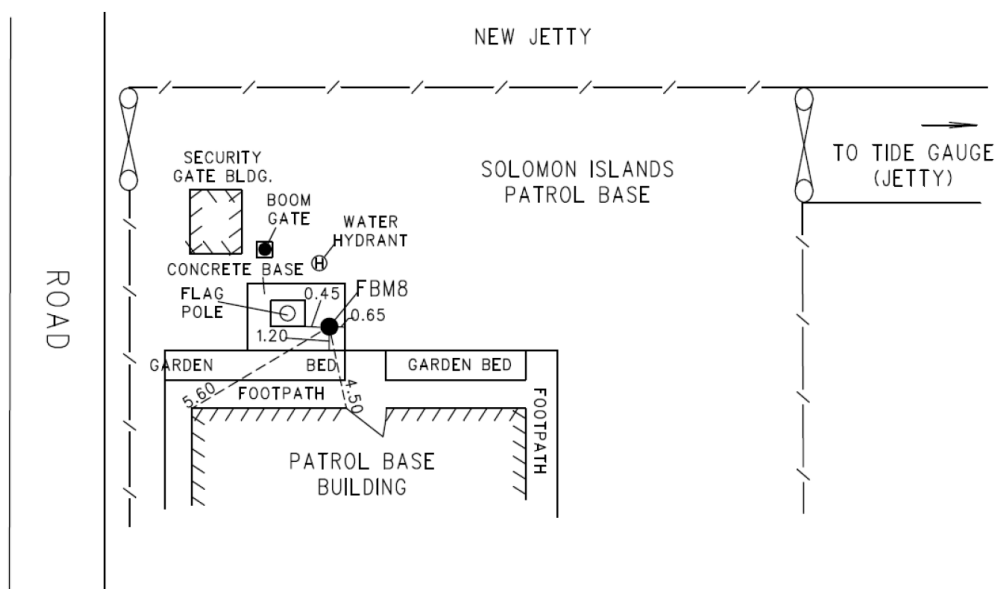
Country: Solomon Islands
Island: Guadalcanal

City: Honiara

Marking and locality sketch

Bench Mark: 3.0m of 19mm diameter stainless steel capped rod driven to refusal.
Rod sheathed with 50mm diameter PVC tube for top 0.3m. Top of mark
0.2m below ground level

Locality sketch: Mark approximately 125m from the tide gauge station.



Not to scale

Distances in Metres

Magnetic bearings

Approved by: Geoscience Australia / SOPAC

Date: Dec 2007

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



Survey Bench Mark Record

Bench Mark Number: FBM9

<i>Original Bench Mark Established by:</i> National Geospatial Reference Systems, Geospatial & Earth Monitoring Division (GEMD), Geoscience Australia.	<i>Date:</i> 20-08-07
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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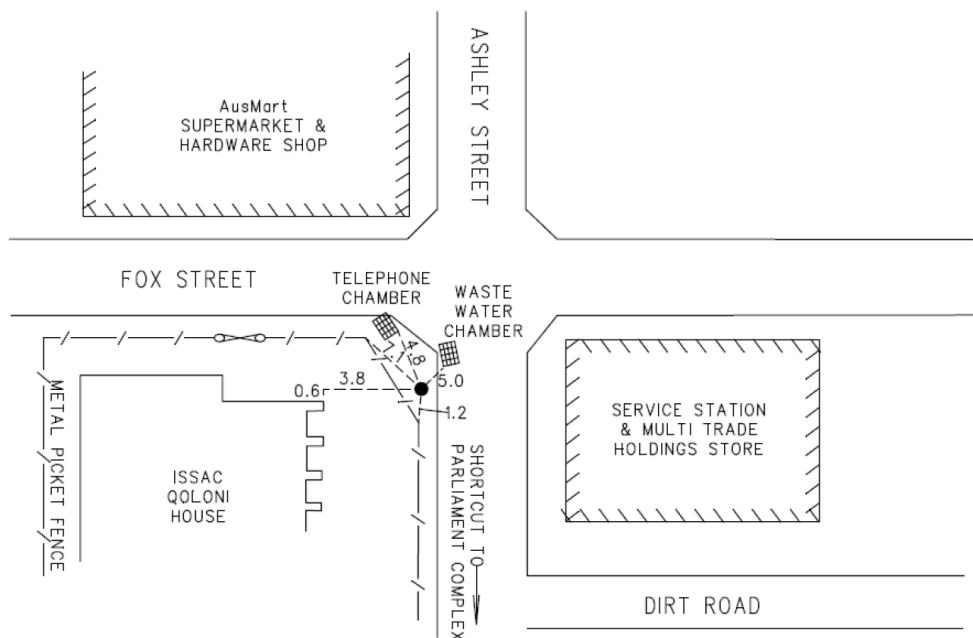
<i>Notes / References:</i> Deep Benchmark This survey mark is in a good locality for GPS occupation.

<i>Country:</i> Solomon Islands <i>Island:</i> Guadalcanal	<i>City:</i> Honiara
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Marking and locality sketch

Bench Mark: 2.0m of 19mm diameter stainless steel capped rod driven to refusal.
 Rod sheathed with 50mm diameter PVC tube for top 0.3m. Top of mark 0.2m below ground level

Locality sketch: Mark approximately 125m from the tide gauge station.



Not to scale	Distances in Metres	Magnetic bearings
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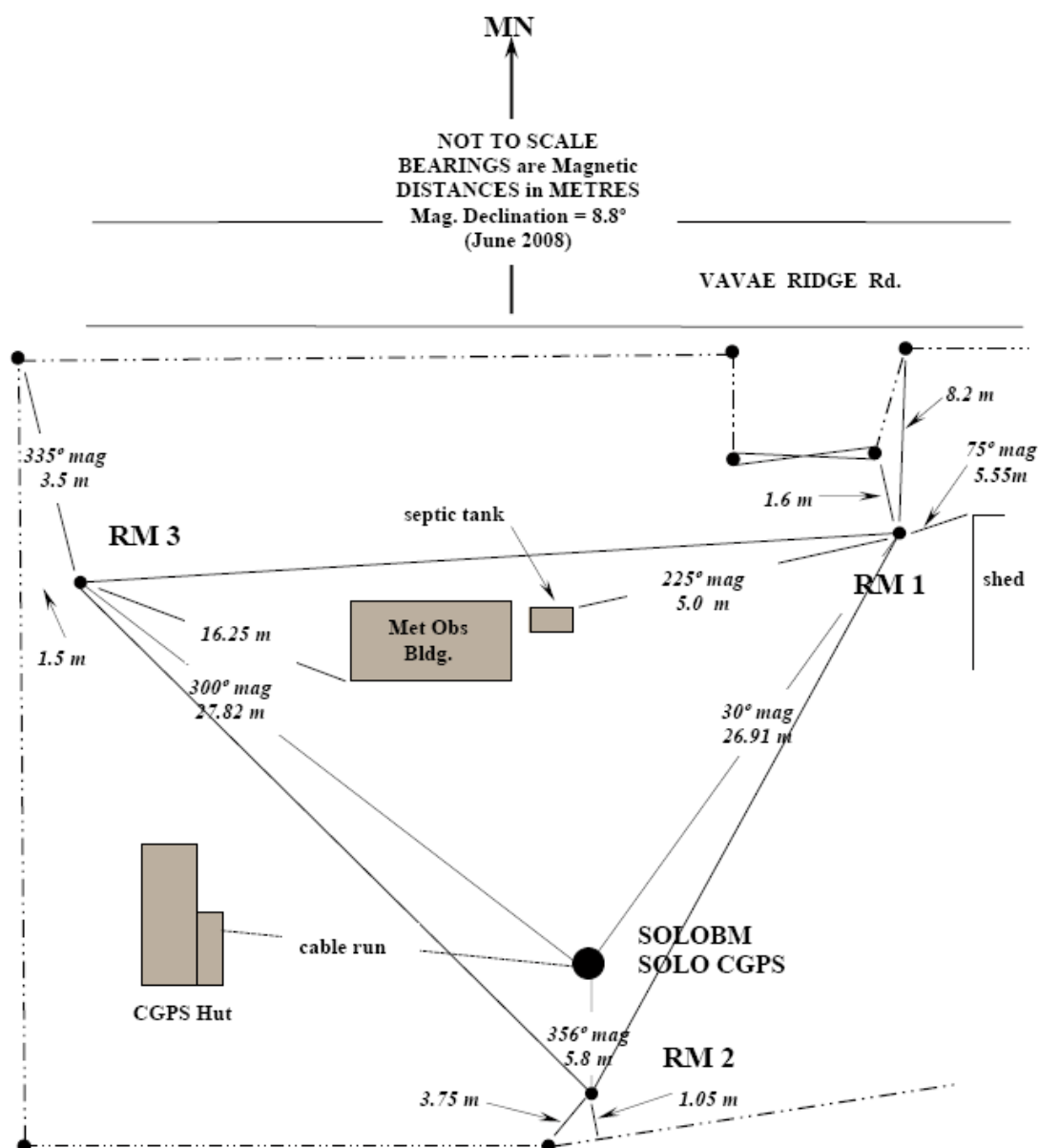
Approved by: Geoscience Australia / SOPAC	Date: Dec 2007 c:\users\landrick\spslcmpl\localitydiagrams\solomons
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5 Reference Mark Locality Diagram

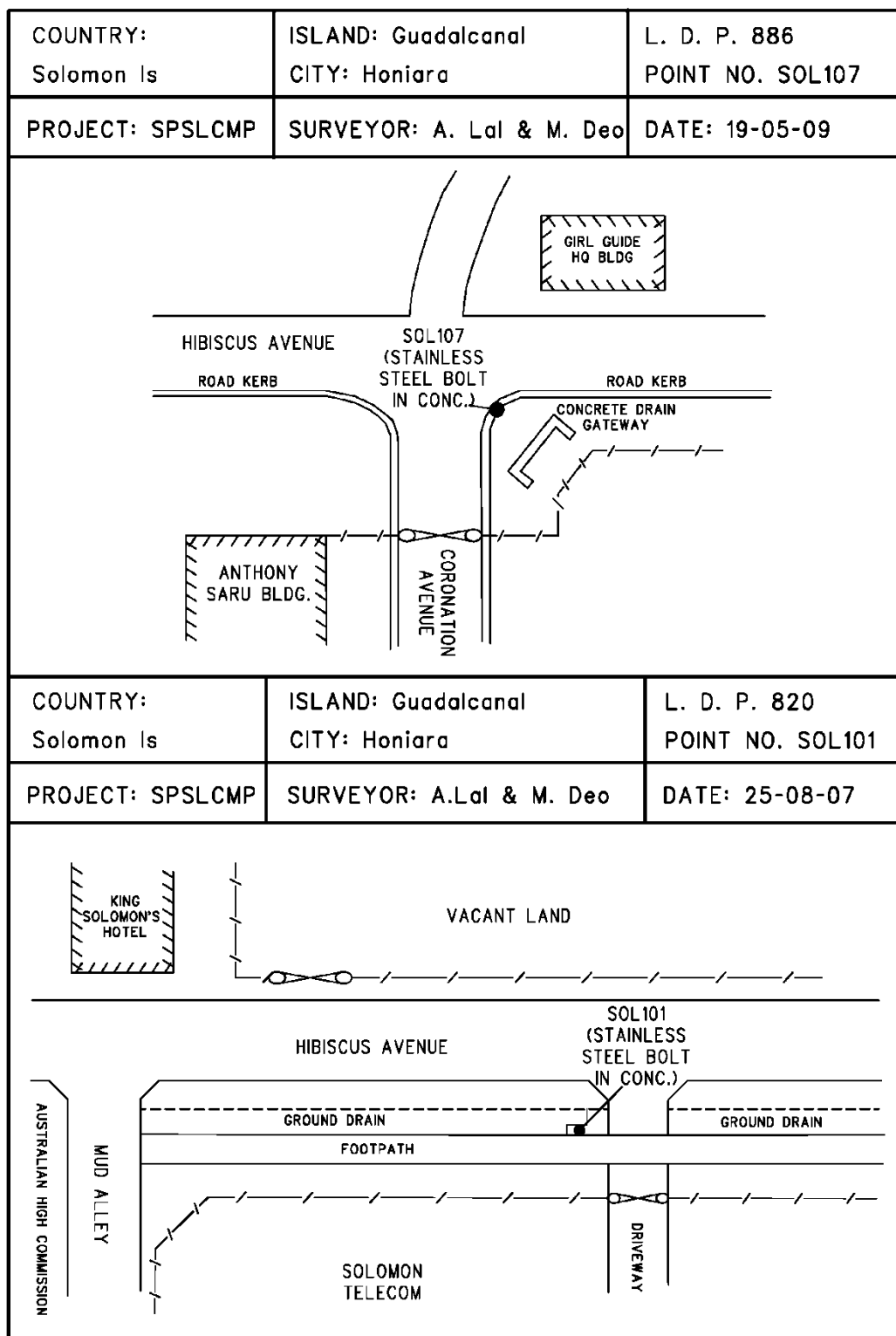
SOLOMON IS. CGPS Station – Reference Marks

REFERENCE MARKS

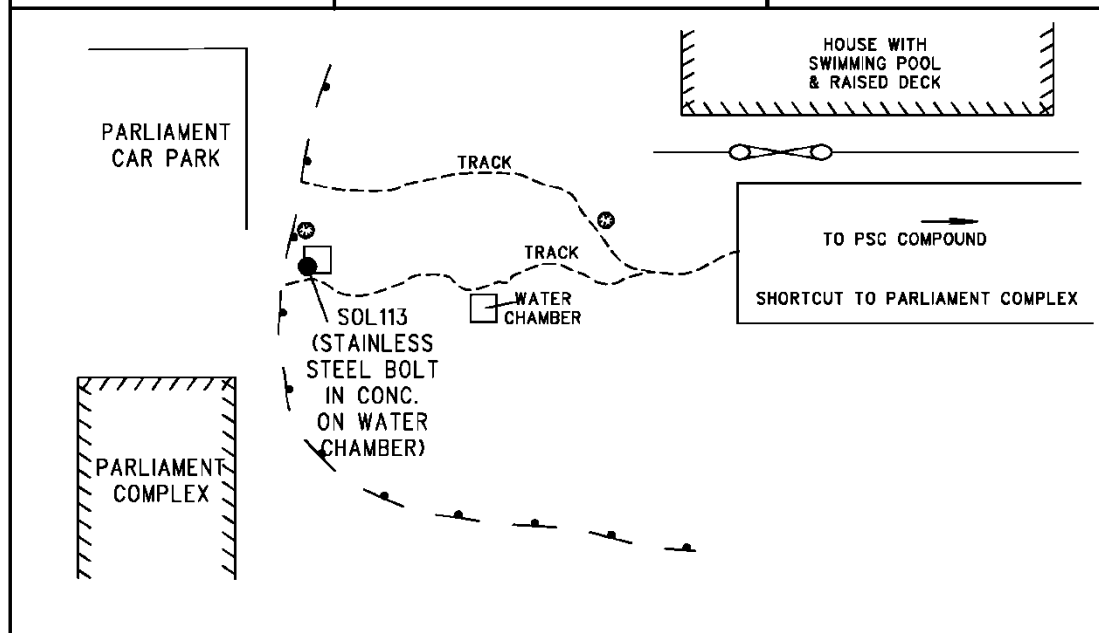
All RM's are capped 20 mm stainless steel rods driven to refusal and protected by 150 mm PVC pipe within circular poly carbonate valve boxes. The valve box lids are approximately 200mm below ground level.



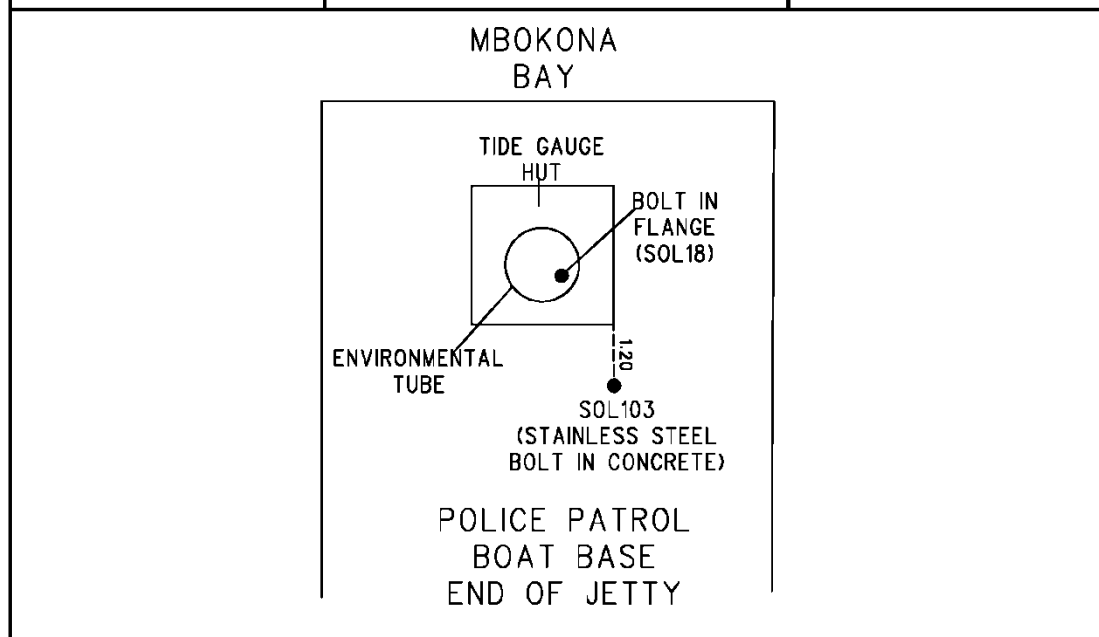
6 Temporary Holding Marks Locality Diagrams



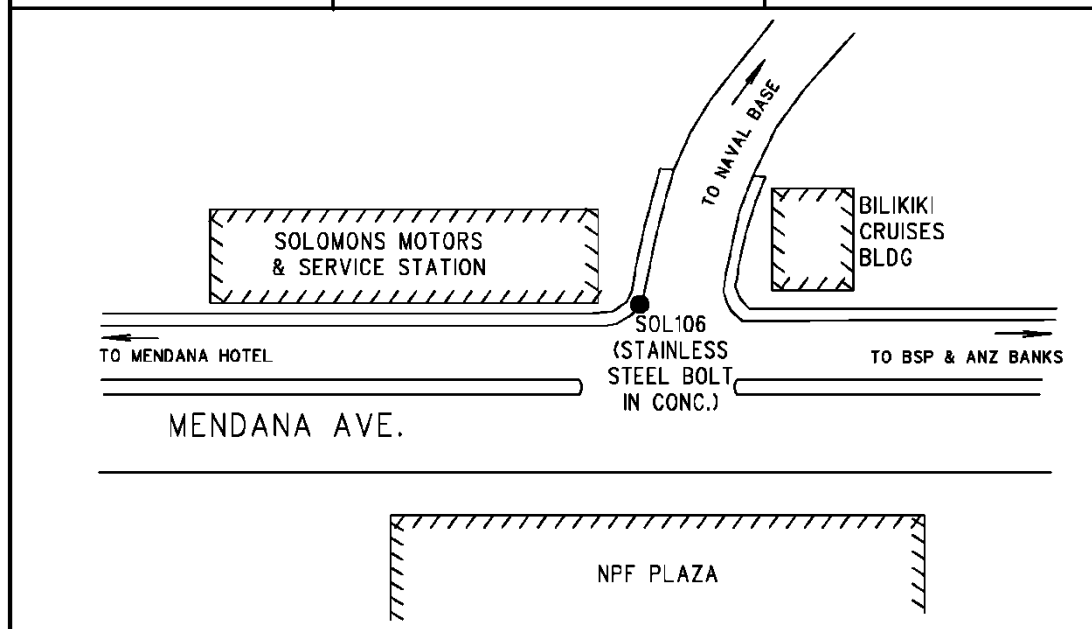
COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 821 POINT NO. SOL113
PROJECT: SPSLCMP	SURVEYOR: A. Lal & G. Hu	DATE: 25-11-10



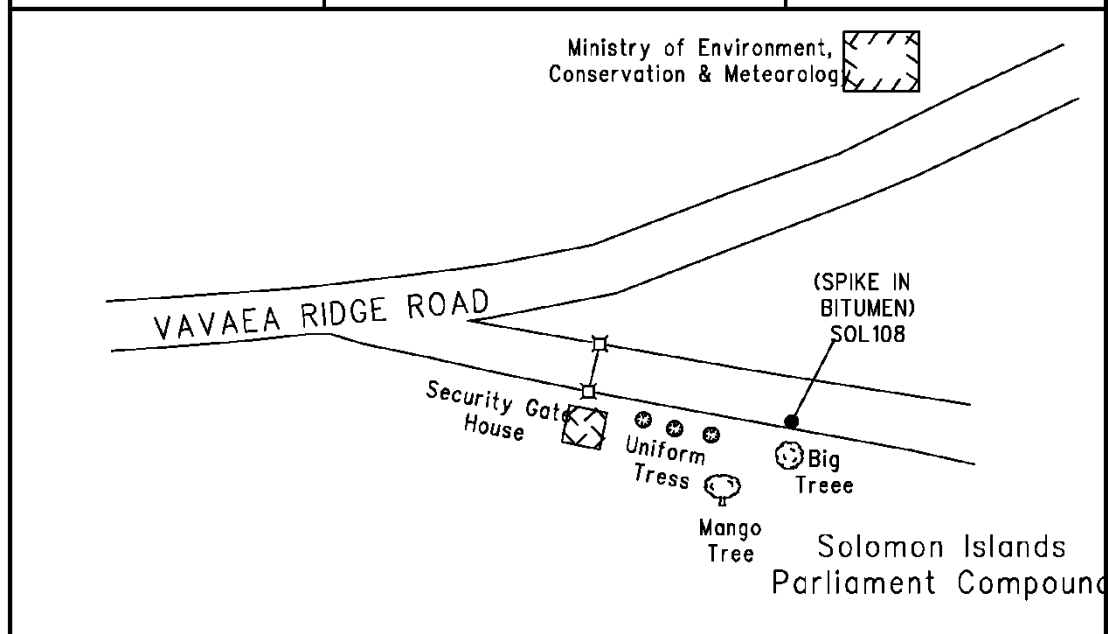
COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 822 POINT NO. SOL103
PROJECT: SPSLCMP	SURVEYOR: A.Lal & M. Deo	DATE: 25-08-07



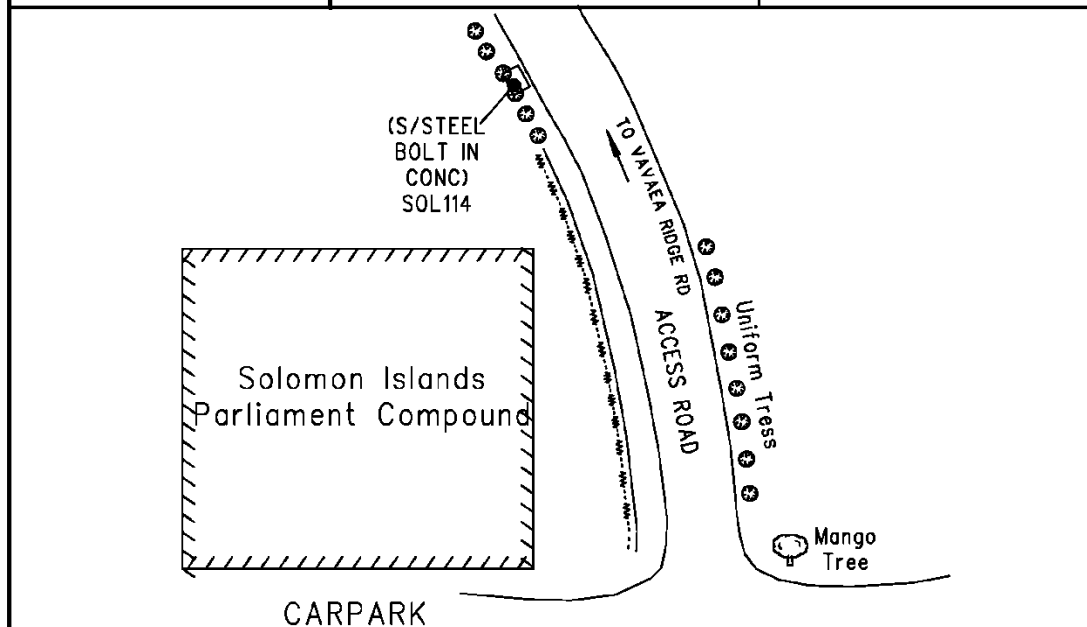
COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 887 POINT NO. SOL106
PROJECT: SPSLCMP	SURVEYOR: A. Lal & M. Deo	DATE: 19-05-09



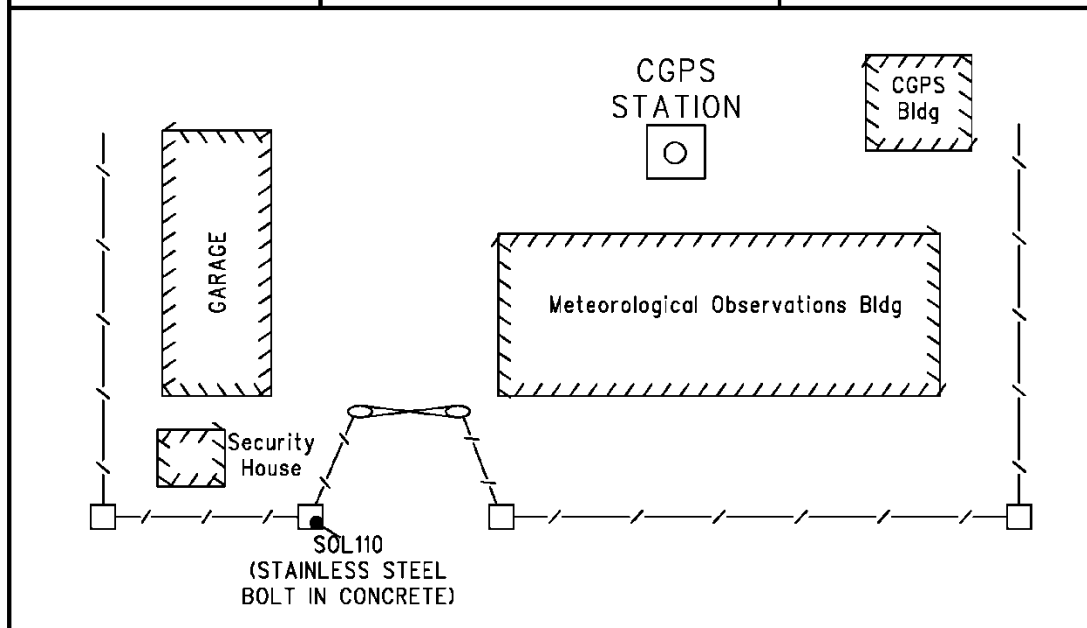
COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 888 POINT NO. SOL108
PROJECT: SPSLCMP	SURVEYOR: A.Lal & M. Deo	DATE: 19-05-09



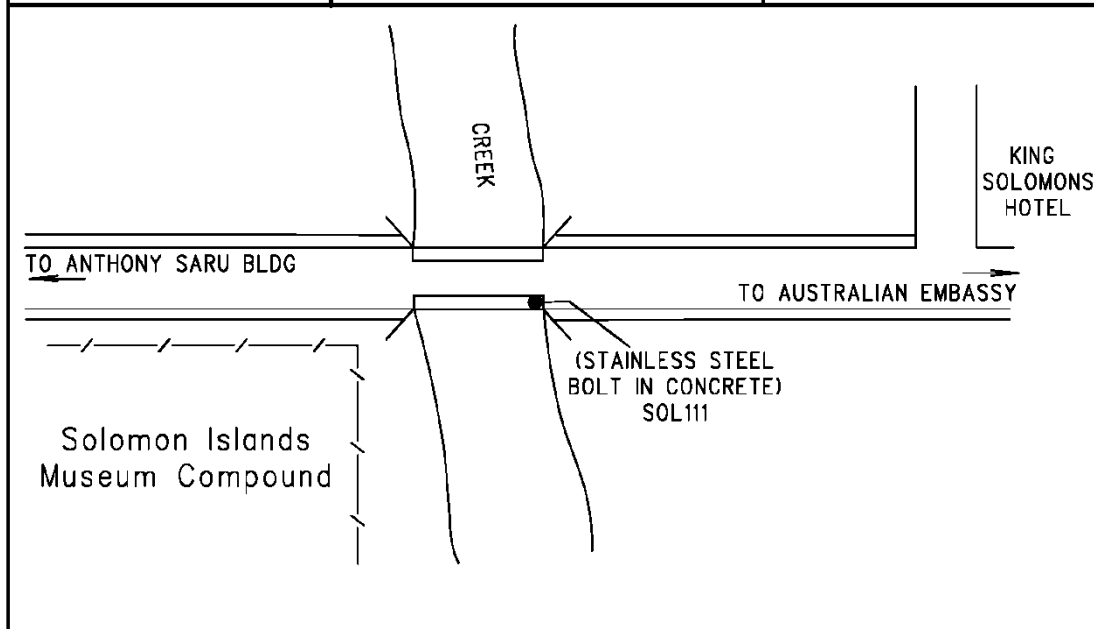
COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 889 POINT NO. SOL114
PROJECT: SPSLCMP	SURVEYOR: A. Lal & G. Hu	DATE: 25-11-10



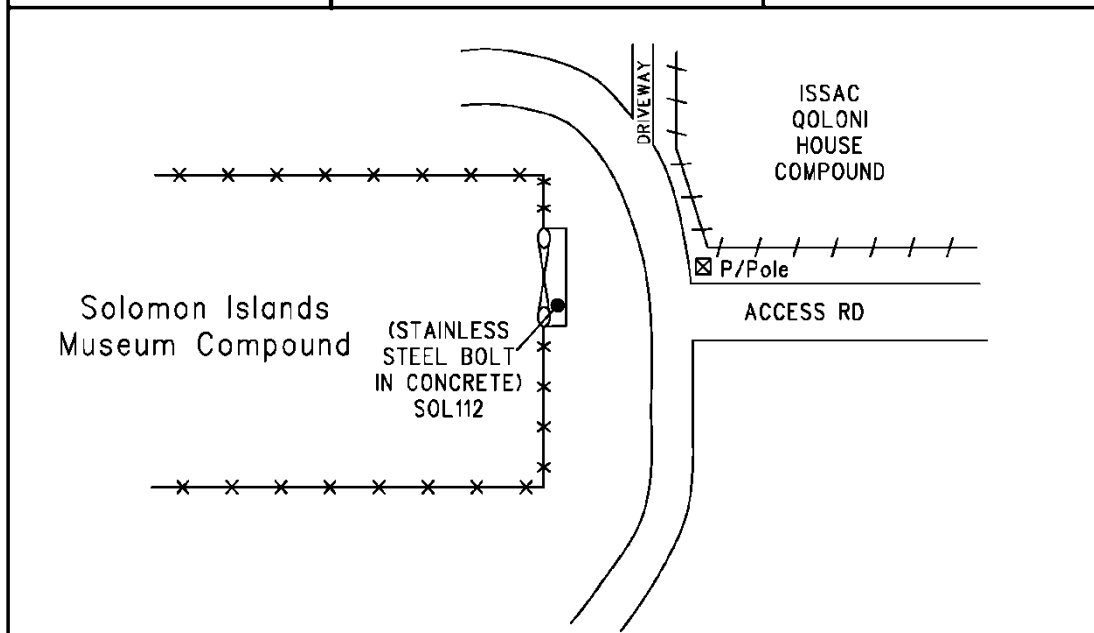
COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 890 POINT NO. SOL110
PROJECT: SPSLCMP	SURVEYOR: A.Lal & M. Deo	DATE: 19-05-09



COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 891 POINT NO. SOL111
PROJECT: SPSLCMP	SURVEYOR: A. Lal & M. Deo	DATE: 19-05-09



COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 892 POINT NO. SOL112
PROJECT: SPSLCMP	SURVEYOR: A. Lal & G. Hu	DATE: 25-11-10



7 References

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