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VAIUSU BAY – MARINA FISHERIES STUDY MULINU'U PENINSULA APIA, SAMOA

Robert Smith
SOPAC Secretariat

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A view of looking north Vaiusu Bay centre, Mulinu'u Point right of center and Apia Harbour behind small hill in center right of photo.

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SOPAC

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SUMMARY

Presently the Government of Samoa is working on an extension to Apia wharf and is currently exploring options to develop a more secure anchorage for the country's' growing fishing fleet. During the course of these investigations it was found that due to the lack of detailed bathymetric and oceanographic data for Apia Harbour Vaiusu Bay and the fore-reef area fronting Apia a number of options considered could not be expanded on. As a result SOPAC was approached and the necessary survey works were completed.

Mapping was done using a multibeam system to delineate the seabed morphology of the 3 above-mentioned areas. This data was then modelled to determine possible channel routes and provide an estimate on the volume of material required to be dredged to facilitate access to the proposed marina site. The proposed marina site is an abandoned dredge site where coral aggregate had been extracted for many years.
Access to the proposed marina is via two isolated pools in the fringing reef platform which are referred to as blue holes some 30 hectares in area. Channel design size for this study was based on an arbitrary configuration of 50 m wide and a working depth of -5 m below lowest astronomical tide. The marina basin size chosen to model was based on the existing dredge pit configuration and size but with a final depth of –5 m below lowest astronomical tide.

The construction of the access channels to the open sea given the current dimension would necessitate the excavation of approximately 63, 000 m^3. The marina and required access channel would require an estimated 15, 000 m^3 of excavation.

Current flow for the existing dredge pit site and across the reef flat along the north east margin of Mulinu'u Point show the flow to be dominantly to the south east with a peak flow of about 16.5 $cmsec^{-1}$, and average flow rates of 4.9 and 7.0 $cmsec^{-1}$ respectively. Current measurements in the northern blue hole on the fringing reef off Mulinu'u Point pool had a northwest trend with a maximum flow rate of 16.5 $cmsec^{-1}$ and an average flow rate of 6.8 $cmsec^{-1}$.

Water level measurements taken in the dredge site show that differences in amplitude at the peak and low tides with a time lag do occur when compared to data from the National Tidal Facility gauge data recorded at Apia wharf. Differences of 5 cm in amplitude and up to a twenty-minute time lag were noted to occur between the data sets. This variation can be attributed in part to the damming effect of the near continuous rubble banks that lie along the northeast margin of the fringing reef. The other contributing factor is attributed to the existing meteorological condition that prevailed at the time of measurement, strong north winds and a heightened sea state, which increased water levels due to wave set up particularly on the high

tide.

Conclusions of the field study are as follows:

- Variations in amplitude and phase difference in water levels on the reef are noted to occur when compared to tide gauge data from Apia harbour.
- Cross reef current flows along the northeast margin of Mulinu'u Point are dominantly to the southeast.
- The damming effect of the near continuous rubble banks along the fringing reef margin appear to influence water level and cross reef current flow.
- The existing data set provides a firm base on which engineering design of the marina configuration can be arrived at.
- The data set provides an excellent platform to develop numerical models to examine marina flushing and impacts of cross reef current flow and water levels.

The major recommendations of this study are as follows:

- A numerical study of the hydrodynamics of the existing system be implemented using this data set for model calibration.

- Based on a working model theoretical configurations for marina configuration can be considered

- An inexpensive jet - probe drilling exercise be conducted to examine sub surface conditions along the proposed channel routes to gauge difficulty of excavation.

ACKNOWLEDEGMENTS

Acknowledgement is due to the South Pacific Sea Level And Climate Monitoring Project for the provision of tidal and wind data to correct the multibeam data set. Also to the Samoan Government Departments of Foreign Affairs and Fisheries for facilitating the logistics to complete the survey works, The Lands and Survey Department for the provision of the digital image data and the staff of the Apia Observatory for their assistance.

OBJECTIVES

The field survey for this study was carried out during the month of February 2002.

- Multibeam survey completed 15 –28th of February

The objectives of the survey were to:

1. Map the bathymetry of Vaiusu Bay dredge sites, Apia harbour and surrounding offshore area.
2. Deploy instrumentation to measure water levels and existing current regime of the proposed marina development site.
3. Provide an estimate on volumes of materials to be excavated for marina and access channels.

INTRODUCTION

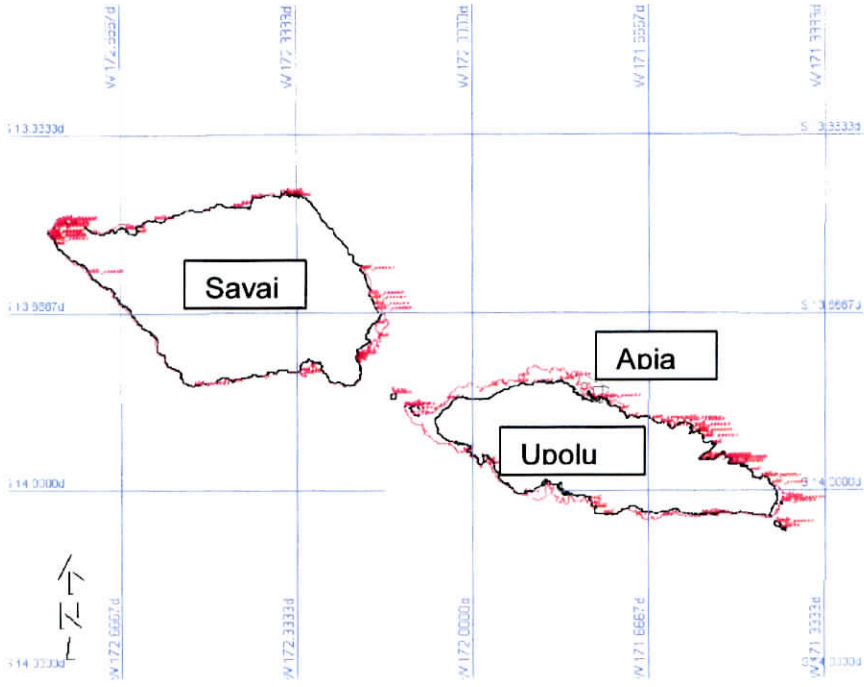

Figure 1. Location map of Apia north coast of Upolu

Currently the Government of Samoa is reviewing options for securing a better anchorage for the country's growing fishing fleet. The existing facility located in Apia, figure1 is very small, congested that affords little to no protection from cyclonic weather, figure 2. Investigations by the Ministry of Foreign Affairs revealed that there was a lack of detailed bathymetry existing in

the shallow inshore and nearshore areas of Apia on which to formulate develop plans for relocating the existing fisheries port. Recognising this SOPAC was approached to collect this data. As a result a multibeam survey of Apia harbour and the surrounding nearshore, offshore and shallow areas of Vaiusu Bay were completed using multibeam swath technology.

Figure 2. Existing fisheries harbour, Apia Harbour Upolu

METHODOLOGY

Navigation

Navigation control was accomplished with a Trimble DML real time DGPS unit. A position fixing update rate was 1 second. All survey map data are reported in Easting and Northing metres based on grid coordinates of the West Samoa Integrated Grid (WSIG). The reference station was sited at on the geodetic control point for the WSIG located within the compound of the Observatory at Mulinu'u Point. Location map and control point details in Appendix 1.

Map Image back drop

The map – image backdrop for data presentation is from aerial photography taken in a 1998 aerial survey and kindly provided by the Department of Lands and Survey Samoa for the

purpose of this survey. The aerial image of the dredge site and fringing reef areas of Apia as provided was geo-referenced based on the WSIG. It should however be noted that the TAB file indicated the DATUM used was WGS 84 rather than the official datum WGS 72 for the West Samoa Integrated Grid.

Multibeam Bathymetry

High-resolution swath mapping, using multibeam echosounders, is able to map a complete underwater landscape in a fraction of the time that is currently required by a single-beam echo sounder, and with greater accuracy. Computer processing of swath mapping data can produce data visualisations that render complex three-dimensional concepts into simple, informative, colour diagrams for the lay observer.

Swath mapping of the sea floor is carried out using sophisticated multibeam echo sounders fitted to a ship or towed at depth. A computer is used to co-ordinate the large amounts of imaging information with the ship's position and attitude at very close time intervals. With further processing, an image can be created that represents, in fine detail, the morphology of the sea floor as well as objects on the sea floor.

Multibeam configuration

The system used is a Reson 8101 multibeam system. Details of the system configuration are given in Appendix 2.

RESULTS

Multibeam bathymetry survey

Bathymetric mapping of the harbour, nearshore and shallow areas of Apia harbour was completed using the multibeam system. The shallow areas associated with the dredged areas in Vaiusu bay could only be surveyed about 1.5 hours either side of the high tide due access into the area was done over the reef flat.

Areas surveyed are illustrated by the rendered bathymetry image against an image backdrop of Apia in figure 3. The data set was processed and bathymetric data reduced to tide gauge zero based on 6 minute data from the NTF tide gauge situated at the main Apia wharf. A 5 m sounding matrix was then used to contour the shape of the seafloor for Apia harbour and offshore areas and for the shallow area of Vaiusu Bay, for the dredged areas a matrix cell size of 2.5 m. Final bathymetric contour map of the areas surveyed as shown in figure 3 at a map scale of 1 :2, 000, Appendix 3. For the dredge area and the natural blue holes in the reef the new bathymetry is reproduced at 1:1 000 scale. Likewise the modelled marina and channels are

also reproduced at a 1:1 000 scale.

Mapping of the dredge areas it was found that they had an average depth of about 3 m with a number of holes exceeding 5 m below chart datum. This morphology reflects to a certain degree the inefficiency of the dredging method and the morphology of the reef substrate, which contains areas of hard or dense coral framework. The survey of the dredge areas could only be completed during high tide to ensure coverage in the shallower areas.

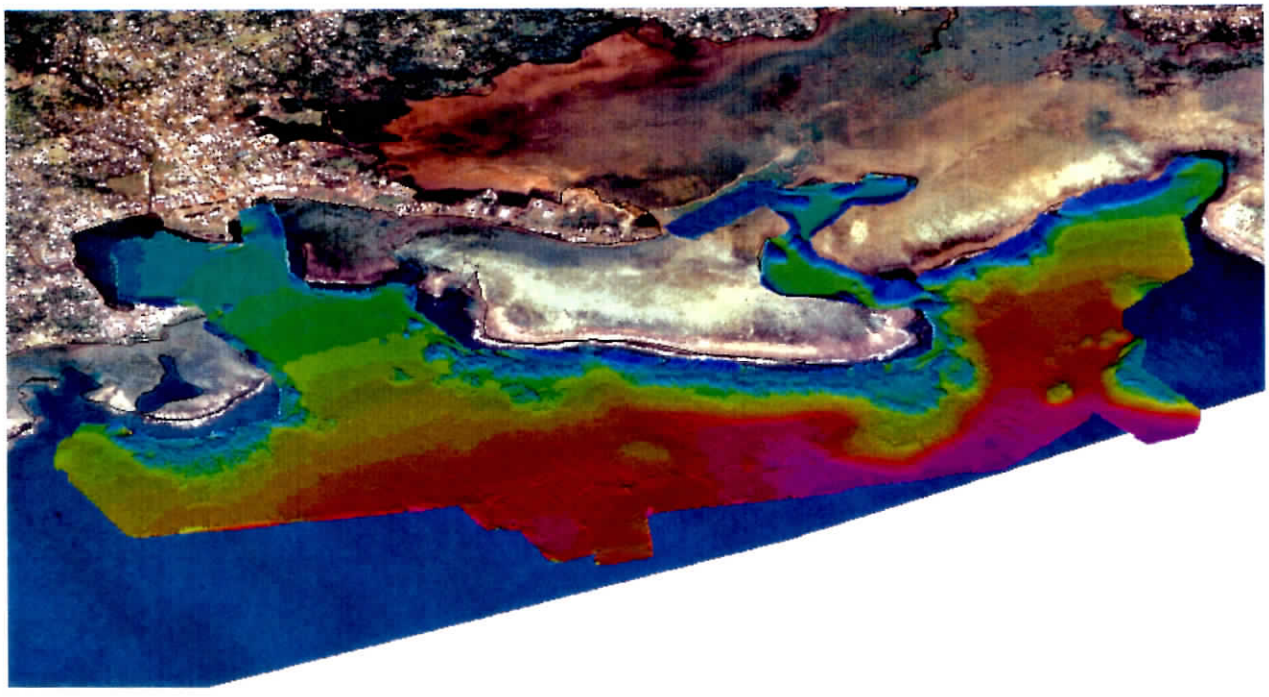

Figure 3. Rendered image illustrating the multibeam coverage of the areas surveyed in Apia

Dredge area and blue hole bathymetry.

In figure 4 the existing dredge area and two natural depressions often referred to as blue holes in the reef are clearly visible. The dredge area is orientated east west with the two blue holes orientated approximately north south. In examining the aerial photo there appears to be a narrow strip of reef flat separating the two blue holes and the outer hole appears to have a small narrow passage exiting through the reef crest.

Bathymetric mapping of these areas was completed to provide baseline data from which to assess the suitability as to whether or not with some modification a secure marina could be built in the existing dredged area with access via passages through the two blue holes thus taking advantage of these existing features. It has been said (Per Comm. Fisheries) that the small passage to the east as seen in figure 4 leading through the reef front was larger and that coral growth and cyclones deposits have contributed to the narrowing of this passage.

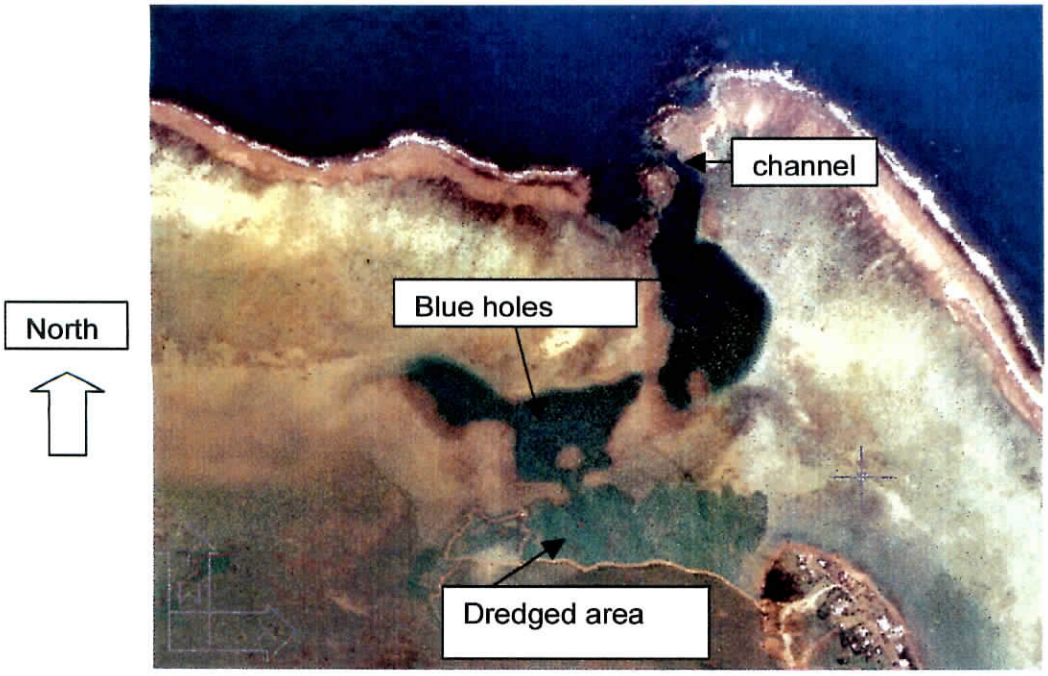

Figure 4 Aerial view of dredged area and two blue hole within the reef flat.

From the multibeam bathymetry the inner blue hole adjacent to the dredged area has an average depth of about 12 m is 13 hectares in area and the outer blue hole deeper with a depth range of 18-20 m and is a little larger covering an area of 16.8 hectares. Both holes are steep walled with a flat featureless seafloor. However in the northern blue hole the bathymetry does show two large coral patches are present.

Model marina and channel construction.

From the bathymetric data using modelling software "Quicksurf™" a conceptual marina basin with the required access channels was modelled. From the model an indicative volume of sediments that would need to be excavated for the marina and channels can be calculated. The location of the marina and channels modelled are shown in figure 5.

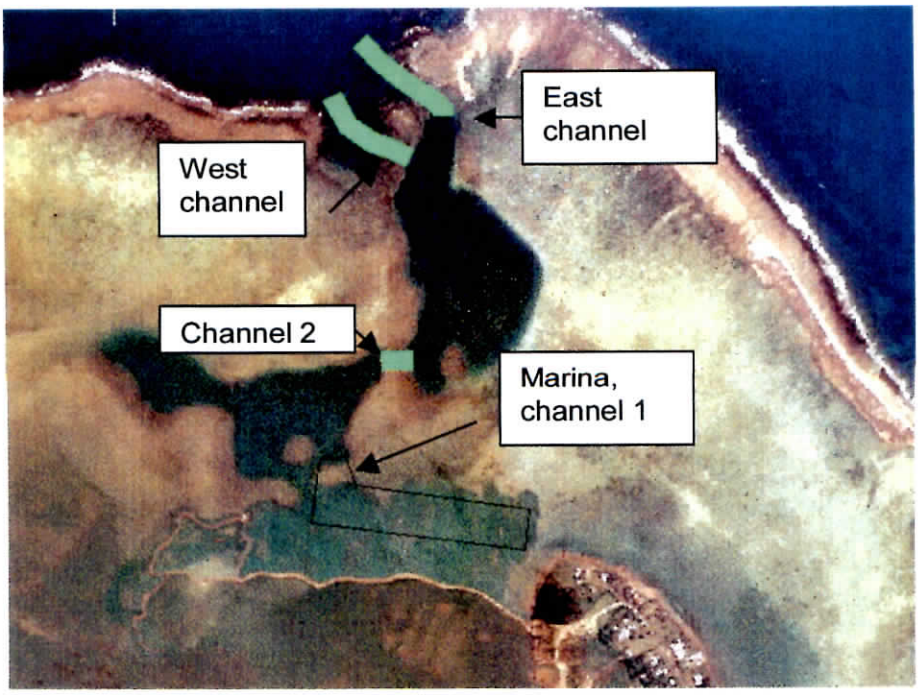

Figure 5. Study area showing possible location for channels and marina.

Marina and channel 1: The marina basin and channel 1 shown in figure 5 is conceptual with the arbitrary dimensions of 560 m in length and 100 m in width. These dimensions are not considered final design size. Based on these dimensions and assigned depth of 5 m below chart datum the cut volume is estimated to be approximately 15,000 m^3.

Channel 2: This channel is required to provide passage between the two blue holes. A conceptual channel with the following dimensions, a width of 50 m dredged to a depth of 5 m below chart datum and some 70 m in length would require the removal of about 14, 300 m^3.

Exit channels: Two options for an exit or entry channel through the reef crest can be considered as shown in figure 5. These have been labelled as east and west. From the aerial photo mosaic it appears that a small channel does exist to the north east of the outer blue hole in the reef platform. During the course of the survey it was found that this passage was not passable due to prevailing weather conditions – strong north winds 20 – 30 knots which generated large wind waves of short period and steep face which often broke at the entrance. From the multibeam data offshore in the vicinity of this small passage a prominent submerged ridge extends seaward from the west side of the east channel, which in effect causes wave convergence due to refraction. This bathymetric feature would present itself as a possible navigation hazard on approach and departure from the basin. As this compounds entry into this area dredging works to deepen the approach or total removal of the ridge would have to be considered. Delineation of this seabed structure shows the advantage of multibeam over single beam reconnaissance survey. Due to the difficulty in approaching the reef edge the morphology

of the seabed and the extent of this structure may not have been delineated as clearly. A preferred alternative is the west channel which assuming a 50 m wide passage would lead directly into open water and does not necessitate additional manoeuvring to enter and leave the outer blue hole. The draw back however is that this channel may be longer in length and therefore require more dredging works. The current model is therefore based on the west channel 50 m wide and approximately 270 m in length. The estimated volume of material to be dredged to create this channel would be about 49,000 m^3. Figure 6 is a 3D view illustrating the design channel to the west and the morphology of the fore reef slope adjacent to the east channel as viewed looking from the south east.

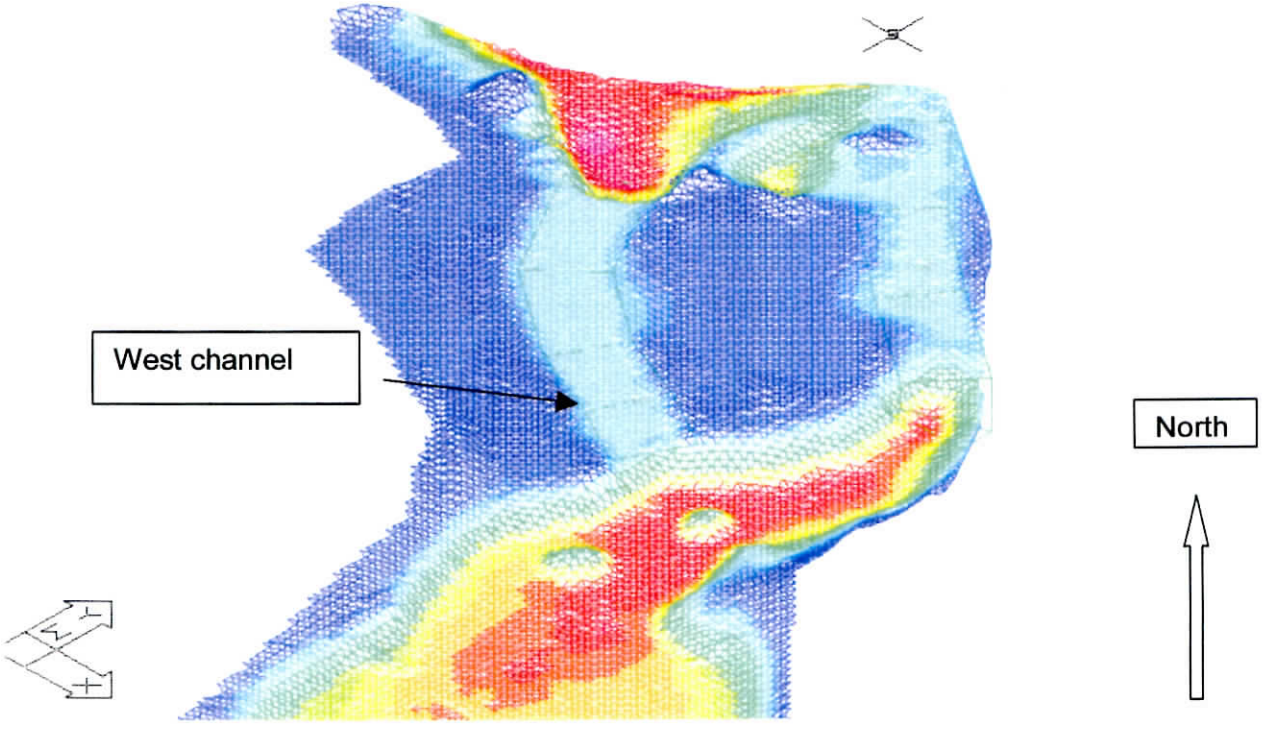

Figure 6 3D view of reef platform morphology and offshore bathymetry showing the conceptual location of the west channel

There are a number of other variables to be considered for determining the optimum size for the marina and channel and these should be based on: best operating size taking into consideration future expansion needs; economics and configuration that result in safe hydrodynamics, good flushing with as little impact on reef top circulation and wave set-up. In terms of the hydrodynamics the final channel size and resulting current flows need to be considered with importance so that safe vessel navigation is present at all states of the tide.

Water levels and Current Measurements

Water surface level of the sea is made up of three constituents these being mean or average sea level, changes that are due to predictable tidal variations a function of astronomical forces and variations attributed to meteorological events. These levels influence cross reef currents, wave transformation and energy levels.

To gain some insight into these parameters a number of instruments where deployed in three locations across the study area. These are shown in figure 7.

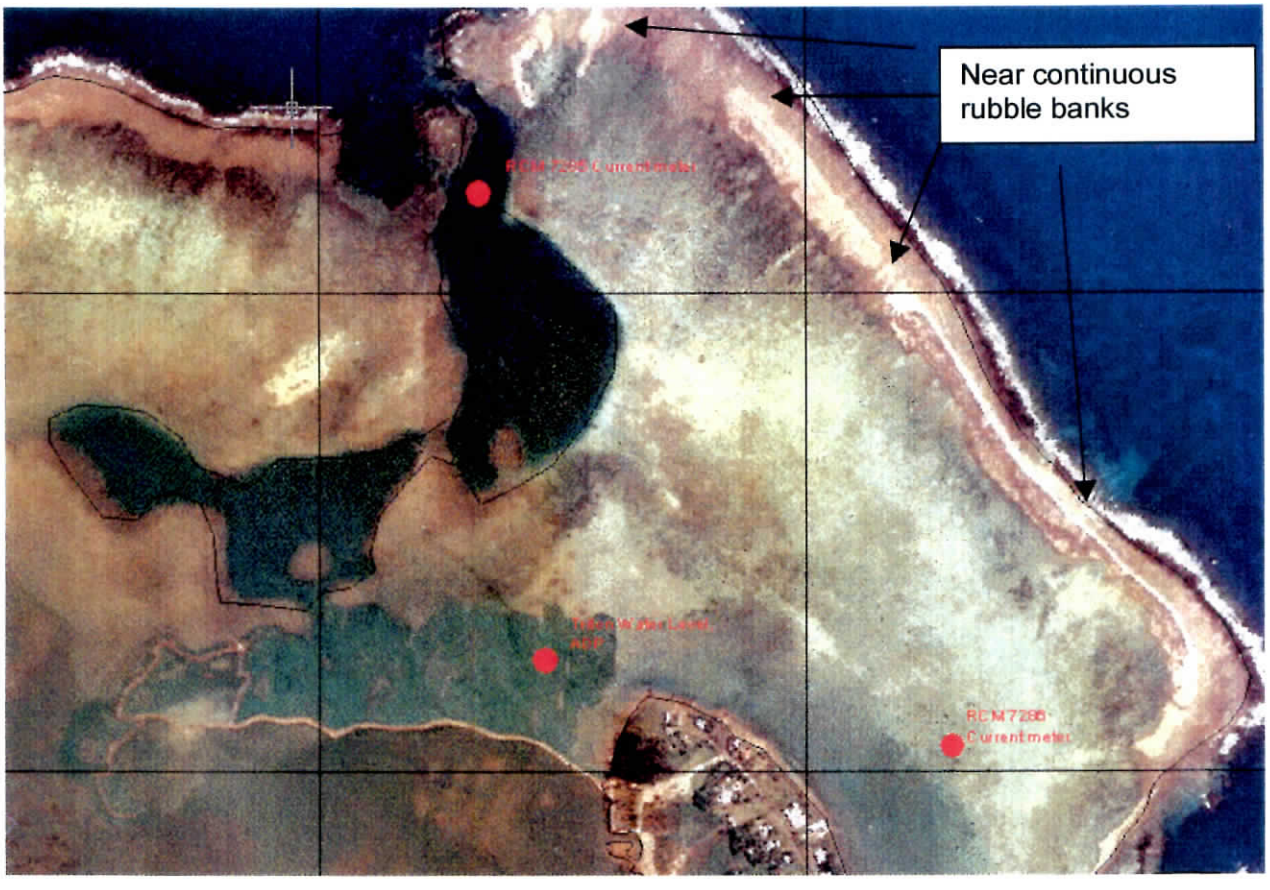

Figure 7 Instrument location map for the two current and the combination tide, wave and ADP gauge

As the marina complex being considered lies within a fringing reef environment variations in water levels as compared to Apia harbour were considered. Water levels measured in the proposed marina area were compared with 6-minute readings from the NTF gauge located at the wharf in Apia harbour to see whether or not differences in levels and period could be observed between the two stations. Water level will play an important role in the flushing of the proposed marina. A Sontek Triton wave and tide gauge was deployed at a depth of 3 m

northwest of Mulinu'u Point, figure 7 in the dredge pit. The sampling period was set at 6 minutes to match the NTF data set. The Triton data set extended over 5 days from the 16th February to the 21st of February. To compare the data graphically, figure 8, a number of steps where taken. The Triton data set was reduced to produce a tidal curve with respect to a mean sea level of 0.729m above tide gauge zero for the NTF gauge. Tide Gauge zero is reported to be 0.024m above Chart Datum.

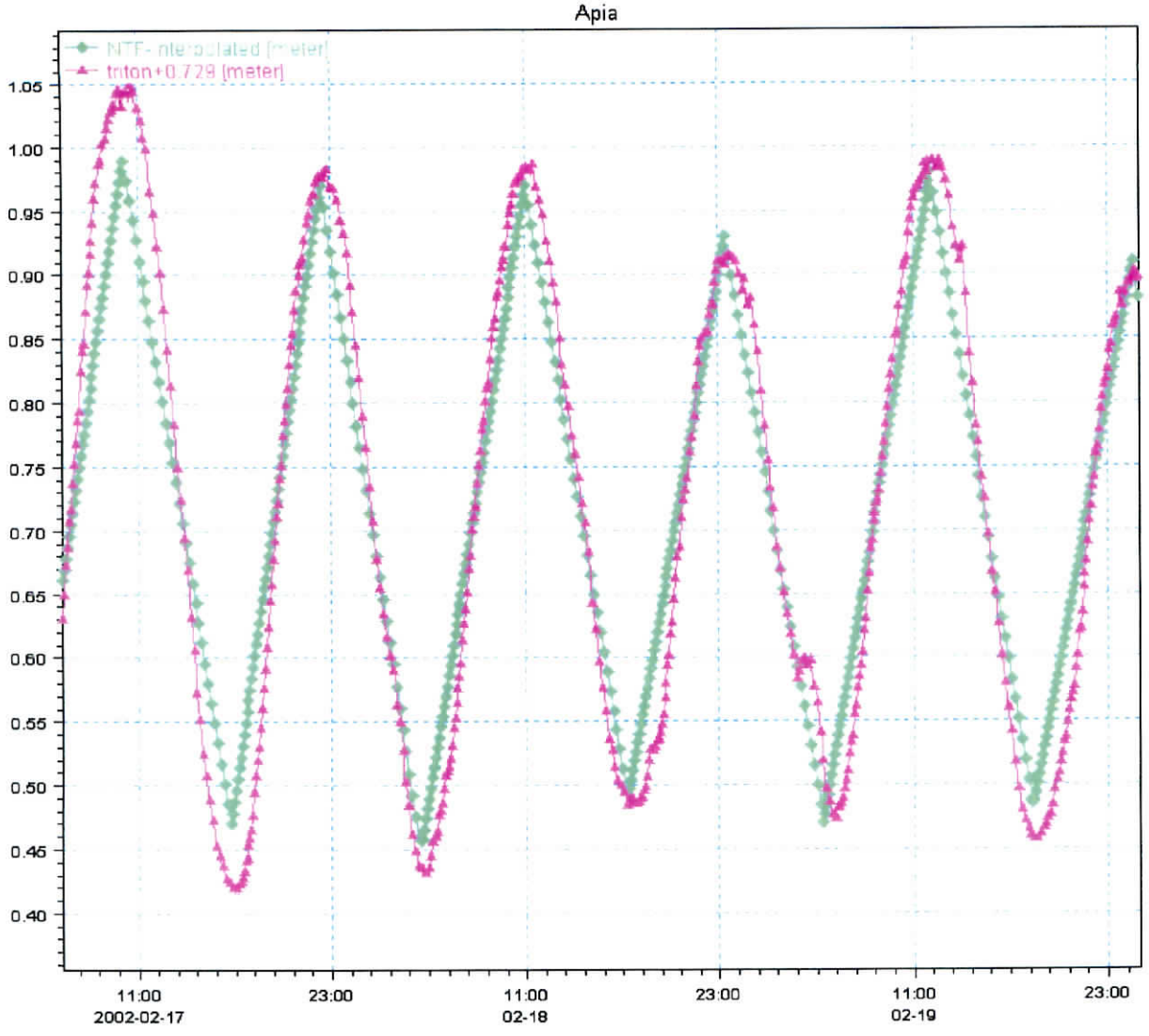

Figure 8 Comparing water level curves reef flat (Triton data) versus Apia harbour (NTF data)

In general the data shows reasonable correlation in amplitude and phase between the two sites however variations in water levels at the peak and lows of the flood and ebb tides respectively do appear to occur with differences of up to 5 cm in height and a phase lag of up to 20 minutes. Water levels across the fringing reef flat adjacent to Mulinu'u Point appear to be influenced by the near continuous rubble banks deposited along the northeast margin of the reef during Cyclone Ofa February 1990, figure 7. The lower levels recorded in the old dredge workings where the Triton tide gauge was deployed point to a possible damming effect which removes the contribution of wave set up on water level during the ebb tide. However the reverse occurs

for high tides where wave set – up increases water level by the damming or containment effect of the rubble banks. Meteorological conditions will also influence water levels and cross reef currents. Figure 9 is a rose plot of winds for the survey period. This data is based on hourly readings from the NTF gauge. Strong offshore winds from the north and north east, with gusts to 31 knots and accompanying heightened sea state generated significant wave set up which would of also contributed to the higher peaks in water levels seen in the tide data from the Triton gauge at high tide.

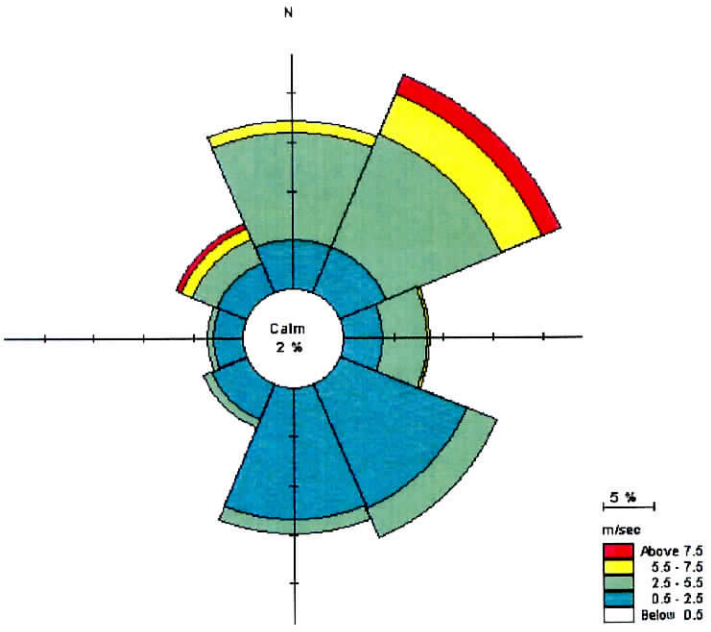

Figure 9 Rose plot of hourly wind speed in m/sec and direction, true, for the period 10-02-02, 00:00:00 to 23-02-02, 23:00:00 GMT. (Data source NTF)

Current measurements.

Currents where measured at three locations in the study area. These are shown in figure 7. Of the three instruments recording the data units 7285 and 7286 are mechanical vector averaging RCM Aanderaa meters with a vane and paddle wheel. The third instrument was a Sontek Triton Acoustic Doppler Profiler (ADP). The sensors of the ADP are in a down looking configuration mounted on a tripod some 30 cm above the seabed, figure 9.

Figure 10 Sontek Triton Tide gauge

This unit measures 3D water velocities. With the inbuilt compass velocity measurements are referenced back to an Earth coordinate system ENU (East-North-Up) independent of probe orientation. In addition to the current sensors tide and wave data was also recorded.
Of the 3 data sets the longest was the Triton gauge site adjacent to Mulinu'u Point in the dredged area. This instrument recorded water level, current and wave data for 5 days from 16-02002 11:06 to 21-02-02, 15:48 hours local time. Two Aanderaa RCM 7 vector-averaging meters were deployed, one opposite the Apia Yacht Club in 1.5 m of water, unit 7286 and a second unit 7285 buoyed at a depth of 2 m in the blue hole adjacent to the passage exiting the reef. The mooring anchor was at a depth of 13 m. Both these units were interfered with resulting in shorter data sets. Unit 7286 was removed by persons unknown, but later found and recovered from a backyard was found to have recorded in situ data from the 16-02-02 08:50 hrs to the 18-02-02 13:30 hrs local time. For unit 7285 the subsurface floatation was stolen leaving the unit lying on the seabed. In situ data was recorded from 16-02-02, 10:00 hrs to the 19-02-02, 18:30 hrs local time for this unit.
From the current data progressive current plots were compiled. A progressive vector plot is calculated by summing the speed and direction vector for each measurement. The results are shown in figure 11.

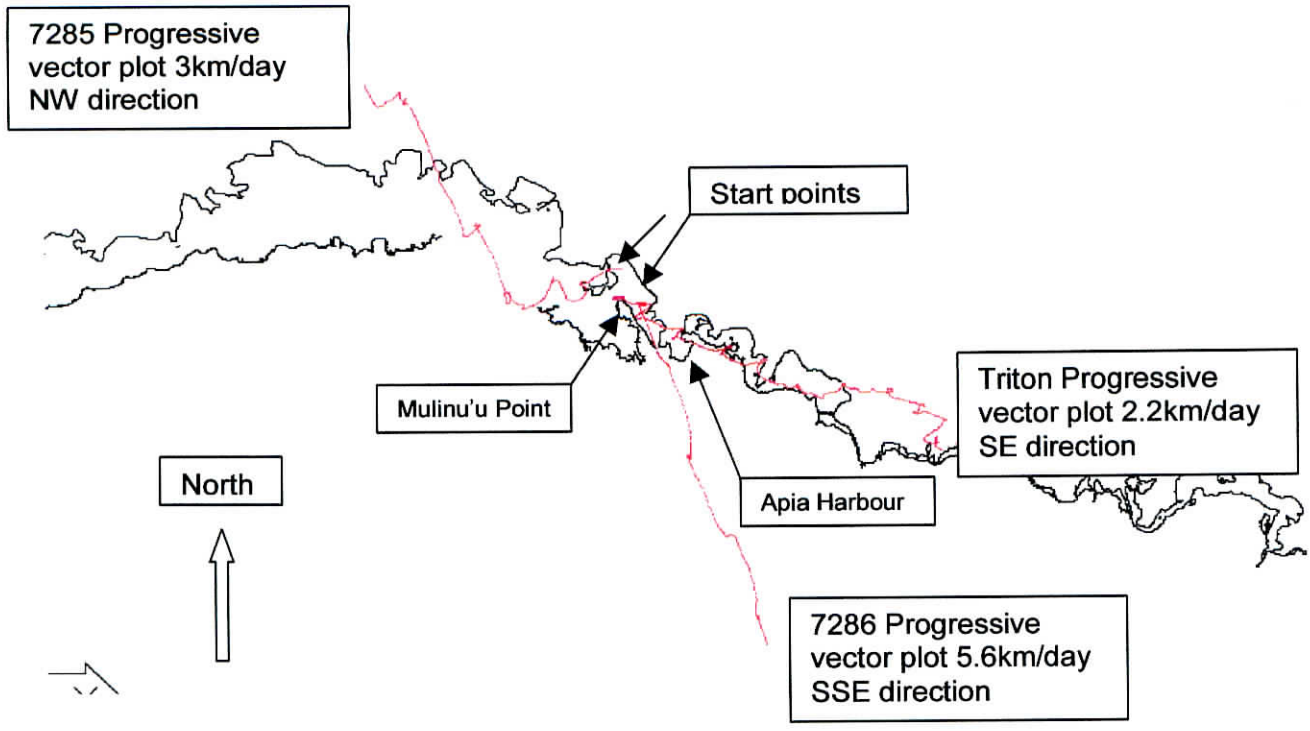

Figure 11 Sketch map illustrating the progressive vector plots for the 3 instrument locations deployed on the fringing reef of Mulinu'u Point.

Data for unit 7286 located offshore Apia yacht club shows the current flow to be dominantly to the southeast. For the meter deployed in the blue hole north of Mulinu'u Point, unit 7285, the progressive vector plot shows a northwest current direction dominating for the same recording period. A third current recording instrument, the Triton located in the dredged area just to the west of Mulinu'u point shows the current to be dominantly towards the southeast. Of the three instrument locations the flow rates are the lowest in the dredge pit site at 2.2 km per day with the highest flow rate occurring on the reef flat at location 7286 at 5.6 km per day. Current velocities as high as 16.5 $cmsec^{-1}$ were recorded for RCM 7286 these occurring during the ebb tide.

Although during the period of measurement much of the wind was from the north and north east the current flow across the reef flat appears to be dominantly towards the southeast around and along the northeast margin of Mulinu'u Point into Apia harbour. Water hydraulically (wave set up) pushed onto the reef combined with the damming effects of the rubble banks appears to maintain this direction of flow during most phases of the tidal cycle.

Seabed morphology and sub-surface conditions

In a 1995 SOPAC study of Vaiusu bay, (Smith 1995) fifty-six holes where drilled using a jet probe drill to assess sediment thickness. In a 1987 survey by JICA for the Samoa Ports

Authority a borehole northwest of the area surveyed penetrated 17 meters of coral sands (JICA1987) but was terminated before reaching bedrock. Based on these data a map illustrating "buried reef pavement" areas where a hard impermeable substrate interpreted to be reef pavement covered by a layer of sand between 0.5 and 2 metres thick was complied. This is shown in figure 12. These areas were identified during the jetprobing. When the probe penetrated through the surficial sand layer and reached a resistive substrate, due to the substrate's low permeability the jet probe bounced as a result of the hydraulic action of the water jet. Also in the 1995 study at location 53 at the western edge of the southern blue hole, a jet probe hole proved 5 m of clean carbonate sand was present. This implies that sediment thickness in the blue holes may be quite substantial.

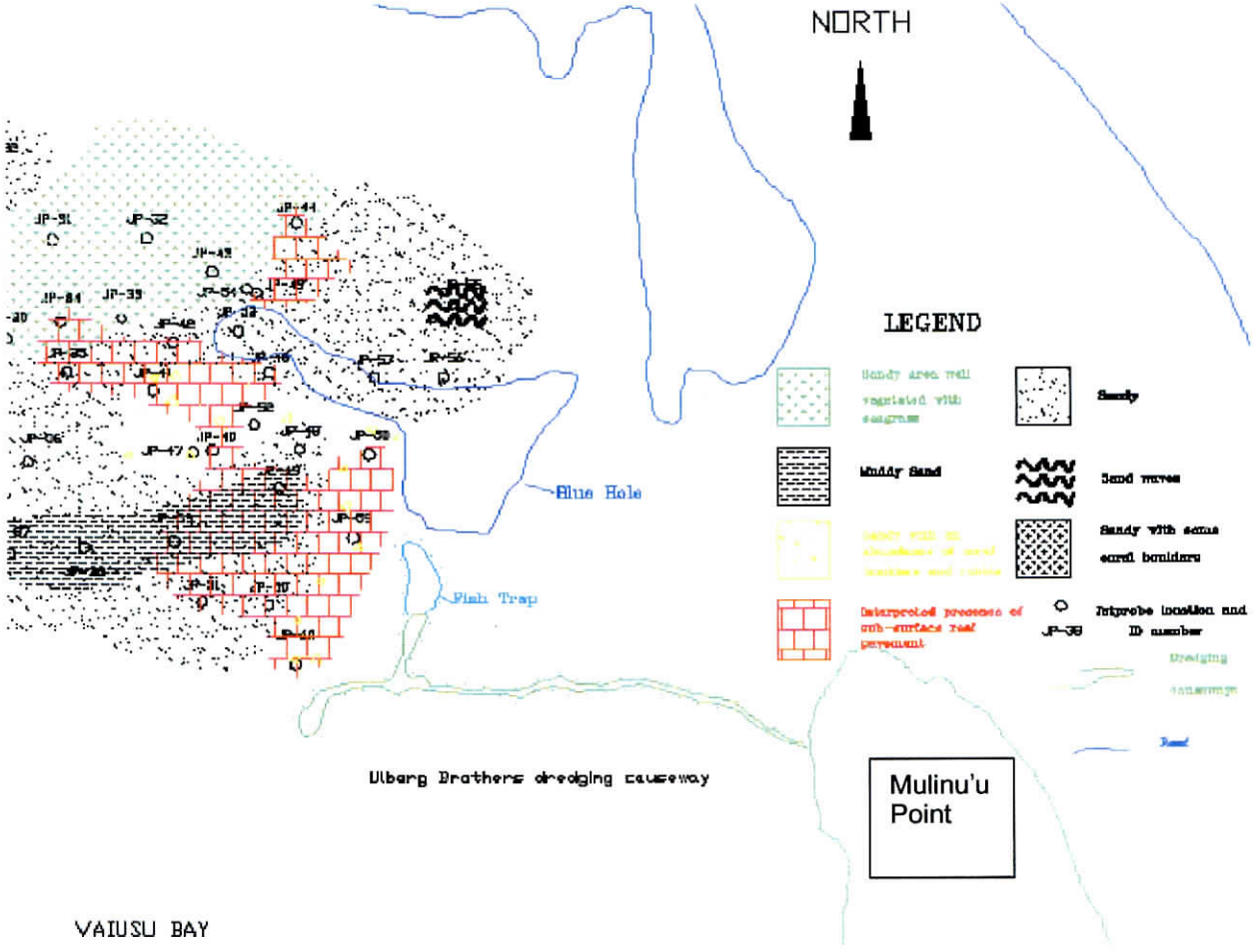

Figure 12 Sketch map illustrating the presence of buried pavement adjacent to study area

The extent of buried pavement in the survey area is not known but based on the data shown in figure 12 it does suggest that it is likely to be present. However a simple inexpensive jetprobing exercise could be completed to investigate the nature of the substrate in the areas where the proposed channels may be constructed. The jet probe is a manually controlled system for drilling into the seafloor consisting of a 3 meter-long galvanised 2" ID pipe with a 1" ID jet nozzle

at one end the other connected to a diesel water pump using non collapsible 2" ID hose with 3" cam lock fittings. In water depths over 2 m the system does require diving support.

CONCLUSIONS

Conclusions of the field study are as follows:

- Variations in amplitude and phase difference in water levels on the reef are noted to occur when compared to tide gauge data from Apia harbour
- Cross reef current flows along the north east margin of Mulinu'u Point are dominantly to the southeast.
- The damming effect of the near continuous rubble banks along the fringing reef margin appear to influence water level and cross reef currents to flow around the north end and along the north east margin of Mulinu'u point into Apia harbour.
- The existing data set provides a firm base on which engineering design of the marina configuration can be arrived at.
- The data set provides an excellent platform to develop numerical models to examine marina flushing and impacts of cross reef current flow and water levels.

RECOMMENDATIONS

Major recommendations of this study are as follows:

- A numerical study of the hydrodynamics of the existing system be implemented using this data set for model calibration.

- Based on a working model theoretical configurations for marina configuration can be considered.

- An inexpensive jet - probe drilling exercise be conducted to examine sub surface conditions along the proposed channel routes to gauge difficulty of excavation.

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Japanaese International Cooperation Agency (JICA) Task Force, 1987. The Study On The Development Of The Ports In Western Samoa. Volume 3 Technical Report.

Smith, R. 1995. Sand and aggregate resources, Vaiusu Bay, Apia, Western Samoa. SOPAC Technical Report 223: 30 p.; figs., 3 app.

APPENDIX 1

Reference Station Location Map and Details

Observatory 'Doppler Station:

Type of Mark: Brass plaque set in concrete in the ground by the Australian Survey Corps.

Location: On the northern lawn near the foreshore of the main Observatory office building at Mulinu'u Point. The mark lies approximately 3 m to the west of a 10 m high-galvanised mast. Also refer to Cadastral Plan # 4619

N.B. This was adopted as the geodetic origin of the W. S. I. G. (West Samoa Integrated Grid) Data abstracted from Department of Lands and Survey Government of Samoa.

For GPS reference station use the WGS 72 geographical coordinates where translated to WGS 84 geographical using two geodetic software programs TWGS (a hydrographic DOS routine produced by the British Admiralty) and the RESON program 6042 used with the multibeam mapping software. Lands and survey could not provide WGS84 coordinates for the this Station.

Coordinates WGS 72 Doppler	TWGS conversion to WGS84	6042 conversion to WGS84
Latitude 13^0 48' 52.98" S	13^0 48' 52.8417" S	13^0 48' 52.8420" S
Longitude 171^0 46' 51.33" W	171^0 46' 50.7760" W	$17^0$1 46 50.7760" W
Elevation 0.91		

Doppler station located here 3 m west of mast

APPENDIX 2

Multibeam Survey log - Data files

APPENDIX 3

Multibeam Configuration, Calibration and Processing

The system used is a Reson 8101 multibeam system with the following configuration of sensors:

Multibeam Echosounder: The 8101 multibeam system has 101 beams operating at a frequency of 240 kHz has a swath width at 150 degrees of 7.4 x the water depth for depths 0-70m. Depth capability of the system is limited to 300 m. The range resolution of the system is 5 cm. The transducer head can be installed on a vessel of opportunity as an-over-the side mount on a rigged pole and plate assembly. The acoustic centre that is X, Y, Z of the subsurface unit is used as the reference position origin for the survey.

Multibeam Bathymetry Collection System, the SeaBat 6042: Essentially a computer with 8 serial ports, this is a dedicated data collection system that combines the data from the onboard sensors for vessel heave, roll, pitch heading and position, time tagging them for post processing. The 6042 record the raw data in its own format with the file extension *.svy*. For post processing, raw data files can be exported in a number of different formats depending on the type of multibeam software used for editing the data.

Multibeam Side Scan: From the multibeam data, sidescan imagery can be recorded and is available in an XTF format. This removes the need for a separate piece of equipment, which is usually towed behind the vessel.

Navigation system: This is required to provide real-time information to the vessel helmsman for navigating along the planned track lines of the survey. This is accomplished using Hypack Hydrographic software. With HYPACK ™, translation of the NMEA output from the mobile GPS receiver into a graphical plot of the vessel movements is done.

Heading Sensor: A heading sensor is required to measure the orientation of the vessel. The system used is a Scan 2000 gyrocompass. This provides heading data to .01 of a degree that is logged by the SeaBat 6042. The heading is output from the 6042 to the motion sensor. The gyro sensor on installation is aligned with the centre line of the survey vessel.

Motion Sensor: This is essential to correct the swath data for vessel movement namely heave, pitch and roll. The unit used is a VRU10 motion reference unit. The sensor once installed require that the offsets of its reference frame of origin is measured with respect to the survey origin, in this case, the acoustic centre of the multibeam system, and inserted in the 6042 program set-up system offsets.

Water Velocity Profiler: Sound velocity measurements in the water column are required to correct for beam refraction as the sound passes through the water column. Sound velocity

profile in the survey area are measured using a Seabird CTD, computed for every 0.5 m and applied during the processing and editing phase. During data collection a constant velocity of 1540 msec-1 was set in the SeaBat processor

Multibeam Bathymetry Data Editor: multibeam data once collected requires editing and cleaning before presentation of data can be considered. This is accomplished using HYSWEEP software from Coastal Oceanographics Inc.

Tidal reductions: All bathymetric data acquired during the survey are reduced to chart datum based on tidal corrections provided by the Nautical Almanac for Vuda Point. These corrections are applied during the editing and cleaning of the data.

Multibeam Data Presentation software: Commercially available software that accepts X, Y, Z points can be used. Once the datasets have been cleaned and reduced, presentation of the data can be accomplished in software package is such as AutoCAD using QuickSURF, MapINFO using Vertical Mapper, or Surfer for that matter.

Patch Test Calibration

The patch test is a multibeam calibration procedure that is completed after installation and set-up to calculate sonar roll, pitch, and yaw and GPS latency errors in the multibeam data. Data for the patch test is collected under specific bottom terrain in a specific order. The roll angle test is done in an area where the bottom terrain is smooth and flat, running the same line in different directions at survey speed. Latency test follows running a line twice in the same direction up a slope once at survey speed and once as slowly as possible. The pitch test is done running reciprocal lines with a slope at normal survey speed. The yaw test is done last by running offset lines in the same direction, approximately 2 to 4 times water depth apart. The roll test is by far the most important, because it is misalignment in the roll direction that leads to the greatest survey errors.

The data collected for the patch test is converted from the Reson 6042 *.svy* file format to a *.hyp* format used in the HYSWEEP patch test program. Having completed the processing for the patch test, the computed angles and latency times are then configured in the set-up system offsets for the multibeam data collection system. An interesting and important feature of the 6042 is that multibeam data can be collected immediately or prior to running the patch test as the raw survey data can be reprocessed and is exported in a different format leaving the raw data unchanged.

Multibeam data processing

Patch Test calibration:

Processing the patch files the following files were used in the final analysis.

Table 2 Patch test processing and results

Patch test	Files	Results
ROLL	Roll023	-1.5 degrees
	Roll024	
LATENCY	API040	0.3 second
	API042	
PITCH	API040	+8.0 degrees
	API041	
YAW	Roll022	+2.5 degrees
	Roll024	

Results of the patch test used for reprocessing the data using the Win6042 program are shown in Table 2.

Multibeam data files

A log of all the files for the multibeam data is provided in Appendix 4. The original data files have the file extension ***.svy** and are archived on CD ROM. For processing the raw Mon*.svy files will be reprocessed with the 6042 program using the patch test parameters and output as Mon*.hyp files. This file format is then imported into HYSWEEP the multibeam editing software. The *.hyp files will also be archived on CD-ROM.
Once the processed *.hyp files have been generated, editing and cleaning of the multibeam was completed, using HYSWEEP. Each file is first imported into the sweep editor along with a tidal correction file and sound velocity file. Tidal and sound velocity profile correction files have been archived along with the .swp files in a directory called \datum. The graphical representation of all collected data, position, heave, heading and soundings make it easier to separate good points from bad.

Once satisfied with the graphs the Sweep Editor will convert the raw survey data into X, Y, Z depth points and redisplays them, again in a graphical format. In multibeam surveys, data spikes in the dataset occur due to fish, bubbles, hull turbulence etc. The application of an automatic filter removes the spikes quickly but is best for flat bottom topography.

Sounding reductions

Multibeam surveys produce a lot more data than is actually required, particularly for presentation. Sounding reductions of a multibeam data set are done using the Mapped program

in HYSWEEP. This program will load an entire survey and reduce the data to the desired density. This data reduction is accomplished through gridding. A grid is created from a matrix with rectangular cells of any size; the soundings are loaded and reduced to one per cell.

APPENDIX 3

Maps of:

1. Apia Harbour and Offshore Bathymetry. Scale 1:10, 000.....
2. Overview exiting bathymetry of proposed marina site. Scale 1:2, 000.....
3. Modelled marina and access channel bathymetry Scale 1:2,000.....

Appendix 4

Project CD

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