EU-SOPAC (EDF9) Project Report No. 80

Reducing Vulnerability of Pacific ACP States

REPUBLIC OF NAURU
KRA 2 (WATER) TECHNICAL REPORT

RAINWATER HARVESTING:
ASSET CONDITION SURVEY OF DOMESTIC INFRASTRUCTURE

13th February to 23rd February 2007

Plastic water storage tank emplaced partially below ground level, Buada, Nauru.

Compiled by:

Mr Stephen K. Booth
Mrs Elizabeth Lomani-Whippy
Mrs Arieta Navatoga-Sokota
Ms Vilisi Tokalauvere

SOPAC Secretariat
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PACIFIC ISLANDS APPLIED GEOSCIENCE COMMISSION
c/o SOPAC Secretariat
Private Mail Bag
GPO, Suva
FIJI ISLANDS
http://www.sopac.org
Phone: +679 338 1377
Fax: +679 337 0040
director@sopac.org

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REPUBLIC OF NAURU.

KRA 2 (Water) Technical Report

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EXECUTIVE SUMMARY.

This document is a record of an in-country technical survey mission to Nauru, completed between 13th February to 23rd February 2007 by the following SOPAC staff:-

- Mr. Stephen Booth (EDF8/9 Senior Advisor -Water)
- Mrs Elizabeth Lomani-Whippy (EDF8/9 Project Intern)
- Mrs Arieta Navatoga-Sokota (SOPAC Project Officer –Water)
- Ms Vilisi Tokalauvere (EDF8 Fiji Country Intern)

The mission was undertaken as an integral part of the Key Result Area 2 (Water) contribution to the SOPAC EU EDF8/9 Project "*Reducing Vulnerability of Pacific ACP States*" with the objective of field surveying the current asset condition status of domestic and community rainwater harvesting infrastructure. Although a little over eight field survey days were achieved on-island, daily progress was compromised by various difficulties, particularly the limited availability of diesel fuel on-island which impacted both ease of transportation and availability of electricity and water. Despite these constraints, two field survey teams visited a total of 308 properties within the districts of Buada, Yaren, Meneng, Anibare and Ijuw, initiating a comprehensive database which can either be fully completed within the remaining island districts at a future date, or used with some confidence as a statistically representative sample for forward interpolation of "whole-of-island" conditions.

The field survey equipment utilised and approach methodology are described in detail Section 3 of this report, whilst Section 4 presents and analyses the spatial data collected. Section 5 of the report considers current population dynamics and their impact on domestic water demand.

The SOPAC project team is particularly indebted to Mr Bryan Star, Director of Projects, Nauru Department of Commerce, Industry & Resources, and Ms Chitra Jeremiah and Ms Judith Solomon, both of Nauru Aid Management Unit, for in-country arrangements. The invaluable assistance with field survey work, on-site equipment security, and back-up administrative support provided by a variety of other staff within the following organizations is also gratefully acknowledged:-

- Nauru Lands & Survey
- Nauru Environment Dept
- Nauru Rehabilitation Company
- Nauru Police Force

1. INTRODUCTION

1.1 Background

Despite a considerable body of historic information, technical advisory reports and even a draft National Water Plan[(1)] concerning recommended water supply and management approaches to resolve Nauru's water problems, negligible positive progress has been witnessed in the sector. Given the extreme limitations of the socio-economic realities of Nauru's current situation compared to its historic affluence, the expensive historic options of large-scale use of desalination (which relied on effective power generation – which by definition requires a reliable diesel supply) and periodic importation of freshwater by boat, clearly no longer represent sustainable options.

There is, and always has been, potential to supply Nauru's freshwater needs from both groundwater and rainwater and it is apparent that conjunctive use of groundwater and rainwater harvesting may well provide the best long-term water supply solution for the whole island. Groundwater investigations, monitoring & protection certainly warrant further study, as does an asset condition survey of the domestic & community rainwater harvesting infrastructure to ascertain what might be required to satisfactorily upgrade system conditions relating to the catchment, transmission and storage of rainwater. Additionally, water conservation & awareness education remain extremely critical issues requiring input, as does the coincident investigation of the viability of (actual) cost recovery mechanisms. ***It cannot be over-emphasised that the prevailing socio-economic living conditions in Nauru present enormous challenges to the operational viability and maintenance sustainability of any proposals to undertake refurbishment or replacement of rainwater harvesting (or indeed any other) infrastructure.***

1.2 Policy Setting

The water infrastructure sector goal of Nauru's Sustainable Development Strategy (2005-2025) [(2)] is to provide a reliable supply of water to all households and businesses. Sector strategies, such as better management of water resources, including underground water; improved collection and storage of water at all levels; and restored capacity for water production, are identified. The water sector strategy sets out the following developmental milestones:-

- ***Short-term Milestones (by 2008)*** Regular supply of water available to each household and business. Refurbishment of national water storage tanks. 100 new household water tanks installed per annum. Desalination plant operational.

- ***Medium-term Milestones (by 2015)*** Quality water available to households and businesses 24 hours a day. Water storage capacity expanded.

- ***Long-term Milestones (by 2025)*** Improved access to a reliable supply of quality water

Whilst these milestones represent admirable temporal focal points, Nauru's MDG Target 10 pragmatically identifies the current reality, in that *"fresh water is available from rain and well water, but desalinated water is no longer available. Constant supply is unreliable due to periodic droughts and quality is questionable. Water use management does not exist. Poor waste management threatens to contaminate the water lens."* In addition, the infrastructure strategy clearly identifies some of the critical constraints and limitations, stating that *"Due to the past lack of maintenance and investment in physical infrastructure over many years, Nauru's current infrastructure is very run down and on the point of collapse in some instances. While investment has been substantial over the past 4 years, ongoing institutional and management problems have contributed significantly to the ongoing poor performance of this system. Major investment, coupled with a new culture of preventative maintenance and forward thinking is required for* *ongoing reliable functionality. In a resource restrained environment the emphasis must be on improving the management and operation of existing facilities."*

The SOPAC/EU EDF9 Project was first introduced[(3)] to Nauru in July 2005, and during the subsequent initial KRA2 reconnaissance mission[(4)] by Mr Booth, SOPAC/EU Project Senior Advisor (Water), in early November 2006, exploratory discussions were held regarding the provision of assistance through the current EU-funded programmes of SOPAC, in conjunction with the programming of Nauru's B-Envelope under the 9th EDF. In an endeavour to avoid duplication and ensure synergy with a number of other water sector aid initiatives, these discussions with the PIFS Representative of the Pacific Regional Assistance to Nauru (PRAN) Aid Management Unit, and during the subsequent period Nov'06 to Feb '07, highlighted the fact that many different aid donors are also currently active, or propose to be in the near future, within the Nauru water sector. Of particular note are:-

- **AusAid** - Essential infrastructure and contingency support in water sector - undertaken under MoU agreements between Nauru and Australia including the refurbishment of a RVO unit for water supply - A$600K. This is understood *(pers. comms. N.Young & D.Melvin, AusAid)* to includes procurement and installation of 150 galvanised water storage tanks, each of 18,500 litre capacity, for community use, including support for community gardens.

- **ADB** – Technical assistance, including strategy for reform of the water and power sector. GON to undertake review and reform of water and power sector in consideration of ADB reports and recommendations.

- **Govt of Japan** - Provision of 3x6000l plastic water tanks to each of 15 communities = 45 tanks in total - USD100,000 (see Annex A for available details provided by AMU).

- **UNDP/SPREP PACC Project** – USD 500k potential input into the water sector, plus

- **SOPAC** - System of intervention in line with disaster preparedness (drought risk) "B-Envelope" funding - At the donors roundtable November 2005, EU agreed to provide up to Euros 500k for Nauru within the project to be managed by SOPAC

The above interventions represent a formidable cumulative amount of money being directed towards Nauru's water sector and an unprecedented opportunity to secure sustainable future water supplies. One factor that will significantly improve the country's resilience to drought risk is to maximise rainwater harvesting opportunities. To enable this, an accurate, high quality spatial database of current infrastructure assets and water demand are essential precursors, both for accurately identifying and targeting immediate specific Aid needs, and for basic confidence in any future water sector management scenarios.

1.3 Rainwater Harvesting

Whilst it is acknowledged that the Japanese (270m$^{3)}$ and Australian (2,775m^{3}) Aid inputs noted in Section 1.2 above will provide valuable additional rainwater storage tank capacity to the residents of Nauru, there would appear scant detail or understanding concerning actual individual households or community needs or the potential suitability of harvesting sites. *(NB: In April '07, a survey of community needs was reportedly (pers. comm. D.Melvin, AusAid) underway by Eigigu Holdings, a SOE who will construct the AusAID tanks on island.)*

The exploratory discussions noted in 1.2 above, outlined the SOPAC/EU Project's approach philosophy combining the application of high resolution, remotely sensed (RS) satellite imagery, global positioning systems (GPS), and geographic information systems (GIS) with local capacity building and training, to provide an accurate spatial database of all domestic and community properties. Identification of associated conditions of rainwater harvesting infrastructure assets such as roofing materials, guttering, down-pipes and storage tanks would formulate the basis of an existing asset condition survey. This would subsequently allow production of engineering specifications and an associated bill of quantities to identify the infrastructure refurbishment and replacement opportunities which could be eminently suitable for consideration for co-funding implementation under Nauru's B-Envelope risk management "drought" funds. Subsequent provision and installation of sufficient domestic & community rainwater harvesting facilities would therefore contribute directly to reducing the vulnerability of Nauru's population to drought risks.

SOPAC's technical Guidelines(5) for the implementation of rainwater harvesting systems, as well as the Manual(6) for participatory training in rainwater harvesting in Pacific Islands, were also provided to Nauru to further assist with application activities under any of its rainwater harvesting initiatives.

2. OBJECTIVE

The ***specific*** survey mission objectives envisaged were originally outlined in proposals submitted by SOPAC for consideration by GoN during January 2007, and this mission proceeded on the basis of these as follows:-

- to introduce and explore the provision of assistance through the current EU-funded programmes of SOPAC in conjunction with the programming of Nauru's B-Envelope funds (see Annex B), also under the 9th EDF. Should a draft plan of action for implementation appears feasible, it was considered that focal areas for development may include one or more of the following:-

  - development of a RS/GIS/GPS database of all properties and associated roof catchments to accurately identify the condition of rainwater harvesting infrastructure assets such as roofing materials, guttering, downpipes and storage tanks.

  - conjunctive use of available water resources through maximising rainwater harvesting and groundwater resource abstraction. Firstly, rainwater harvesting and storage improvements can be made in the immediate to short-term, both at the domestic and communal/institutional level and be considered as major components under the B-envelope. Secondly, groundwater abstraction is envisaged as a long-term investment for which a thorough investigation of current aquifer conditions and baseline monitoring is required. A proposal(7) for a groundwater investigation programme, initially developed for AusAID and subsequently being advanced by Nauru Rehabilitation Corporation in 2006/07 could also be considered for implementation under Nauru's B-Envelope

  - transfer of SOPAC's Technical Guidelines for the implementation of rainwater harvesting systems as well as the Manual for community participation developed for rainwater harvesting in Pacific Islands.

This technical survey mission was subsequently formalised by GoN on behalf of the NAO, via receipt of letter of approval dated 29/01/07 from the Director of the Aid Management Unit, Department of Finance & Economic Planning. A summary of the mission itinerary is presented in Annex C.

3. FIELDWORK SURVEY METHODOLOGY

As previously noted in Section 1.3, the SOPAC/EU Project's approach philosophy combines the application of high resolution, remotely sensed (RS) satellite imagery, global positioning systems (GPS), and geographic information systems (GIS) with local capacity building and training, to provide accurate spatial databases for development planning applications.

3.1 Satellite Imagery

A recent (2006) QuickBird satellite image (Figure 3.1.1) was ordered for the island and used as a reference map during the survey. The 0.6 metre resolution clearly showed buildings and assisted the field surveyors in accurately identifying areas to be mapped. The actual properties visited and the identifying reference number allocated to each of them for the purposes of this survey are identified in the following sequence of eight Figures 3.1.2(a) through to Figure 3.1.2(h).

Figure 3.1.1: QuickBird (2006) Satellite Image of Nauru

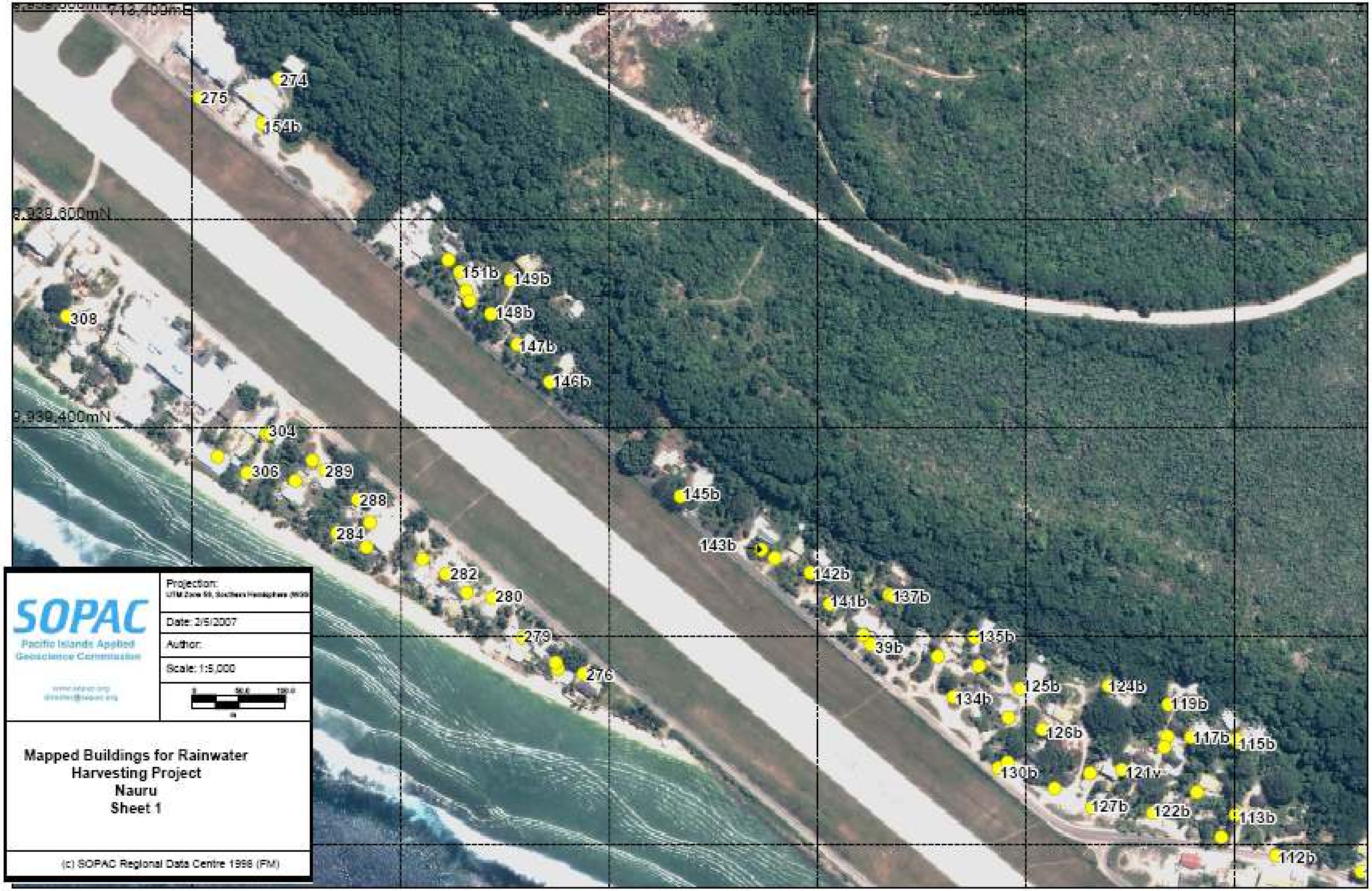


Figure 3.1.2(a) Surveyed properties & reference numbers – Yaren District

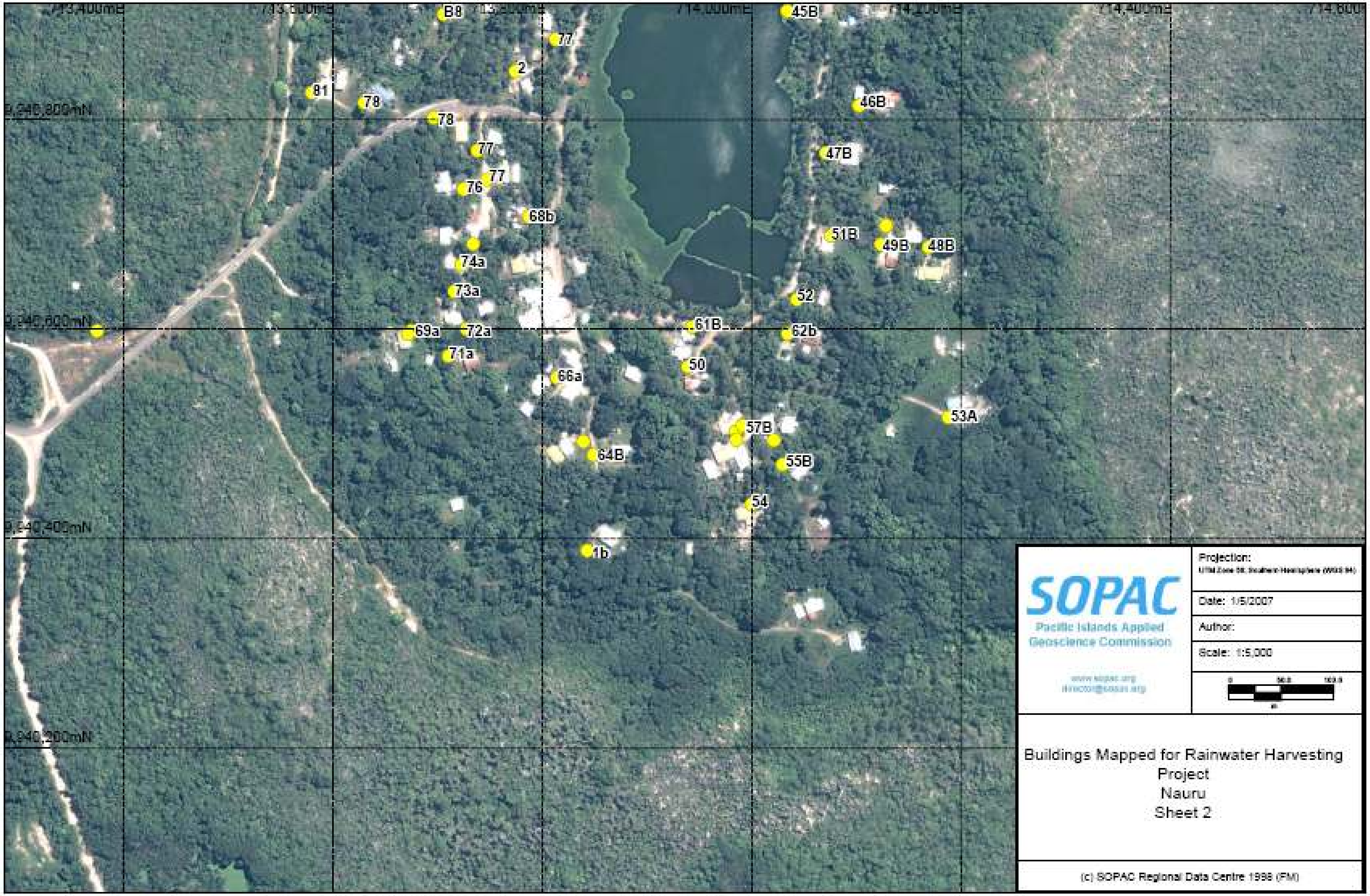


Figure 3.1.2(b) Surveyed properties & reference numbers – Buada (South) District

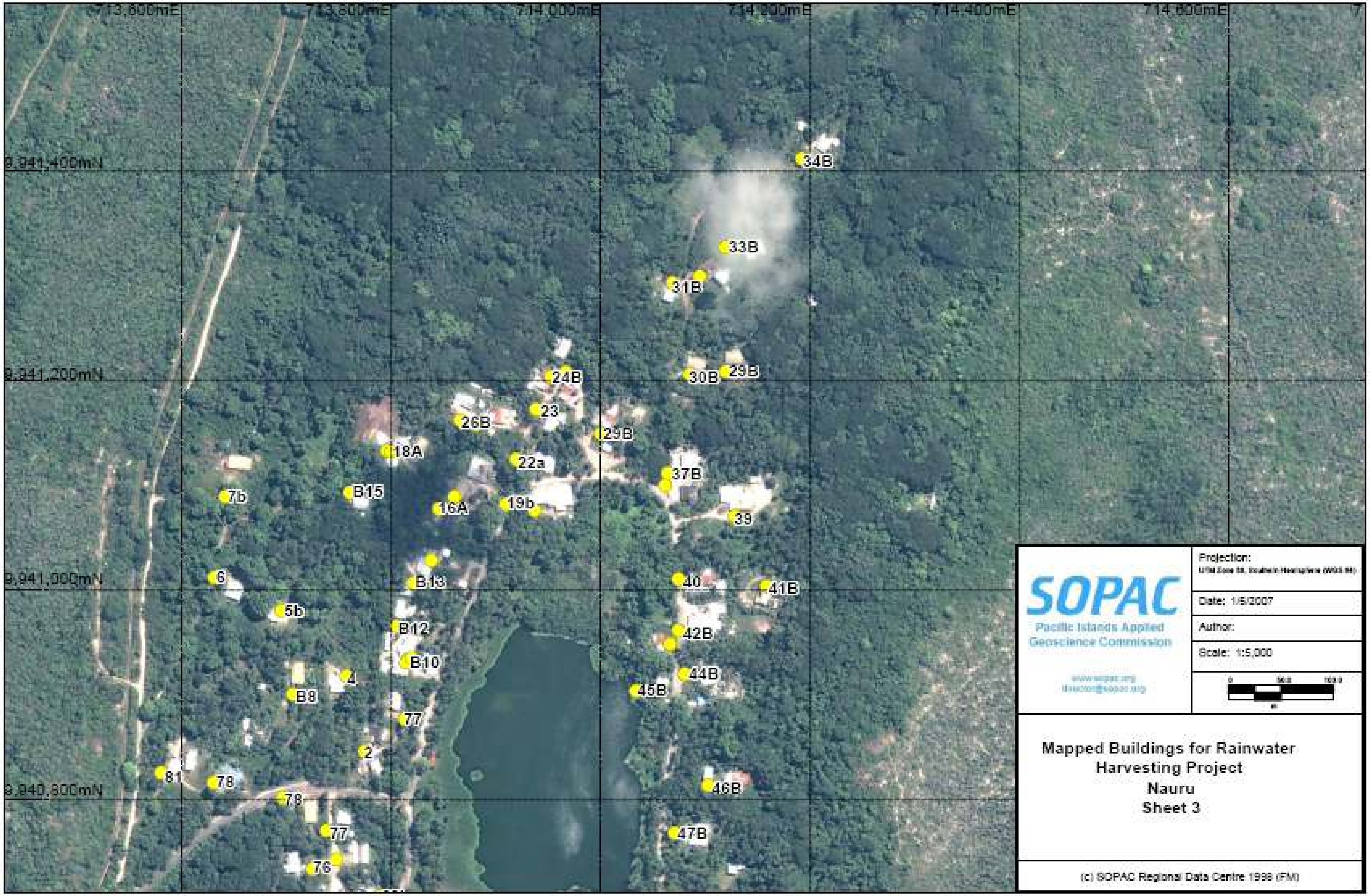


Figure 3.1.2(c) Surveyed properties & reference numbers – Buada (North) District

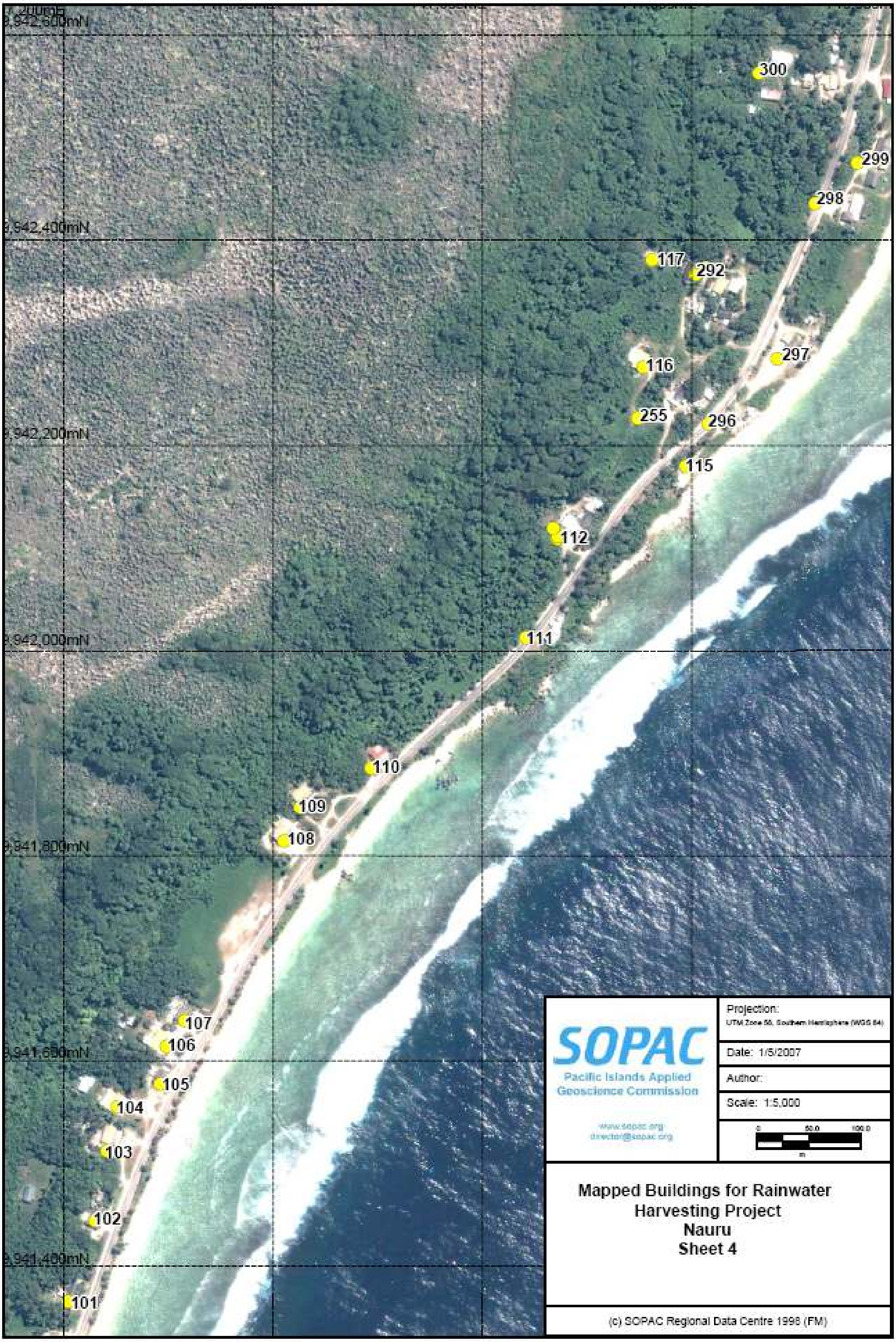


Figure 3.1.2(d) Surveyed properties & reference numbers – Anibare & Ijuw Districts

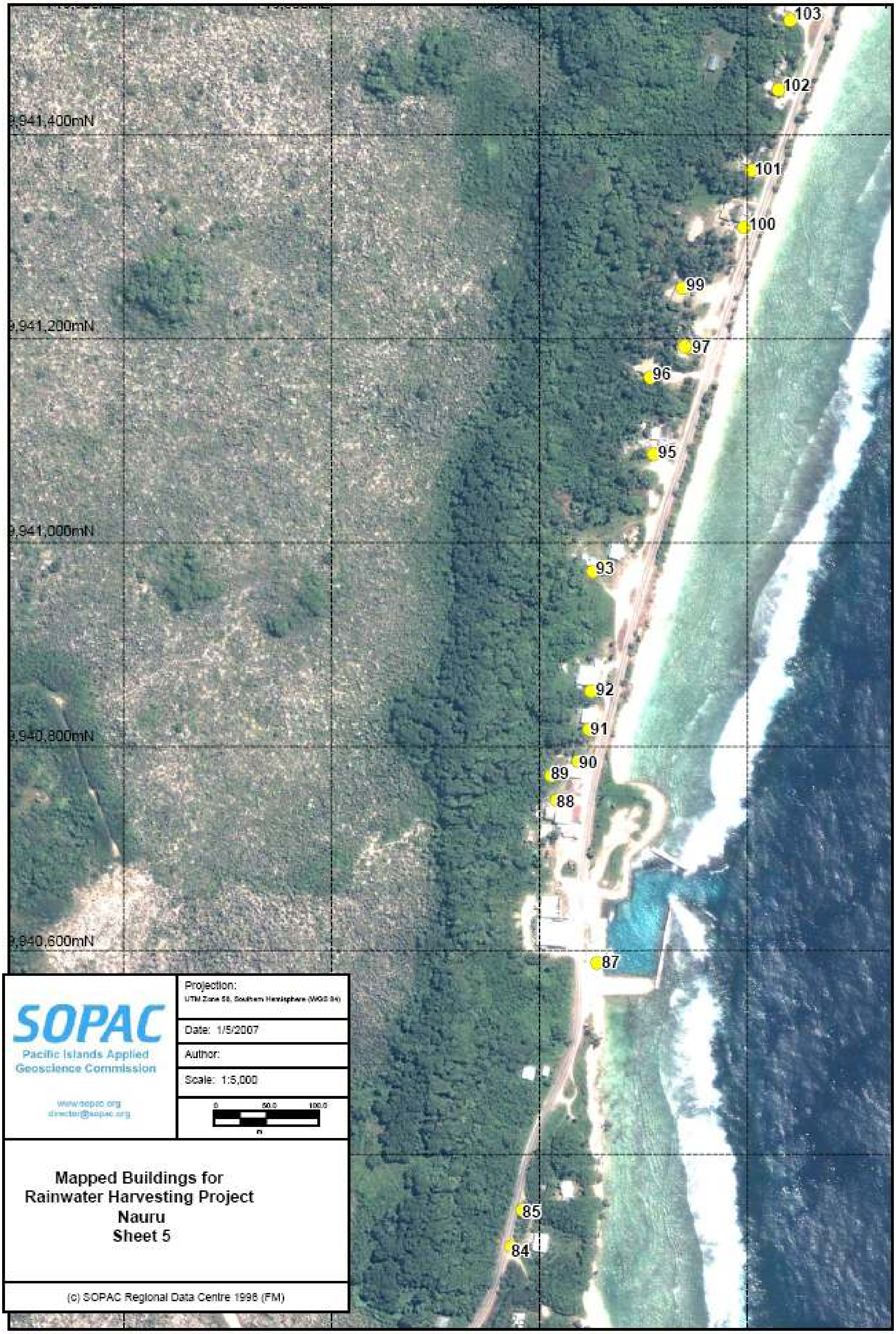


Figure 3.1.2(e) Surveyed properties & reference numbers – Anibare District

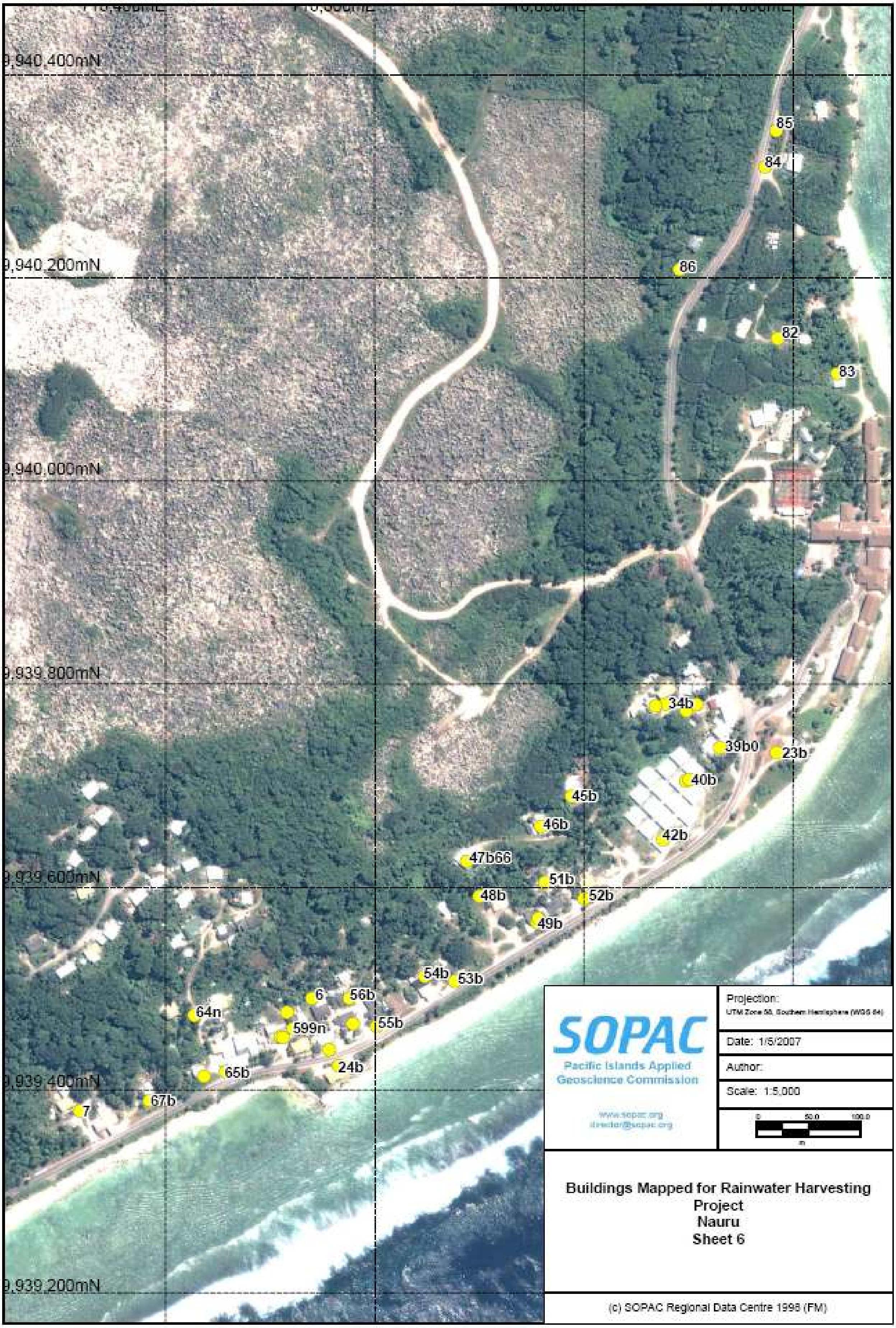


Figure 3.1.2(f) Surveyed properties & reference numbers – Meneng District

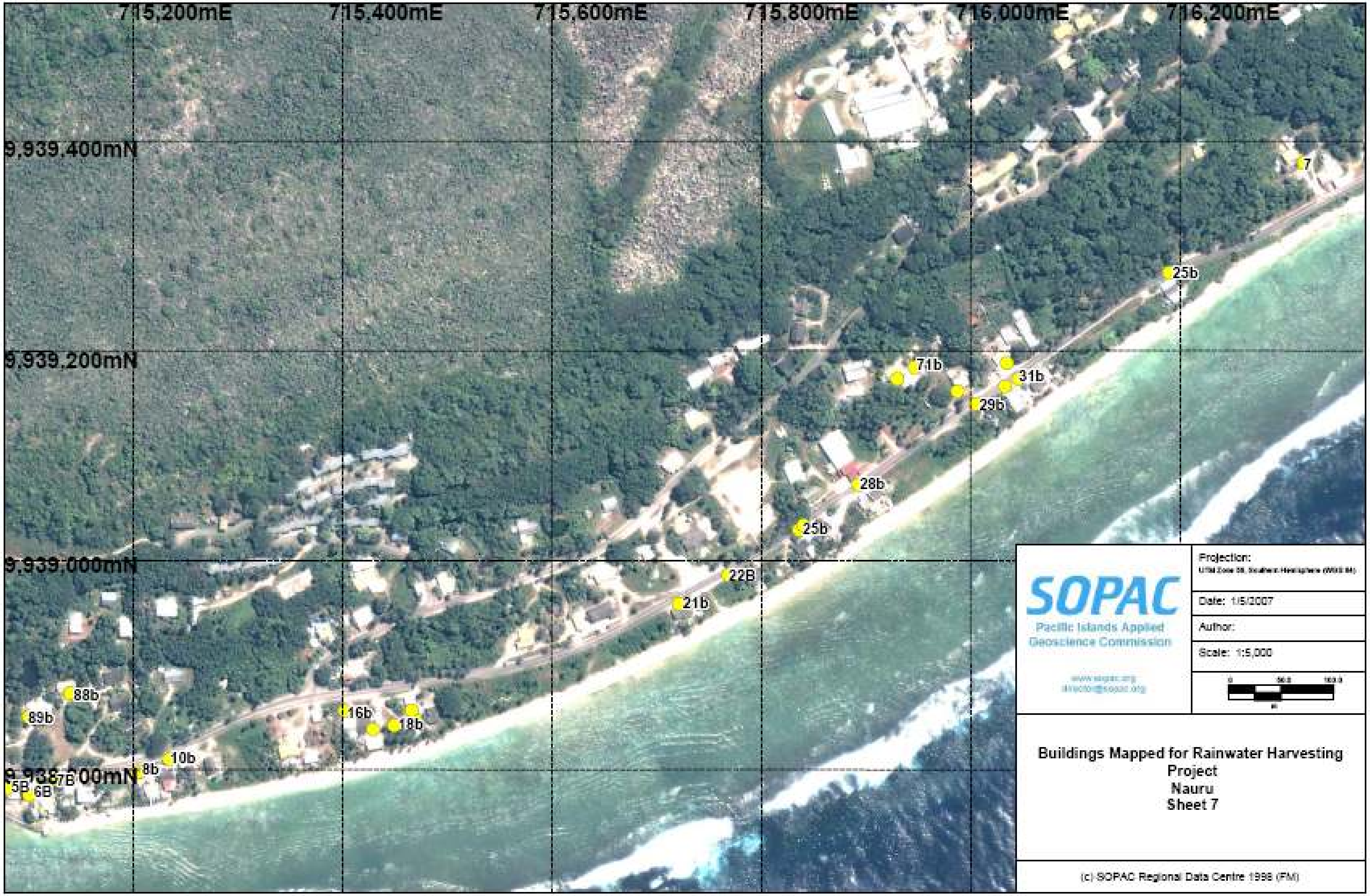


Figure 3.1.2(g) Surveyed properties & reference numbers – Meneng District

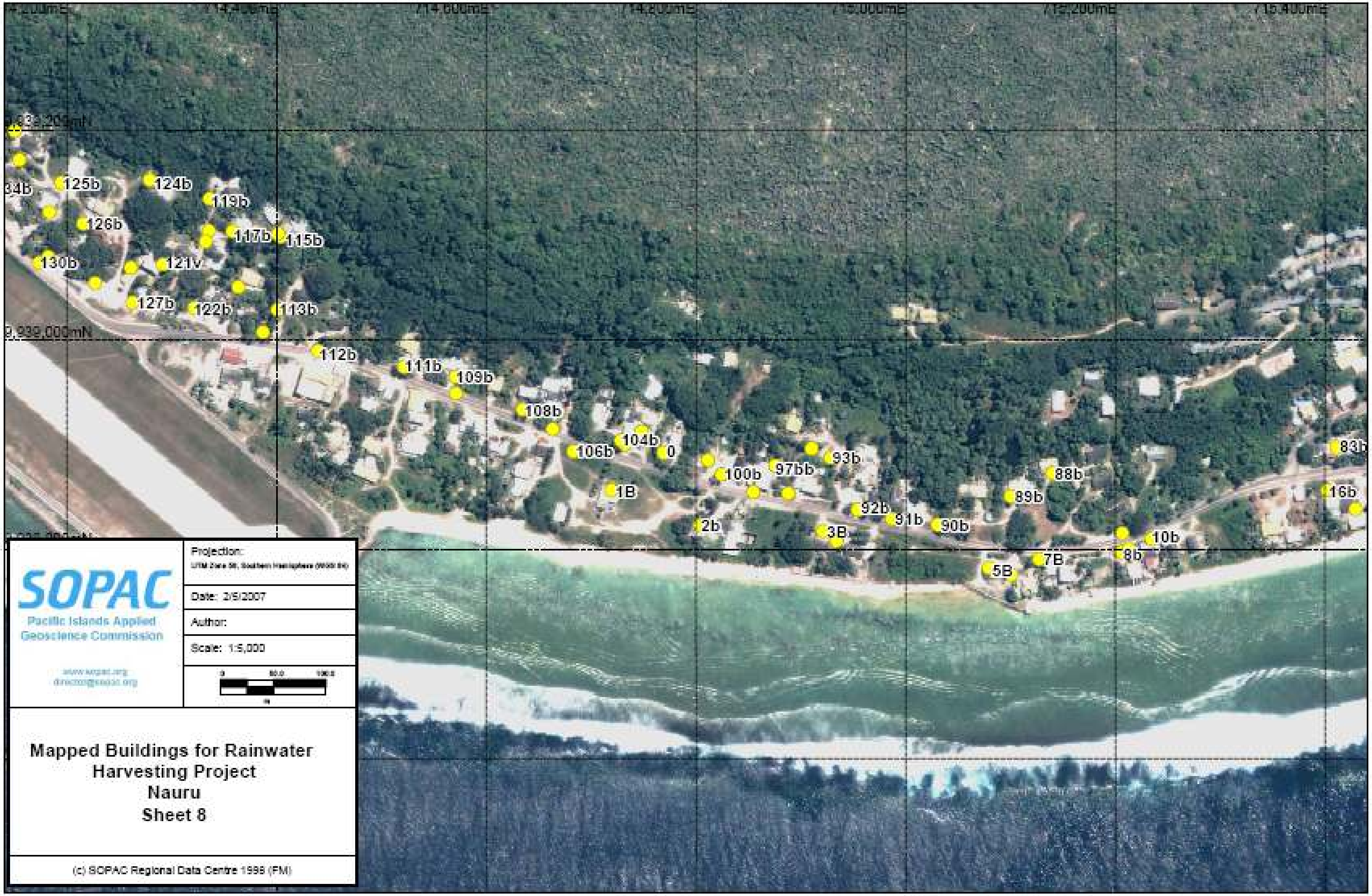


Figure 3.1.2(h) Surveyed properties & reference numbers – Meneng & Yaren Districts.

3.2 Global Positioning Systems

The Project's field survey equipment utilized in Nauru comprised the following:-

- Handheld units (mobile): Trimble GeoXM, (Fig 3.2.1) and a
- Base Station (static): Trimble 4600LS (Figure 3.2.3)

Figure 3.2.1: GeoXM hand held GPS

Preparations for the fieldwork on Nauru were assisted by reference to a similar Rainwater Harvesting survey undertaken on Tuvalu(8) which also used a GPS/GIS approach for mapping of household assets. This approach was amended to include the information requirements of the Nauru project and a data dictionary was created in GPS Pathfinder Office software (Figure 3.2.2). The benefits of using a data dictionary (see Annex D for the full listing utilised) include efficient and effective data collection in the field, which also helps to minimise and cross-check errors that can easily be made when manually filling in survey forms (see Annex E for example of manual form).

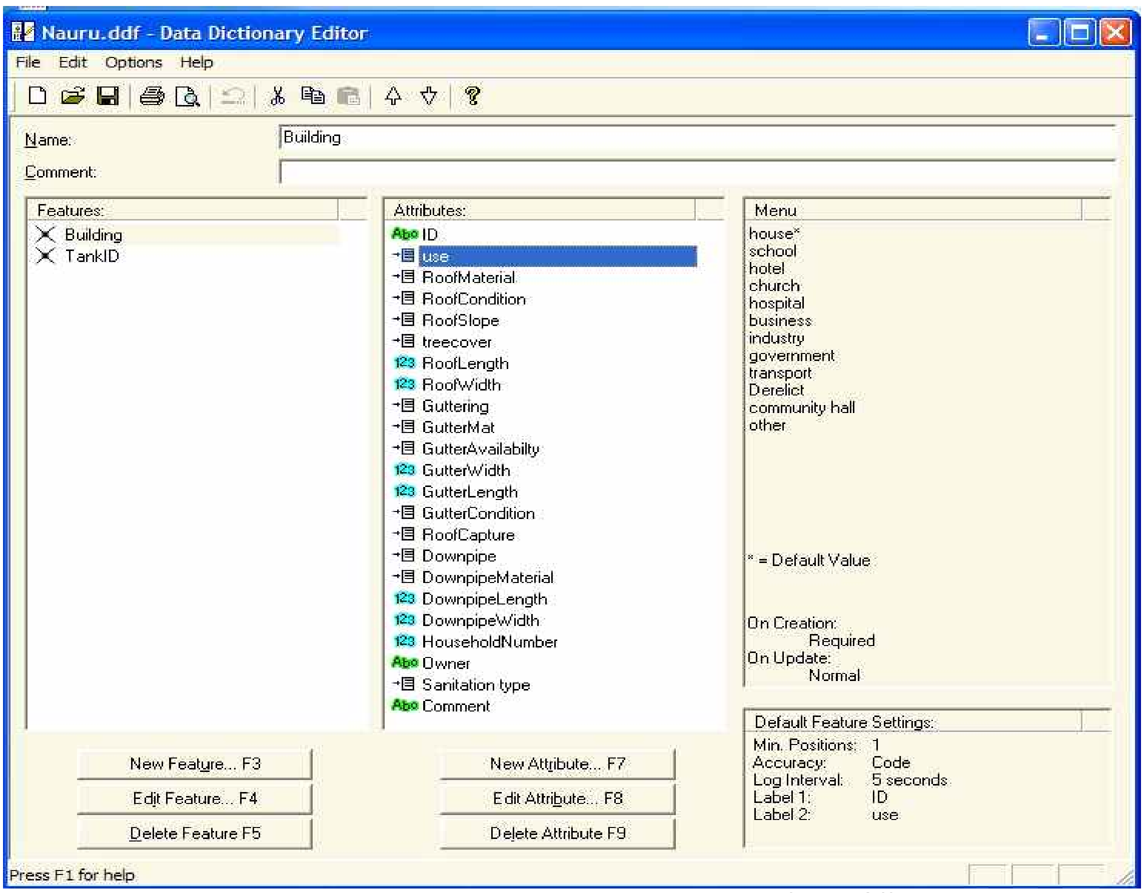


Figure 3.2.2: Data dictionary editor created in Pathfinder Office.

Approximately one hour before the start of each days field survey work, the 4600LS static unit (Figure 3.2.3) was set-up as a base station on Reference Mark 2 of the Nauru continuous GPS (CGPS) station (Figure 3.2.4). It should be noted that the selected benchmark is referenced to the Nauru Island Datum. The base station is powered by a small solar panel and battery assembly and logs a continuous positional record every five seconds.

The base station files are required for differential correction. This increases the accuracy of the handheld GPS units (GeoXM) from 10m to between 2m to 5m, which is sufficiently accurate for the 1:10,000 scale mapping requirements of this Project. The base station was switched off and dismantled at the end of each survey day, approximately one hour after completion of all the field work and once both field teams handheld GPS units had been collected.

Figure 3.2.3 : Trimble 4600LS base station set up over RM2 at the Nauru CGPS

Permission to enter the CGPS site was granted by Mr Steven Yates of National Geospatial Reference Systems, Geospatial & Earth Monitoring Division (GEMD), Geoscience Australia, who also provided the following reference data:-

Table 3.2.1 – Nauru CGPS Reference Data

NAUR - The Nauru CGPS Reference Point (GPS Monument)
RM2 - Reference Mark No. 2

Mark	Latitude	Longitude	elevation(m)
NAUR	S 0 33 6.23238	E166 55 31.98521	5.2570
RM2	S 0 33 6.89881	E166 55 32.12438	4.3820

NOTE – The elevations stated are Nauru Island Datum (NID)

The reference marks had clearly been undisturbed for a considerable time period and with the assistance of Nauru Lands & Survey staff, it initially took about 1 hour to locate, clear vegetation and "dig-out" the valve box lids on first arrival at the site. The CGPS site is unfenced and assistance with security of the base station equipment throughout daily fieldwork operations was provided by a combination of Lands & Survey staff and the Nauru Police Force.

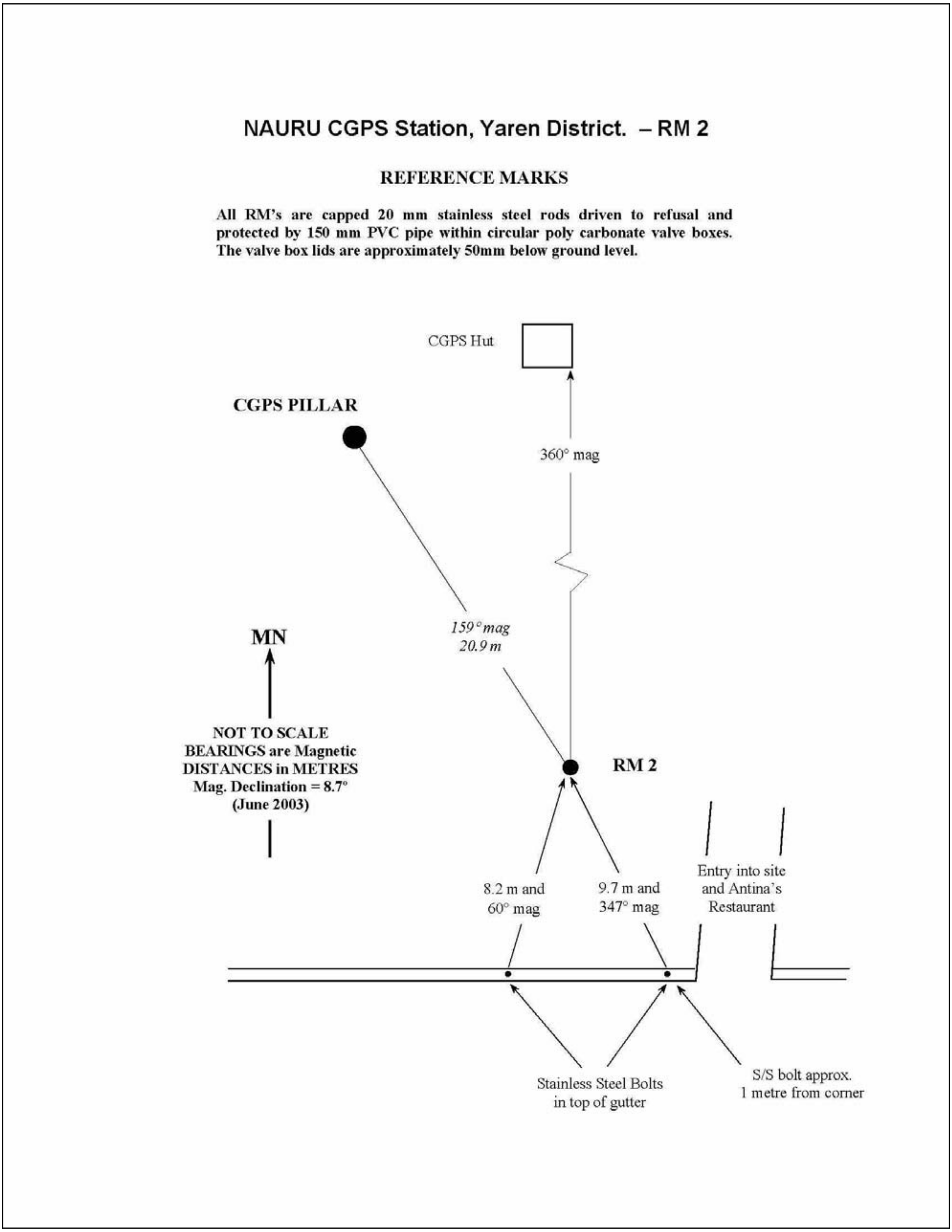


Figure 3.2.4: Location sketch of Nauru CGPS and RM2

3.3 Geographic Information System & Data Processing

The GIS software utilized by the SOPAC/EU Project, supplied to and supported within the Pacific ACP nations is MapInfo Professional v7.0, a comprehensive desktop mapping tool that enables flexible management, analysis and presentation of spatial geographic data and linkage to associated databases.

Data processing was undertaken at the end of each day; the data collected was downloaded and processed in GPS Pathfinder Office and the base station files were also downloaded using GPSurvey. It was important to process the data daily to ensure that the data collected was actually captured.

In GPS Pathfinder Office, field data was differentially corrected and exported as MapInfo Interchange Format (mif). These *.mif files could then be imported into MapInfo and viewed within the GIS.

Due to the limitations of the MapInfo tables, it was decided that the main attributes of the data collected be exported and stored in an Access database. This allows a better management and query process of the data. Within MapInfo only the map objects and spatially related information such as coordinates are stored. The two databases can be linked using a common ID. A benefit of handling data in Access is the ability to carry out queries quite simply. For instance, water tanks can be relationally linked to the appropriate roofs to which they are connected whereas in MapInfo these would show as separate elements without an apparent link.

3.4 Field Survey Personnel

The visiting SOPAC/EU Project team comprised the following personnel:-

- Mr Stephen Booth
- Mrs Elizabeth Lomani-Whippy
- Mrs Arieta Navatoga-Sokota
- Miss Vilisi Tokalauvere

The composition of the Nauru in-country support personnel varied almost daily due to local availability and other job demands, however the following gave primary daily assistance with property access discussions in local Nauruan language, associated English translation services; on-site measurements; CGPS security arrangements; visual, written and electronic data recording; transport and driving services:-

- Mr Nodel Neneiya, Project Officer of Environment Unit
- Mr Madison Tsitsi and Mr Giovanni, both of Lands & Survey Department:
- Mrs July Debao, Mr Creedence Halstead, Mr Ricktanson Dade and Mr Dandy, all of Nauru Rehabilitation Corporation

Secondary assistance and support with fieldwork was received from Mr Wes Tsitsi, Land & Survey and Mr Raymond Itsimera, Environment Unit.

3.5 Field Survey Techniques

For mapping of the rainwater harvesting assets, two field teams (Teams A & B) of between 3-5 people were assembled from the personnel noted above in Section 3.4, utilizing two separate rental vehicles. Each team was equipped with two (one operational and one standby/spare) GeoXM units (Figure 3.2.1), blank paper survey forms (Annex E), imagery printouts of the areas to be surveyed and a 50m tape for measurement purposes.

To ensure that all personnel were familiar with the field survey objectives, data recording requirements and techniques, a demonstration area in Yaren adjacent to the CGPS was initially piloted utilizing all personnel. This introductory exercise was also essential to ensure that the GPS data dictionary was comprehensive enough for Nauru's requirements and that the equipment was fully functional. Amendments were made to the data dictionary at the end of the first day's demonstration – all attributes collected are defined in the data dictionary (Annex D).

At every household property, data was collected on each respective element of the household rainwater harvesting system – represented in simple terms of the relative directional "flow diagram", these are:-

Catchment System → Transmission System → Storage System
(roofing) (gutters & downpipes) (tanks & cisterns)

Subsequent to tank storage might be added other logical "downstream" elements, comprising:-

Household Delivery System → Disposal System
(pump/bucket etc) (wastewater & sanitation methods)

In terms of the geographic spatial coverage achieved during the 8 available field survey days, Team A covered Yaren and Meneng districts (properties symbolised in red on Figure 3.5.1) whilst Team B covered Buada, Anibare and part of Ijuw districts (properties symbolised in blue on Figure 3.5.1). Given the statistics in Table 3.5.1, an average field survey rate of 38.5 households per day was therefore achieved during this mission.

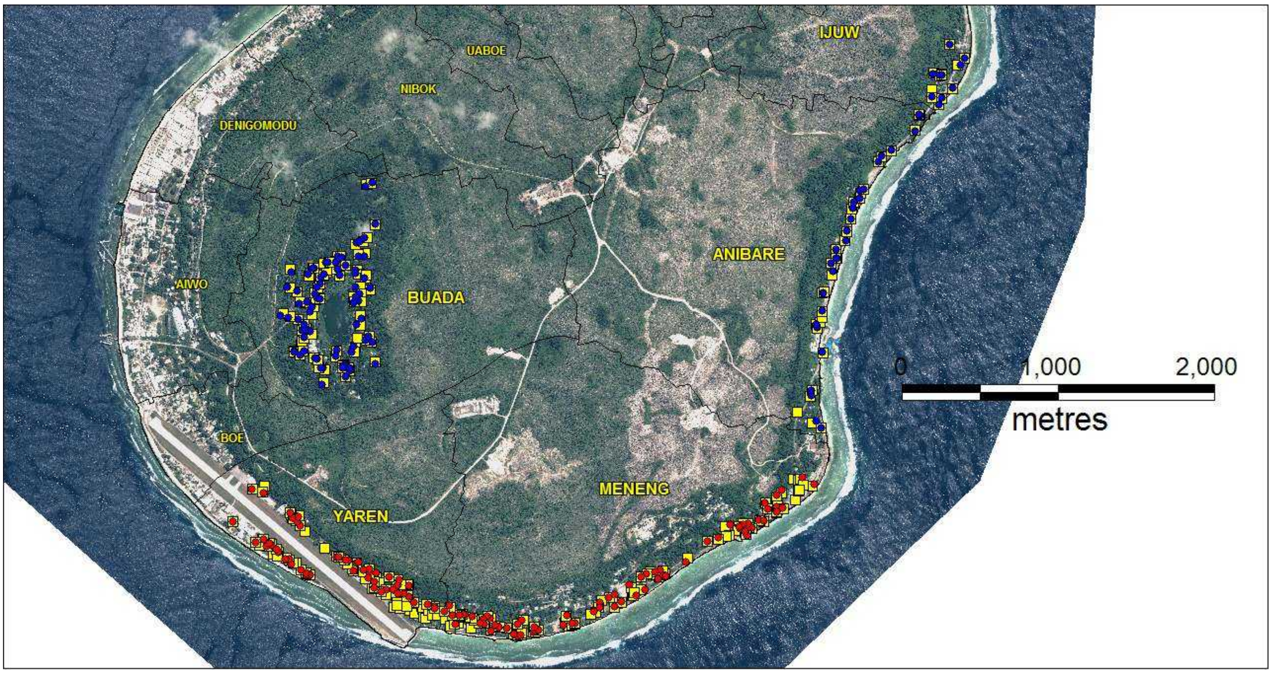


Figure 3.5.1: Spatial coverage achieved by survey teams

Apart from the anticipated slow start-up due to initial equipment checks and training of in-country personnel during the first survey day, subsequent progress was also adversely impacted by the interaction of numerous external factors such as extreme mid-day heat, continuous high humidity, occasional heavy rain showers, equipment malfunction, manpower (personnel collection and return was restricted by RoN working hours and clocking-on/off procedures), GPS base station site security issues (the Nauru Police Force eventually provided a constable to remain on-site as a watchman each field day) and general transport and fuel restrictions. Power & water rationing at the hotel also had intermittent and additionally limiting impacts on the ability of the team to download and process data, recharge GPS unit batteries or operate notebook computers, and attend to personal hygiene and subsistence.

Teams	Total Building	Total Tanks
A	180	126
B	128	124
Total	**308**	**250**

Table 3.5.1: Total number of houses and tanks surveyed by team A and B.

A number of recommendations for any future field survey work of a similar nature on Nauru can clearly be noted following these experiences:-

- SOPAC personnel need to arrange for a good, dedicated in-country support team well in advance of arrival (this would normally be one of the primary duties of the Project's in-country intern). The support team needs to include people to carry out actual GPS survey and a watchman for the base station, especially as the base station location is in a public area with no access restrictions to members of the public or animals.
- The survey man-power, transport requirements, time-frame and area to be survey should be realistically balanced given the average progress rate achieved.
- Where local government working practices restrict capacity for working overtime or weekends, financial incentives will be required to encourage and maximize in-country support for "out-of-hours" input.
- If a small team is working to cover a large area within a limited period of time, then it is essential that data collection should be simplified as much as possible to ensure rapid field progress.
- If at all feasible, a venue should be arranged and time allowed to provide for data processing, so that the in-country personnel could further gain from capacity building in these issues.

3.6 Nauru Geospatial Content Management System

A Geospatial Content Management System (GeoCMS) or Mapserver is a web application enabling multiple users to put up content on the website using the web itself. It is an all in one package for building a full featured web community and is an open source web application. It holds interactive maps and the viewer can somehow interact with the map. This can mean selecting different map data layers to view or zooming into a particular part of the map that you are interested in. All this is done while interacting with the web page and a map image that is repeatedly updated. This is fundamentally different from static maps because they are really a type of web-based program or application.

The SOPAC/EU EDF8/9 Project is tasked (KRA 4) with providing up-to-date RS satellite imagery and installing a GeoCMS in each of the Project's 14 ACP countries. The Nauru GeoCMS was installed, with associated local training, on the 29th of May 2006. The server is currently housed within the Office of the Chief Secretary. The Chief Secretary's Dept is directly under the President's portfolio as Minister responsible for Public Service. It performs secretariat functions for the Nauru Government. It's core functions fall under respective sections of Presidency, Cabinet Secretariat, Public Administration, Human Resources and Labour, Salaries Section, the Nauruan Affairs Office which handles - Registry of Births, Deaths & Marriages and the Govt Gazette.

Irrespective of where the server is physically located, it is a web based application and can be accessed on the internet – http://www.lands.gov.nr/.

The QuickBird satellite imagery and all the field results obtained during this asset condition survey work have been subsequently uploaded onto the Nauru GeoCMS and are readily accessible to all in-country stakeholders for future use and reference.

4. ASSET CONDITION SURVEY RESULTS

4.1 Catchment Systems - Roofing

Roofing Materials

Rain water is harvested from the roofs of private houses, storage areas and warehouses. The lack of development and any new building on Nauru during the last 20 years means that a high proportion of the roofing materials are old and in a highly weathered state. Reference to Table 4.1.1 indicates that only two types of roofing material were encountered during the survey period, with almost one quarter of the roofs surveyed comprising of asbestos cement sheeting (presumably dating back to "standardised" importation and installation during the active British Phosphate Company period). The majority of roofs (77%) recorded were of more modern metal sheeting construction.

Roof Materials	Total Properties	Total (%)
Asbestos	70	23 %
Metal Sheeting	238	77 %
Total	**308**	**100 %**

Table 4.1.1: Types of roofing materials.

Although the IRC International Water and Sanitation Centre of the Netherlands has stated that there is no evidence that rain water collected from asbestos-cement sheeting on roofs forms a health risk, the airborne fibres from cutting and drilling the sheets do pose a serious health risk, as does any dust generated during breakage which may be associated with removal and replacement (re-roofing) activities. The subsequent safe disposal of old asbestos sheeting is also a significant environmental problem that Nauru faces. Although the dangers associated with asbestos actually relate to inhalation of fibres within the respiratory tract, and not ingestion within the digestive tract, sufficient public health "scare" is perceived to be present amongst the general population to have deterred most people from collecting and drinking rainwater if they have an asbestos roof.

The spatial distribution recorded for the two types of roofing materials is shown in Figure 4.1.1 and it is immediately apparent that the old asbestos roofing (shown in yellow) interestingly exhibits a significant concentration within the Yaren district.

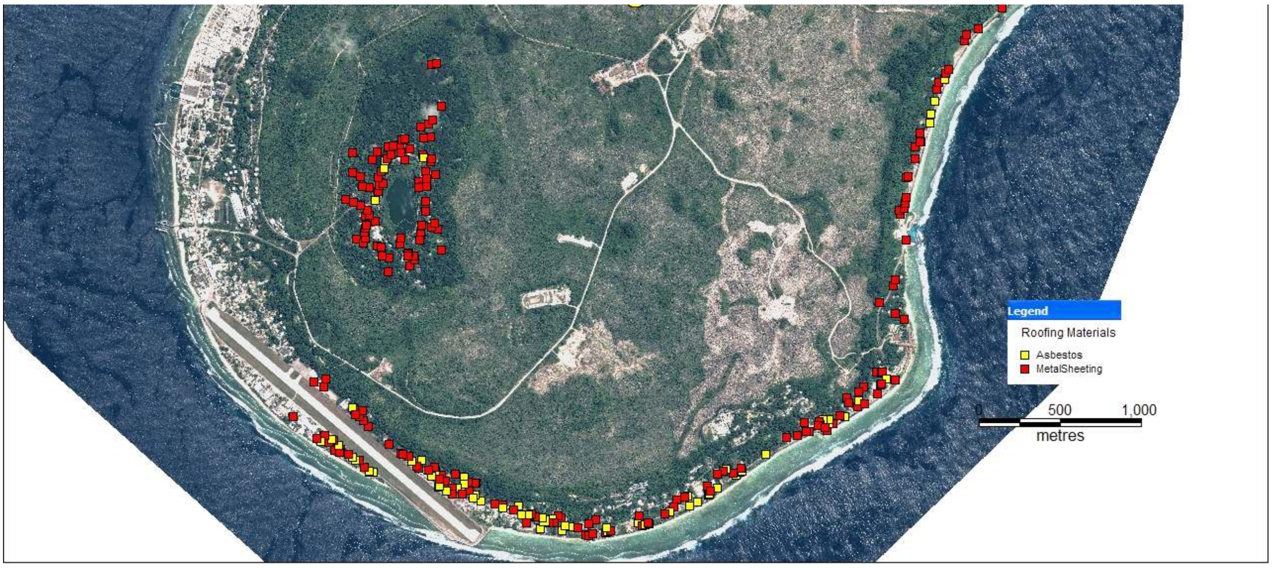


Figure 4.1.1: Types of roofing materials.

Roof Condition

The visible external condition of the roofing materials was also recorded as either *Good, Fair* or *Poor.* Reference to Table 4.1.2 indicates that almost a quarter (23%) of the roofs surveyed were considered to be in a *Poor* condition. The greater majority of roofs examined (it should be remembered that the "examination" only represented a brief visual scan from a distance at ground-level) appeared to be in relatively good external condition.

Roof Conditions	**Total Properties**	**Total (%)**
Good	208	68
Fair	28	9
Poor	72	23
Total	**308**	**100 %**

Table 4.1.2: Condition of roofing materials

The spatial distributions of these categories is shown below in Figure 4.1.2 and, whilst there is a suggestion of an apparent correlation of roofing materials in *Poor* condition with the old asbestos roofing concentrated within the Yaren district, the distribution of *Poor* condition roofs also exhibits a relatively general scatter.

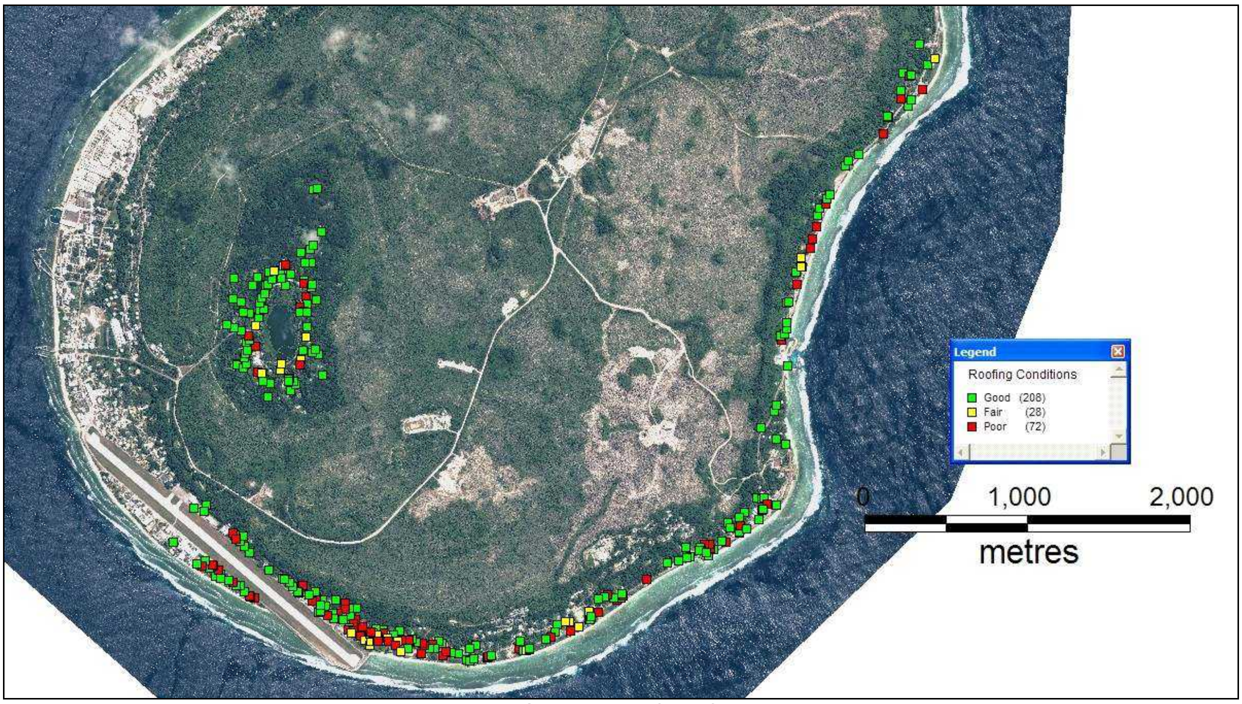


Figure 4.1.2: Condition of roofing materials.

Roof Pitch or Slope

The pitch, or slope of the roof from a horizontal plane, was also recorded during the survey, and reference to Table 4.1.3 indicates that the overwhelming majority (92%) are of flat to low pitch (shallow slope) construction. The spatial distributions of these categories is illustrated in Figure 4.1.3

Roof Slope	Total Properties	Total (%)
Flat	164	53%
Low	121	39%
Medium	18	6%
Steep	5	2%
Total	**308**	**100%**

Table 4.1.3: Pitch (or slope) of roofs.

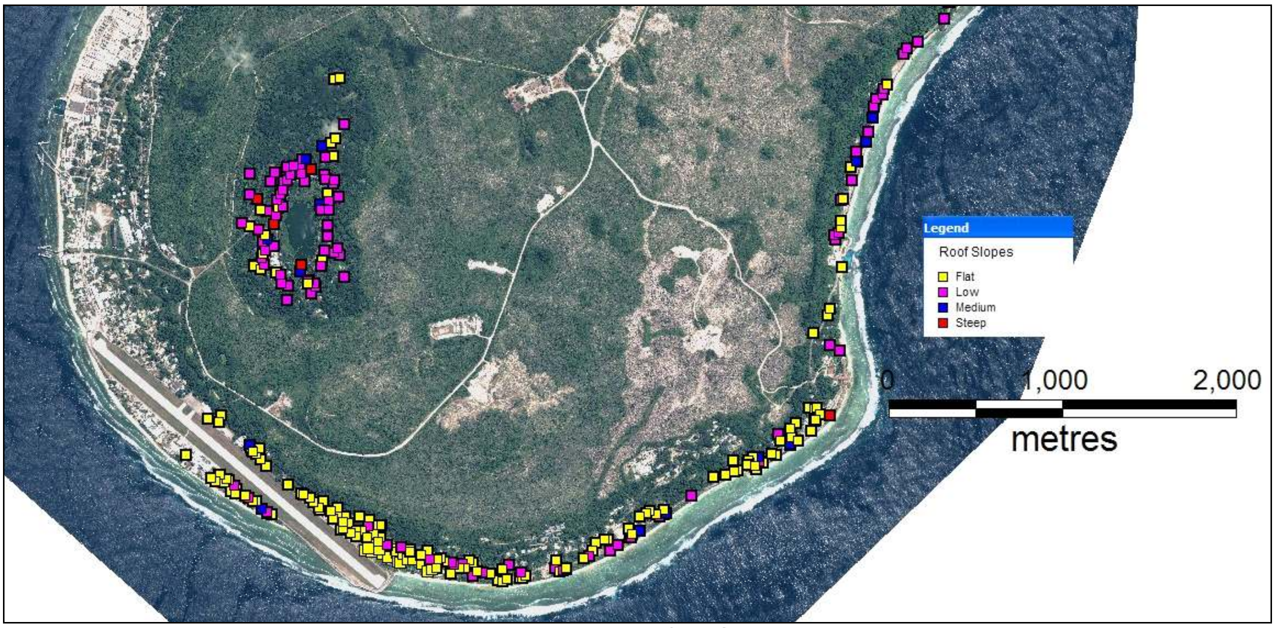


Figure 4.1.3: Roofing Slopes.

Vegetation Overhang

The survey also noted when any vegetation was seriously overhanging the roof area, as the close proximity of tree canopy cover not only reduces, via interception, the amount of rainfall that can reach a roof (thereby lessening the potential resource for capture and subsequent storage), but can also create significant other problems due to leaf, fruit or branch debris fall blocking guttering and downpipes. Adverse water quality impacts can also result due to biological decay (taint/colour/taste) of leaf matter and encouraging microbiological contamination from insects, bird and bat droppings. Ocean salt aerosol carried on the wind can also get concentrated by evaporation on leaf surfaces; this will eventually get taken back into solution during rainfall events, providing an unwanted chemical (salt) input into the roofwater catchment system. Vegetation overhang was recorded by observers as a relative percentage cover and reference to Table 4.1.4 indicates that this does not appear to be a significant problem on Nauru, with 80% of properties being free of any vegetation overhang.

Vegetation Overhang	Total Properties	Total (%)
0 - 25%	252	81%
25 – 50%	52	17%
50 – 75%	2	1%
75 - 100%	2	1%
Total	**308**	**100**

Table 4.1.4: Vegetation Overhang

The spatial distribution of vegetation overhang is shown in Figure 4.1.4. The majority of houses along the south and east coastal strip on Bottomside are sited closer to the road and coastline and tend to lie well clear of the more densely vegetated foot of the Topside escarpment. The un-mined area encircling Buada Lagoon represents perhaps the only significant area of mature, original woodland on Nauru and hence the potential for vegetation overhang is greater for houses constructed there. However, very few properties were troubled by this issue.

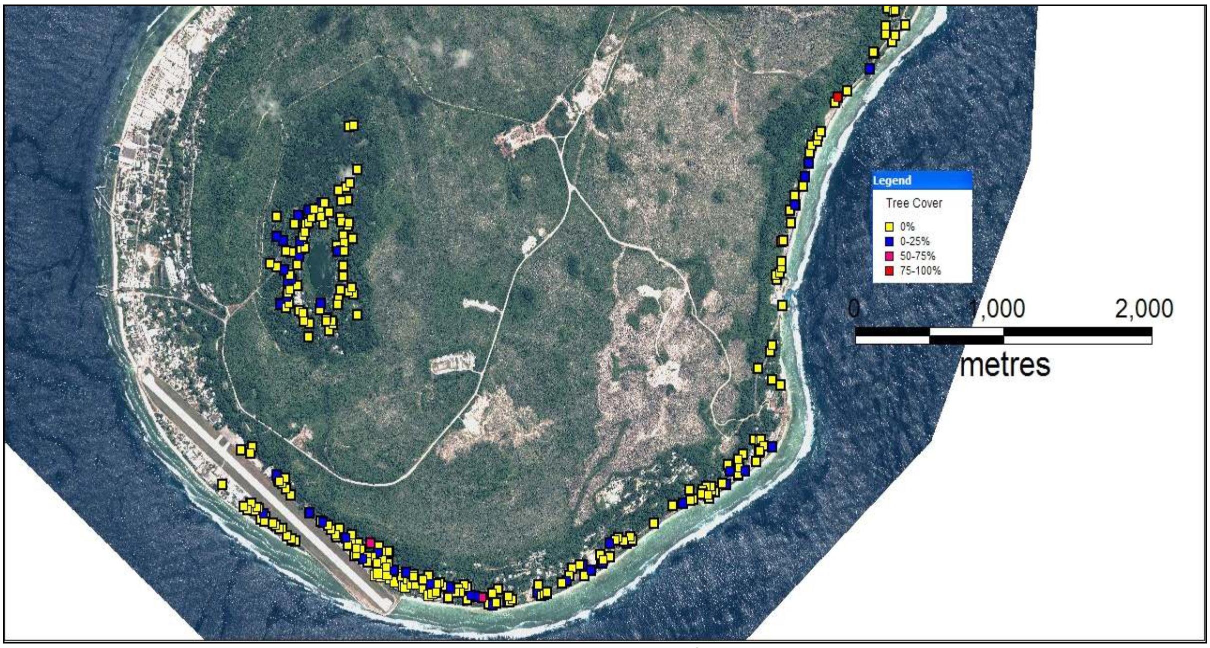


Figure 4.1.4: Vegetation Overhang

Roof Areas
The primary roof areas available on each property were assessed by field measurement of roof length and width and subsequently computed in the database spreadsheet; these are individually and cumulatively presented in Annex F. Of the 308 properties surveyed, the observed mean roof length was 15.35m and the mean roof width was 11.89m, representing a mean roof area of 187.67 square metres.

4.2 Transmission Systems - Guttering & Downpipes

Guttering Materials

Reference to Table 4.2.1 indicates that three primary types of guttering materials were encountered during the survey period, namely metal, PVC plastic and asbestos. Approximately one sixth (16%) of the domestic properties surveyed had no guttering at all affixed to the fascia boarding. Obviously such properties currently exhibit a vital "missing-link" in the rainwater catchment & transmission equation and, because of this relatively simple and basic omission, are currently unable to consider rainwater harvesting and storage.

Gutter Materials	Total	Total%
Plastic	62	20
Metal	148	48
Asbestos	49	16
No Guttering	49	16
Total	**308**	**100%**

Table 4.2.1 – Gutter Materials

The spatial distribution of gutter materials is illustrated in Figure 4.2.1, and it is apparent that there is no particular geographic pattern or concentration that might explain gutter non-availability – the properties with no guttering are well scattered and appear randomly distributed. Asbestos guttering was also witnessed on approximately one sixth of the surveyed properties and a reasonably distinct "remnant" concentration is again visible in the Yaren District.

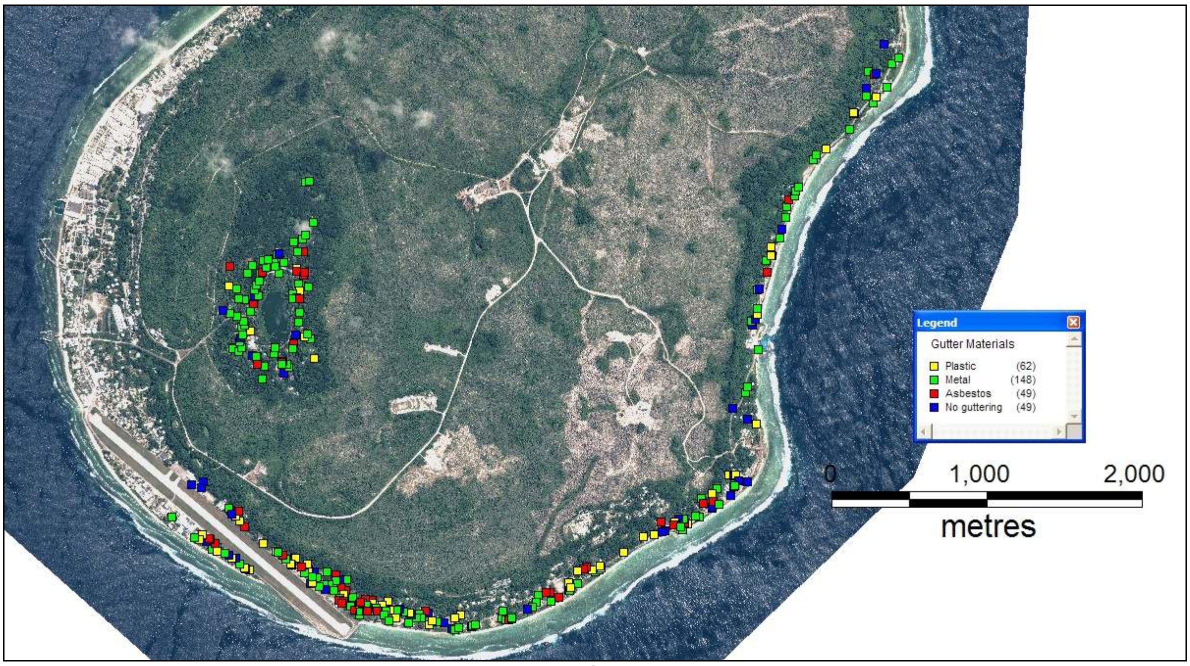


Figure 4.2.1 – Gutter Materials

The spatial distribution of the different guttering materials may also suggest a pattern of more frequent use of PVC materials along the coastal strip (eminently sensible in term of proximity to the corrosive marine environment!) compared to a more dominant application of metal guttering in Buada District.

Gutter Condition

The visible external condition of the guttering materials was also recorded as either *Good, Fair* or *Poor.* Reference to Table 4.2.2 indicates a high proportion (38%) of gutters could only be cumulatively considered in *Fair to Poor* condition. This suggests that there is significant scope for improving awareness of domestic maintenance issues.

Gutter Conditions	Total Properties	Total%
Good	141	46%
Fair	44	14%
Poor	74	24%
No Guttering	49	16%
	308	**100%**

Table 4.2.2 – Gutter Condition

The amount of guttering being employed is also of interest with respect to the total available roof catchment that is actually being captured. It is apparent from Table 4.2.3 that considerably less

Gutter capture of total available roof catchment area	Total Properties	Total%
100%	125	41%
75%	28	9%
50%	50	26%
25%	25	8%
No Guttering	49	16%
	308	**100%**

Table 4.2.3 – Gutter capture of total available roof catchment area

than half (41%) of the total number of properties surveyed had sufficient guttering to capture all the potential runoff from their roof. As well as the 16% of properties recorded with absolutely no guttering at all, an additional 34% of the properties only captured 25% to 50% of the available roof area, so there is clearly significant scope for improvement in guttering provision to enable a much higher proportion of the rainfall roof runoff to be diverted to potential tank storage facilities.

The spatial distribution of the different guttering conditions is illustrated in Figure 4.2.2, and illustrates the widespread pattern of mediocre or absent guttering.

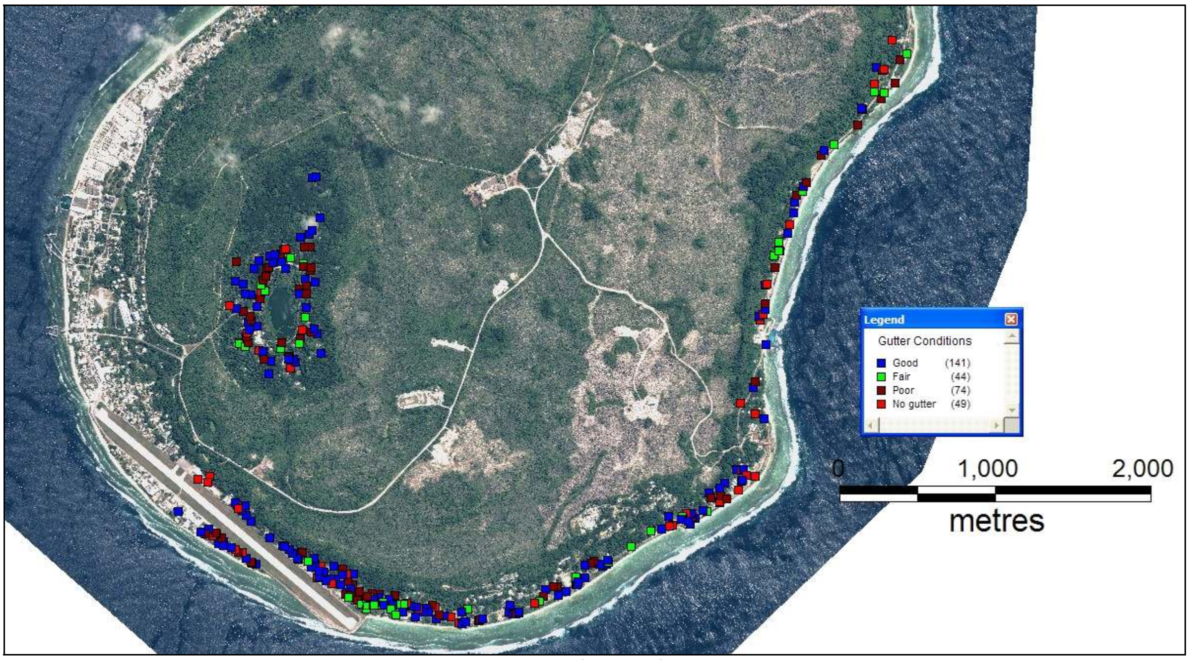


Figure 4.2.2 – Gutter Conditions

Downpipe Materials

Reference to Table 4.2.4 reveals that plastic is effectively the sole material (85%) utilised for system downpipes and also that 10% of the domestic properties surveyed recorded downpipes as completely absent. Obviously the latter properties currently exhibit a vital "missing-link" in the rainwater catchment & transmission equation and, because of this relatively simple and basic omission, are currently unable to consider rainwater harvesting and storage.

Down Pipe Materials	Total	Total%
Plastic	265	85
Metal	11	4
Others	2	1
No downpipe	30	10
Total	**308**	**100%**

Table 4.2.4 – Downpipe Materials.

The spatial distribution of properties with and without downpipes is illustrated in Figure 4.2.3, and it is apparent that there is no particular geographic pattern or concentration that might explain downpipe non-availability – the properties with no downpipe are well scattered and appear randomly distributed.

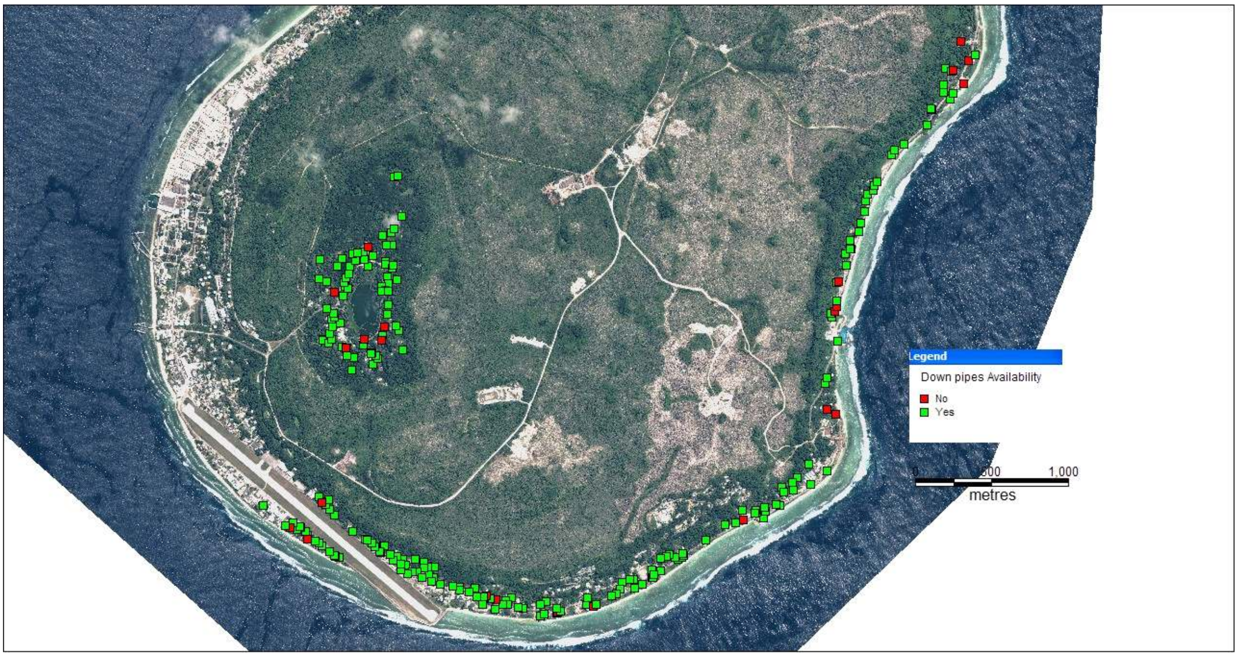


Figure 4.2.3 – Properties with and without downpipes

4.3 Storage Systems – Tanks & Cisterns

Tank Materials

The older style of rainwater tanks used for private dwellings was of concrete, galvanised iron or steel sheeting construction. However more recently, newer styles of tanks are being installed that are made of polyethylene in the size range from $2m^3$ to $45m^3$. Reference to Table 4.3.1 indicates that a almost one fifth (19%) of the properties surveyed had no rainwater storage tank present. General observation during the field survey also suggested that the usually older tank installations made of concrete or metal have been increasingly replaced or supplemented by those of more recently introduced plastic manufacture, which now comprise close to two thirds (60%) of the total of 250 tanks identified.

Tank Materials	Total Properties	Total (%)
Concrete	28	9%
Metal	73	24%
Plastic	149	48%
No Tank	58	19%
Total	**308**	**100%**

Table 4.3.1 – Storage Tank Materials

The spatial distribution of tank materials is illustrated in Figure 4.3.1, and it is apparent that there is a notable concentration of properties with metal tanks in Yaren District, whilst concrete appears the more dominant material in Anibare and Ijuw Districts. These distributions may relate to specific, historic Aid packages targeting certain Districts?

For all properties where circular tanks were observed, the external dimensions of the tanks (mostly sited with base sitting at ground level) and their calculated volumes are fully tabulated within Annex F. The mean volume of circular tanks was observed to be 29.1 m^3.

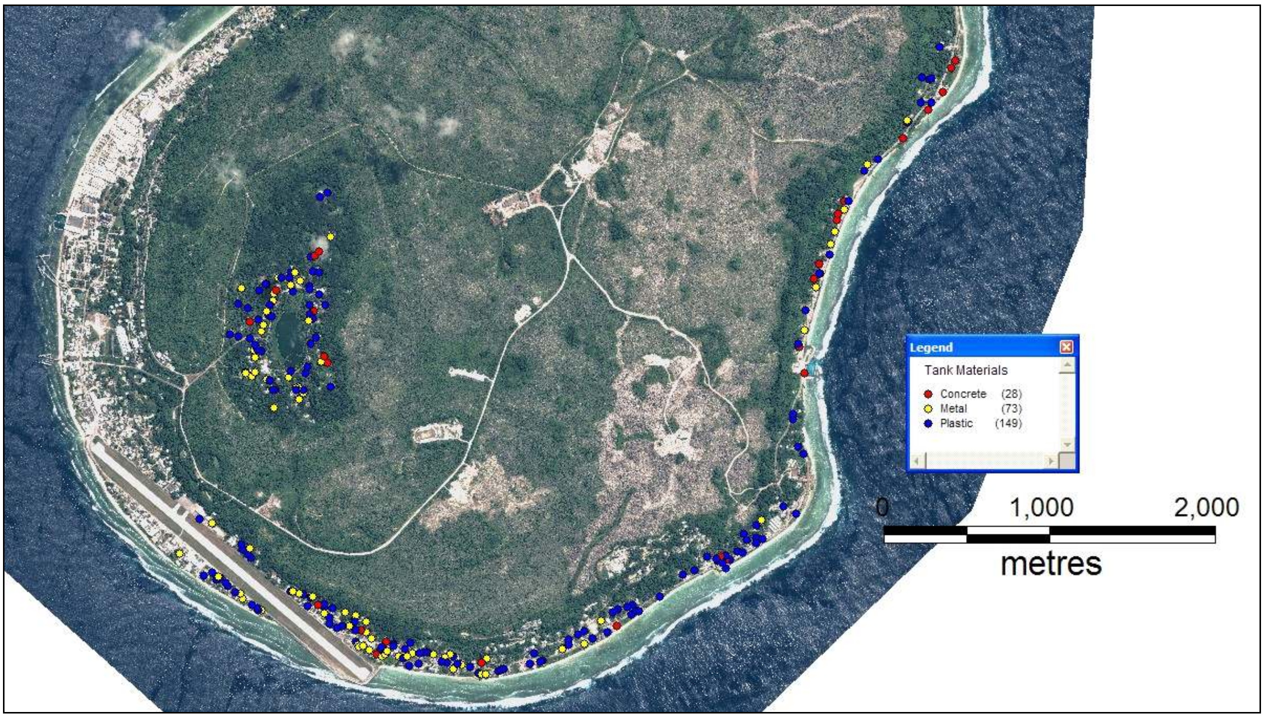


Figure 4.3.1 – Tank Materials

Property Tank ID	Tank Shape	Tank Length (m)	Tank Width (m)	Tank Height or Depth (m)	Total Volume (m3)
56	REC	8	3	2	48
110	REC	3	3	3	27
114	REC	9	4	2	72
122	REC	9	4	2	72
140	REC	7	4	4	112
196	REC	1	1	1	1
200	REC	3	2	2	12
254	REC	5	3	3	45
299	REC	9	4	2	72
310	REC	20	19	7	2660
312	REC	9	7	2	126
325	REC	8	4	2	64
339	REC	8	4	3	96
345	REC	6	4	12	288
393	REC	50	14	4	2800
470	REC	8	3	2	48
472	REC	8	3	2	48
474	REC	8	3	2	48
496	REC	11	3	2	66
518	REC	4	3	1	12
520	REC	9	3	2	54
532	REC	3	2	2	12
538	REC	3	3	2	18
564	REC	4	3	1	12
566	REC	9	3	2	54
578	REC	3	2	2	12
584	REC	3	3	2	18
				TOTAL	**6897**

Table 4.3.2 – Properties with rectangular tanks

Where rectangular tanks (or cisterns) were observed, they were invariably of concrete construction, mostly with the greater percentage of the structure sited partially beneath ground level, sometimes partially or fully beneath the house structure itself. The external dimensions and calculated volumes of the observed rectangular tanks are fully tabulated within Table .4.3.2. As can be seen, at two locations (310 and 393) the rectangular tanks are of significant size and capacity, more akin to strategic storage reservoirs, and it would therefore be interesting to note details of ownership, access and usage pattern. Other than these two large installations, the mean volume of rectangular tanks was observed to be 46.04 $m^{3.}$

The spatial distribution of properties with and without tanks is illustrated in Figure 4.3.2, and it is apparent that there is an unusual concentration of properties with no tanks in the south eastern sector of Yaren District – the reasoning for this cluster remains to be explained!

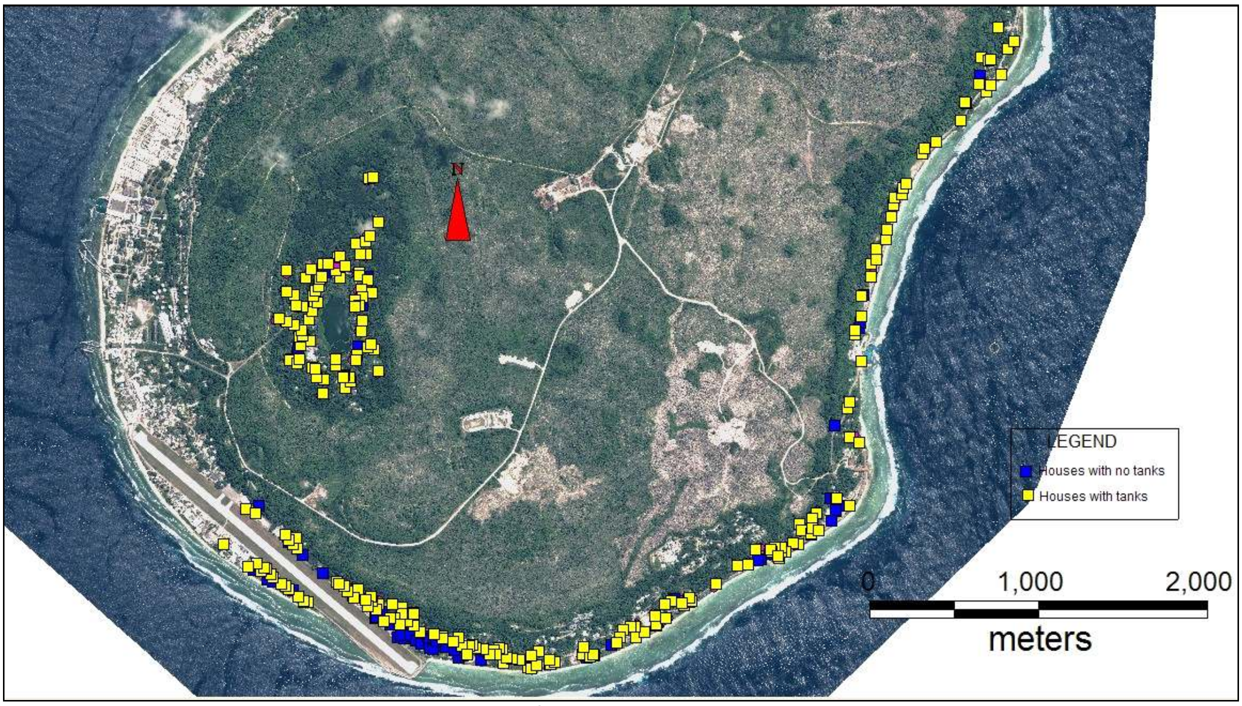


Figure 4.3.2 – Distribution of properties with and without storage tanks

Tank Condition

Reference to Table 4.3.3 indicates that almost three quarters (69%) of the 250 observed tanks during the field survey appeared to be in a *Good* condition, with quite a high proportion (31%) only in a *Fair to Poor* condition.

Tank Conditions	Total	Total (%)
Good	172	69
Fair	33	13
Poor	45	18
Total	**250**	**100**

Table 4.3.3 – Tank Condition

The spatial distribution of tank conditions is illustrated in Figure 4.3.3, and it is apparent that the 18% of tanks recorded to be in a *Poor* condition are seemingly concentrated around Buada Lagoon and along the northern coastal strip of Anibare.

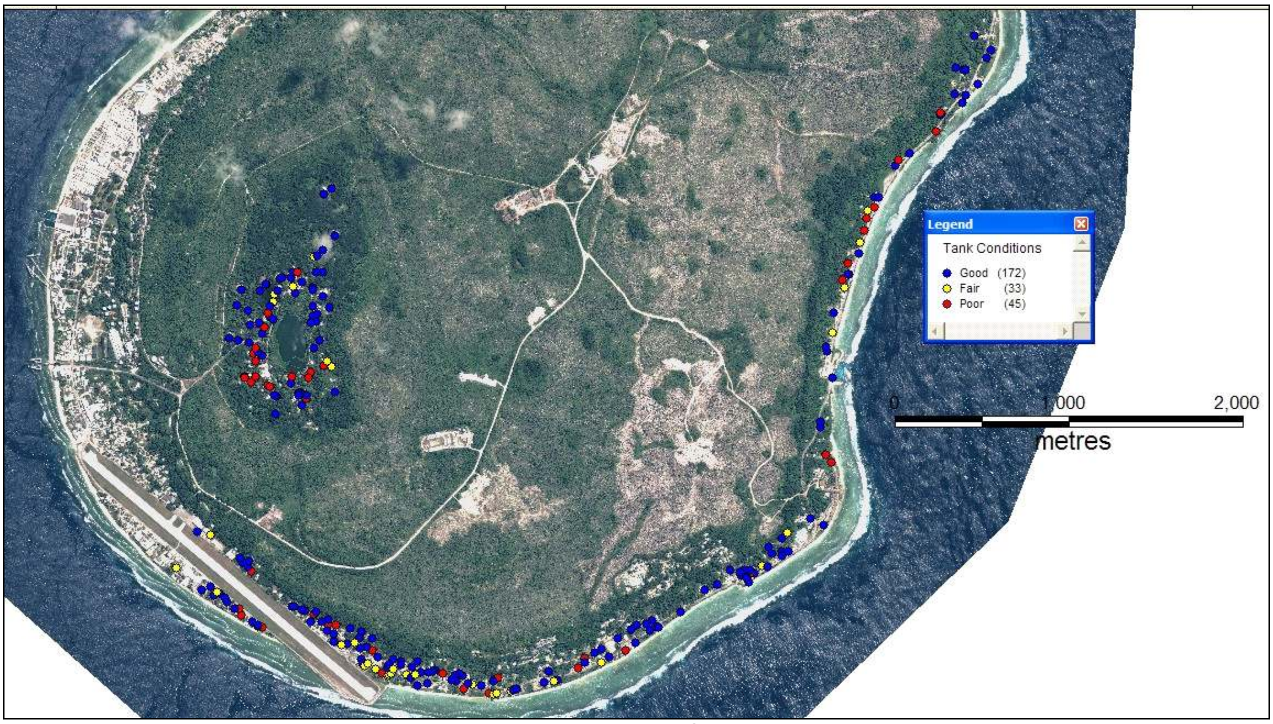


Figure 4.3.3 – Tank Conditions

Abstraction Methods

Reference to Table 4.3.4 indicates that a (basal) tap is the commonest method (44%) utilised to draw water from the storage tanks, though a significant proportion (31%) of the population can afford to utilise a small electrical pump (Davy manufacture commonly observed) to transfer water from the tank into their household.

Abstraction Method	Total	Total (%)
Bucket	33	13
Gravity	25	10
Other	5	2
Pump	77	31
Tap	110	44
Total	**250**	**100**

Table 4.3.4 – Abstraction Methods (from tanks)

The spatial distribution of tank abstraction methods is illustrated in Figure 4.3.4, seemingly indicating a high concentration of small electrical pump usage in properties around Buada Lagoon and along the coastal strip of Anibare; it is speculated these may relate to a particular Aid package that these Districts selectively benefited from, or are the residents generally more affluent? In contrast, a (basal) tap appears to be the more common practise utilised in properties along the coastal strip of Yaren and Meneng.

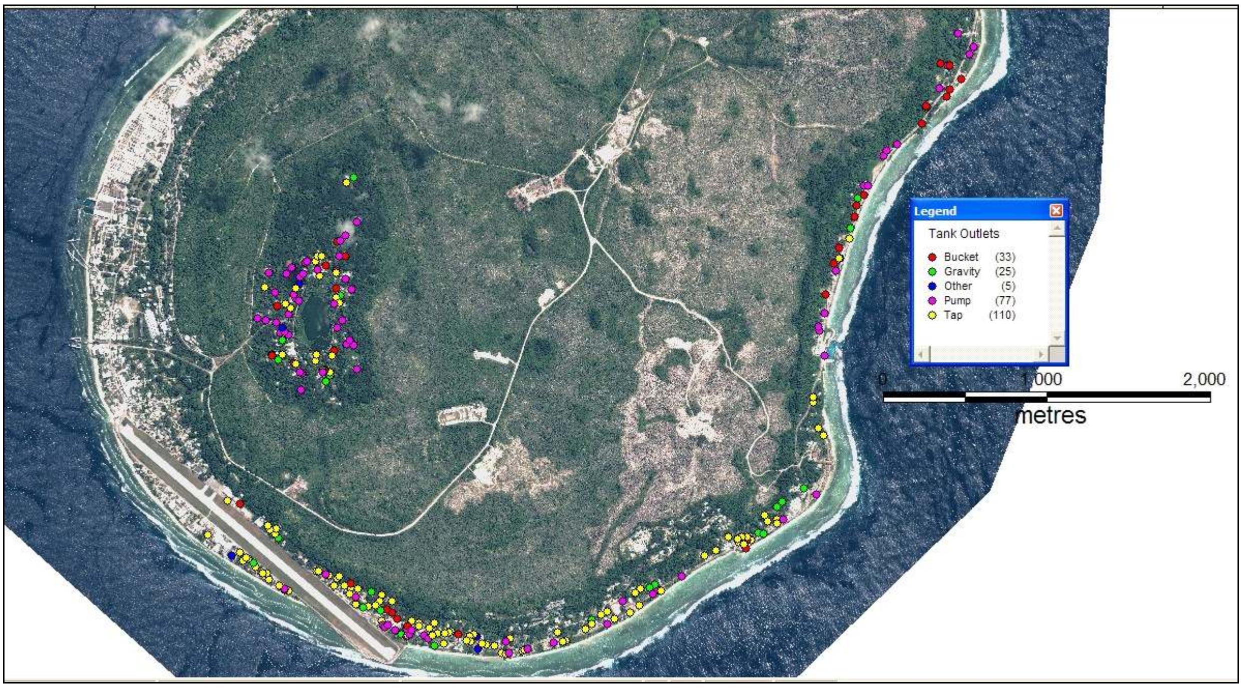


Figure 4.3.4 – Tank Abstraction Methods

Alternative supply methods

Reference to Table 4.3.5 indicates that just over half (56%) of the properties with tank storage available have no alternative supply methods, whilst a high proportion (37%) of the remainder do have a small well that they can abstract groundwater from.

Alternative supply methods	Total	Total (%)
Well	92	37
From water truck	2	1
Not available	140	56
Others	10	4
Disuse	6	2
Total	**250**	**100**

Table 4.3.5 – Alternative Supply Methods

The spatial distribution of alternative supply methods is illustrated in Figure 4.3.5. The high concentration of groundwater wells along the coastal strips in the central area of Anibare District and close to the airport runway in Yaren District is immediately apparent. A typical alternative groundwater supply well is illustrated in Figure 4.3.6.

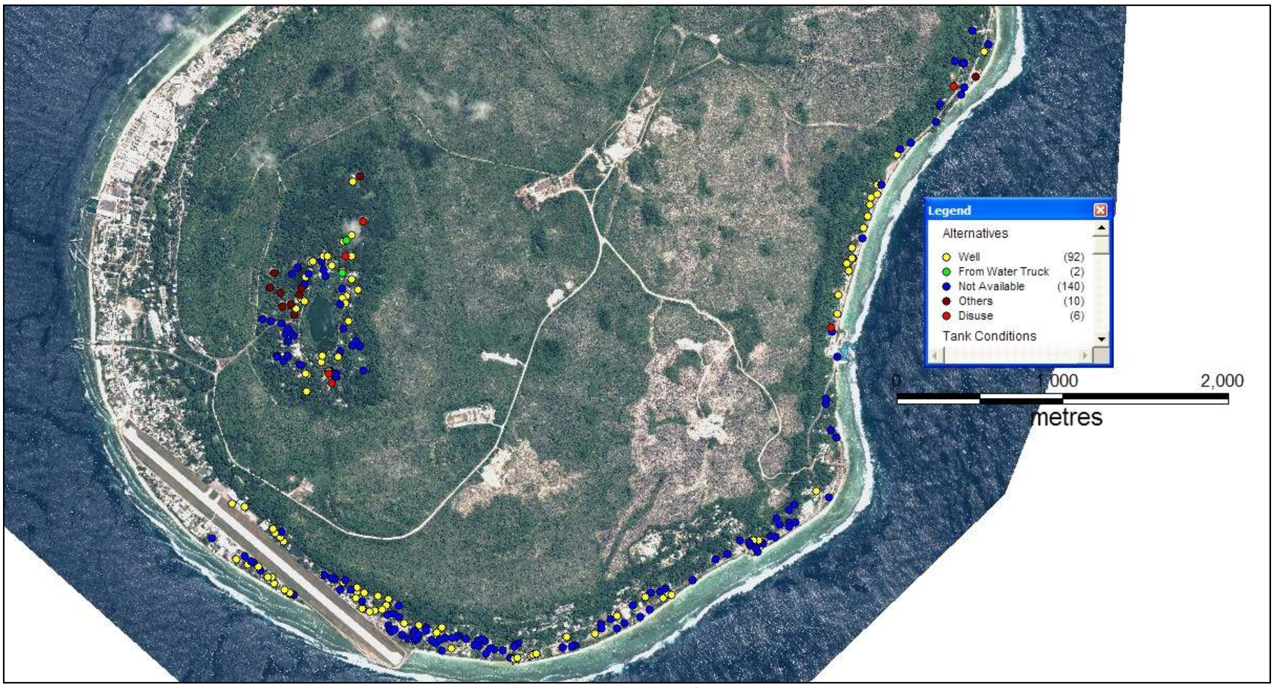


Figure 4.3.5 – Alternative Supply Methods

Figure 4.3.6 – Alternative supply well, Buada District.

5. Population Dynamics and Domestic Water Demand

5.1 Population Size

The most recent census to be undertaken in Nauru was 2002, which recorded Nauru's resident population, defined as comprising all people who have had an established residence in Nauru for at least one year, to be 9,872. This compares to 9600 residents in 1992, representing a very small annual population growth of 0.27%.

In the past, Nauruans were not known for migrating to other countries like other Pacific Islands peoples did, but this might have changed during the last few years. Nauru's low population increase during the period 1992–2002 was mainly due to high levels of negative net migration that almost counterbalanced Nauru's natural growth. If the current economic situation prevails, this trend will most likely continue in the near future.

The number of non-Nauruans declined from 2769 in 1992 to 2300 in 2002, and included mainly people from Kiribati, Tuvalu and the People's Republic of China. It is to be noted from Table 5.1.1 below that the area known as Location, which provided housing for mining company and government expatriate workers, represented almost 24% of the total population in 2002 – a similar proportion to 1992.

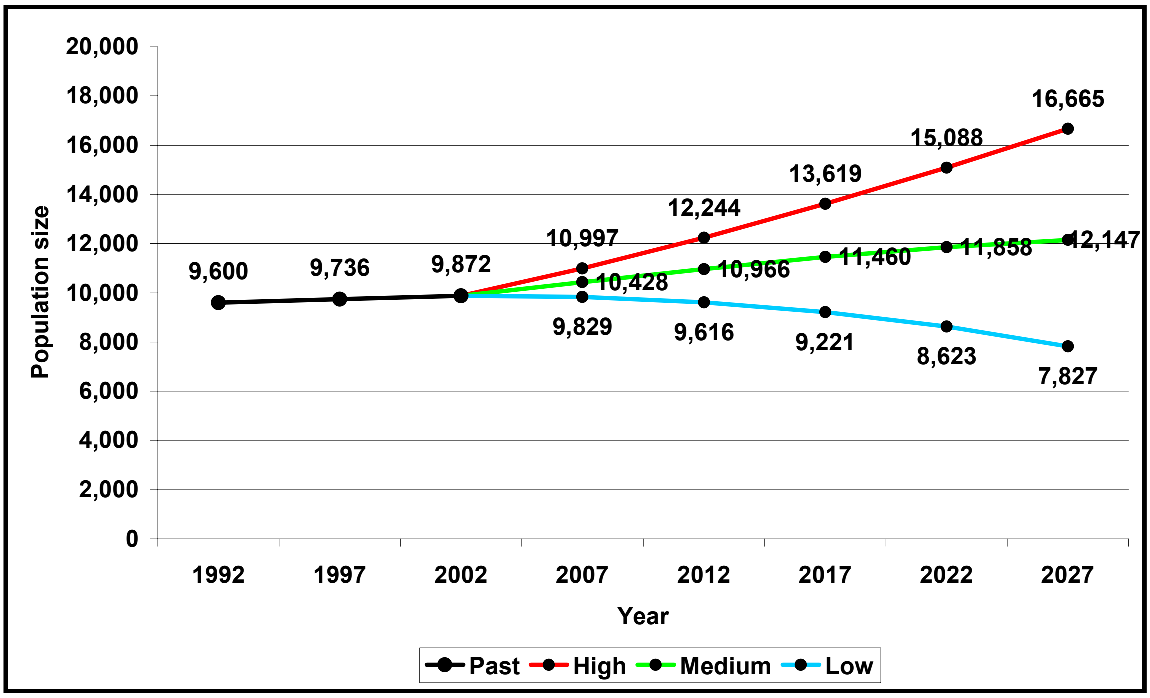
District	Total	Proportion of total population (%)
Yaren	632	6.3
Boe	731	7.3
Aiwo	1051	10.4
Buada	673	6.7
Denig	292	2.9
Nibok	479	4.8
Uaboe	386	3.8
Baitsi	443	4.4
Ewa	397	3.9
Anetan	498	4.9
Anabar	378	3.8
Ijuw	169	1.7
Anibare	232	2.3
Meneng	1323	13.1
Location	2381	23.7
Total	**10,065**	**100.0**

Table 5.1.1 - Population by District in 2002

Furthermore, it is understood that the great majority of those remaining i-Kiribati and Tuvaluan mine workers living in Location were finally repatriated (as a result of Taiwanese Aid intervention) to their respective countries during 2006, which suggests that Nauru's current (2007) total population realistically now lies somewhere within the range of 7,500-8,000 people only. This represents a significant demographic shift with direct implications not only for water demand assessment, but also all other strategic development planning and related demand horizons. The impact of fertility on Nauru's population dynamics, particularly future population growth, is less pronounced than that of migration and it is apparent that continued economic uncertainties as experienced on Nauru may well be conducive to relative stagnation of population growth or continued negative migration rates for years to come.

Given the observed evidence of population dynamics since 2002, and the lower base population figure that must now apply in 2007, the most representative current and future predictive scenario may arguably be closer to, or even lower than, the "Low" population trend presented in the 2002 Census (Fig 5.1.1 below)

Figure 5.1.1 - Future population trend according to three projection variants, 2002–2027



5.2 *Population Mortality*

As can be seen from Table 5.2.1, studies on the level of mortality presented in profiles within the Census 2002 indicate that the life expectancy at birth for indigenous Nauruans, especially for males, has been decreasing and is very low.

	1997–2002	
	Residents	**Nauruans**
Males	52.5	**49.0**
Females	58.2	**56.9**

Table 5.2.1 - Life expectancies by sex, total resident and Nauruan population, 1997–2002

It is reported[(9)] that the low overall life expectancy seems to be caused by a growing prevalence of lifestyle diseases such as diabetes, combined with high alcohol consumption, smoking and little exercise. Furthermore, it has also proven difficult to understand the high infant mortality rates (IMR) in an environment like Nauru, which does not experience the climate, health conditions (e.g. vector-borne diseases), physical environment, inaccessibility to health services and general communication problems that are prevalent in high IMR Pacific countries such as Solomon Islands, PNG, Vanuatu and Kiribati. **It is notable in both the above instances relating to low life expectancy and high IMR that neither water supply nor sanitation & hygiene issues were reported as contributory factors to these adverse statistics**. The Census concluded that concerted efforts need to be undertaken to improve infant, child and maternal health care programmes, leading to better overall child care, and the unfortunate adult male mortality statistics could be counteracted by intensifying health advocacy/public health awareness campaigns promoting healthier lifestyles.

5.3 Household Size

As can be seen from table 5.3.1, the 2002 census recorded the lowest average household size in Location (four persons), while the highest was found in Baitsi District with about nine persons. The average household size was recorded as 6 persons per dwelling. Location had the highest concentration of both population and households, and the lowest household size. This is because most residents in this district were foreign nationals living and working in Nauru, but as noted in Section 5.1, this dynamic can almost certainly be expected to have changed dramatically during the past few (2006-07) years.

District	Resident population		Households		Household size
	Number	%	Number	%	
Total	9872	100.0	1676	100.0	5.9
Yaren	625	6.3	80	4.8	7.8
Boe	728	7.4	117	7.0	6.2
Aiwo	1042	10.6	175	10.4	6.0
Buada	673	6.8	89	5.3	7.6
Denig	283	2.9	53	3.2	5.3
Nibok	479	4.9	70	4.2	6.8
Uaboe	385	3.9	51	3.0	7.5
Baitsi	443	4.5	47	2.8	9.4
Ewa	394	4.0	65	3.9	6.1
Anetan	497	5.0	69	4.1	7.2
Anabar	378	3.8	44	2.6	8.6
Ijuw	168	1.7	25	1.5	6.7
Anibare	231	2.3	31	1.8	7.5
Meneng	1316	13.3	199	11.9	6.6
Location	2230	22.6	561	33.5	4.0

Table 5.3.1 - Average household size by District, (from 2002 Census)

The 2002 Census also noted that most private dwellings in Nauru were constructed over 20 years ago. Only two out of every 100 were constructed in the previous two (2001-02) years, with one in 10 constructed over the previous 10 years. There is little to no evidence of any significant change in this building pattern environment during the subsequent period 2002 to-date (2007).

With respect to household water supply, of the 1652 private dwellings recorded during the 2002 Census, 1403 (85%) claimed to have access to drinking water with dispatches *(deliveries via road tanker)* from the desalination plant operated by the government providing the main source of drinking water for 81% of private dwellings. The remaining dwellings recorded using rainwater (14%), wells or other means.

With respect to household sanitation (toilet facilities), 83% of private dwellings recorded during the 2002 Census claimed access to modern indoor toilet facilities (tank-flush), with a further 12% having access to external tank or pour-flush facilities. Only 2% (N=28) of private dwellings claimed not to have access to a toilet facility.

5.4 Domestic Water Demand

Based on the earlier comments in Sections 5.1 to 5.3 of this report affecting population dynamics, a total base population of 7,500 to 8,000 would appear to be a reasonably accurate representation of Nauru's current 2007 situation. Given historic trends, existing and probable future socio-economic conditions, a very low to negative population growth rate is also considered to be the likely future scenario, so it is difficult to imagine conditions that would cause Nauru's total resident population to rise exceed 9,000 within the next 20-year demand horizon.

Predictions for future domestic water demands to 2027, assuming a continuation in present social customs and lifestyle by the Nauruan population, are based on the following typical design standards:-

POTABLE REQUIREMENTS

- Basic drinking water supply 30 l/c/d
- Additional uses (washing, cooking) 70 l/c/d

NON-POTABLE REQUIREMENTS

- Toilet flushing, cleaning, other 70 l/c/d

Based upon the recorded average Nauruan household size of 6 persons per dwelling and the reasonably typical potable water design standards noted above, the average household may therefore be expected to require an annual potable water supply of:-

6 persons x 100 l/c/d x 365 days = 219,000 litres per Annum = 219 m^3 per Annum (*equivalent to 219 tonnes/Annum, a form of expressing water supply by weight, perhaps uniquely utilised by Nauru as a result of its past history of having to import shipped freshwater [by the tonne], during the active phosphate mining period)*

Alternatively, for a total 2027 population of 9000 persons, potable domestic requirements will equate to:-

9000 x 100 l/c/d x 365 days = 328,500 m^3 per Annum or 328,500 tonnes/Annum

Under non drought conditions, continuous rain water collection will generally keep storage tanks well provisioned and significantly reduce the demand for potable water (historically delivered by road tanker from the desalination units). Under drought conditions, the average Pacific household would normally instigate careful self-management and domestic conservation measures with respect to their stored rainwater reserves, and a reduced demand of 50 l/c/d for a 3- or 6-month drought period becomes a feasible design standard. As an example in such circumstances, the volume of tank storage required to get the average household through a 3- or 6-month design drought would therefore equate to :-

3 month storage = (6people x 50l/c/d x 90 days) = 27,000 litres = 27 m^3
6-month storage = (6people x 50l/c/d x 180 days) = 54,000 litres = 54 m^3

It is apparent from the observations recorded in Section 4.3 and Annex F of this report that the mean storage of the circular tanks surveyed to-date is approximately 29 m^3 , so many households already seem quite well provided for in this respect. In view of the currently dynamic situation of RON's water Aid sector, it is clearly important for Nauru to clarify the exact installation locations of, the population numbers to be served by, and the additional rainwater storage contributed by the 150 galvanised tanks and 45 plastic tanks being donated by AusAid and the Government of Japan respectively. When combined with a completed asset database, it should then prove feasible to assess on a national household basis, exactly where the remaining "gaps-and-needs" are for RON government or Aid-donor support to strategically target future RWH infrastructure improvements.

6. CONCLUSIONS & RECOMMENDATIONS

6.1 The SOPAC/EU Project's approach philosophy, combining the application of high resolution, remotely sensed (RS) satellite imagery, global positioning systems (GPS), and geographic information systems (GIS) with local capacity building and training, was applied in Nauru to provide an accurate spatial database of domestic and community properties. Identification of associated conditions of rainwater harvesting infrastructure, such as roofing materials, guttering, down-pipes and storage tanks, formed the basis of the asset condition survey. This could subsequently allow production of engineering specifications and associated bill of quantities to accurately identify the infrastructure refurbishment and actual replacement needs; provision and installation of sufficient domestic & community rainwater harvesting facilities would therefore contribute directly to reducing the vulnerability of Nauru's population to drought risks.

6.2 During February 2007, two field teams visited 308 properties over 8 days on Nauru to initiate a detailed asset condition survey of domestic rainwater harvesting infrastructure. A comprehensive database has resulted for the districts of Buada, Yaren, Meneng, Anibare and Ijuw, which can either be fully completed within the remaining Districts at a future date, or perhaps used with some confidence as a statistically representative sample for forward interpolation of "whole-of-island" conditions. With a land area of just 21 km^2 Nauru is spatially by far the smallest of the fourteen nations within the EDF8/9 Project and a "whole-of-island" approach is therefore considered appropriate to such water sector tasks.

6.3 At every household property, data was collected on each respective element of the household rainwater harvesting system; in simple terms of the relative directional "flow diagram", these are respectively:-

Catchment System (roofing) **Transmission System (gutters & downpipes)** → **Storage System (tanks & cisterns)**

6.4 The results of the field survey work, analysed in Section 4 of this report, are partially summarised in Table 6.4.1 below.

RWH Asset	Good Condition	Fair Condition	Poor Condition	Nil Count	Total Properties.
Catchment	208	28	72	n/a	308
Transmission	141	44	74	49	308
Storage	172	33	45	58	308

Table 6.4.1 - Summary of domestic RWH asset conditions.

6.5 Analysis of the field survey work concluded the following points of interest with respect to the ***Catchment Systems:-*** Almost one quarter of the roofs surveyed comprised of old asbestos cement sheeting, the remainder being of more modern metal sheeting construction. Asbestos roofing appeared significantly concentrated within the Yaren district. Although the dangers associated with asbestos actually relate to inhalation of fibres within the respiratory tract, and not ingestion within the digestive tract, sufficient public health "scare" is perceived to be present amongst the general population to have deterred most people from collecting and drinking rainwater if they have an asbestos roof. The safe disposal of old asbestos sheeting is a significant environmental problem faced by Nauru. Vegetation overhang of roof areas is not a particular problem, but almost a quarter of the roofs surveyed were considered to be in a *Poor* condition. Of the 308 properties surveyed, the observed mean roof length was 15.35m and the mean roof width was 11.89m, representing a mean roof area of 187.67 m^2.

6.6 Analysis of the field survey work concluded the following points of interest with respect to the ***Transmission Systems:-*** three types of guttering materials were encountered during the survey period, namely metal, PVC plastic and asbestos. As with roofing materials, the Yaren District again shows an apparent spatial concentration of asbestos guttering. Approximately one sixth of the domestic properties surveyed had no guttering at all affixed to the fascia boarding. When combined with the fact that a high proportion of gutters could only be ranked as *Fair to Poor* condition, it suggests that this component of the RWH infrastructure gets particularly neglected at the domestic level and there is significant scope for improving awareness of basic maintenance issues. Considerably less than half of the total number of properties surveyed had sufficient guttering to capture all (100%) of the potential runoff from their roof. As well as the properties recorded with absolutely no guttering at all, an additional one third of the properties only captured 25% to 50% of the available roof area, so there is clearly also significant scope for improvement in guttering provision, to enable a much higher proportion of the rainfall roof runoff to be diverted to potential tank storage facilities. Plastic is effectively the sole material utilised for system downpipes and one tenth of the surveyed properties recorded no downpipes present.

6.7 Analysis of the field survey work concluded the following points of interest with respect to the ***Storage Systems:-*** Almost one fifth of the properties surveyed had no rainwater storage tank present. Tanks of plastic manufacture comprise close to two thirds of the total of 250 tanks identified. Spatial mapping appears to infer a concentration of properties with metal tanks in Yaren District, whilst concrete appears the more dominant material in Anibare and Ijuw Districts. It is speculated that these distributions may relate to specific, historic installations relating to distinct Aid packages targeting certain Districts? The mean volume of circular tanks was observed to be 29.1 m^3. Rectangular tanks were invariably of concrete construction, mostly with the greater percentage of the structure sited partially beneath ground level, sometimes partially or fully beneath the building structure itself. Apart from two particularly large tanks (Fisheries building at Anibare Harbour and at the airport), the mean volume of rectangular tanks was observed to be 46.04 $m^{3.}$ Spatial mapping appears to indicate a particular concentration of properties with no tanks in the south eastern sector of Yaren District. Almost three quarters of all the tanks observed during the field survey visually appeared to be in a *Good* condition. The dominant method of abstraction from the tanks was via a basal tap, though a significant proportion of the population were also utilising a small electrical pump (Davy manufacture commonly observed) to transfer water from the tank into their household.

6.8 It is recommended that the EDF9 KRA4 training in RS/GPS/GIS, understood to be nominally programmed for Nauru during July'07, should especially target continued capacity-building of water-sector staff within the following Nauru organisations:-

- Public Utilities
- Nauru Rehabilitation Corporation
- Ronphos
- Environment
- Planning

The training workshop should provide an ideal and timely impetus to encourage a follow-on, field survey which can be undertaken primarily by local staff with limited SOPAC support, to complete the RWH asset condition database for the remaining northern and western Districts on Nauru.

6.9 In the near future, perhaps coincident with the completion of the RWH Asset survey as mentioned in 6.8 above, it is also important for Nauru to clarify the exact installation locations of, the population numbers to be served by, and the additional rainwater storage contributed by the 150 galvanised tanks and 45 plastic tanks being donated by AusAid and the Government of Japan respectively. When combined with a completed asset database, it should then prove feasible to ascertain, on a national household basis, exactly where the remaining "gaps-and-needs" are. This will enable the RON government, or Aid-donor support, to strategically target future RWH infrastructure improvements and determine what might be required to satisfactorily upgrade conditions relating to the catchment, transmission and storage of domestic rainwater harvesting systems.

6.10 The repatriation of previous phosphate mine workers to their respective countries during 2006, probably results in Nauru's current (2007) total population realistically lying somewhere within the range of 7,500-8,000 people only. This represents a significant demographic shift from previous years, with direct implications not only for water demand assessment, but also all other strategic development planning and related demand horizons. The impact of fertility on Nauru's population dynamics, particularly future population growth, is less pronounced than that of migration and it is apparent that continued economic uncertainties as experienced on Nauru may well be conducive to relative stagnation of population growth or continued negative migration rates for years to come. Given historic trends and existing and probable future socio-economic conditions, a very low to negative population growth rate is also considered to be the likely future scenario, so it is difficult to imagine conditions that would cause Nauru's total resident population to exceed 9,000 within the next 20-year demand horizon through to 2027. For a total 2027 population of 9000 persons, domestic potable water demand is assessed at 328,500 m^3 per annum.

6.11 The prevailing socio-economic living conditions in Nauru present enormous challenges to the operational viability and maintenance sustainability of any proposals to undertake refurbishment or replacement of rainwater harvesting (or indeed any other) infrastructure. In addition, water conservation & awareness education remain extremely critical issues requiring input, as does the coincident investigation of the viability of (actual) cost recovery mechanisms relating to the water sector.

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