



Jordan River, Santo, Vanuatu

Directory of Wetlands of Vanuatu - 2014

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This work was implemented for the Secretariat of the Pacific Regional Environment Programme. Funding was provided by the Australian Government, Ministry of Environment.

Cover image: Jordan River, Santo, Vanuatu; by J. Terry

Citation: Kalfatak D and Jaensch R. 2014. Directory of Wetlands of Vanuatu - 2014. Report to the Secretariat of the Pacific Regional Environment Program.

1993 Publication: Scott DA, Asian Wetland Bureau, International Waterfowl and Wetlands Research Bureau. 1993. A directory of wetlands in Oceania. Slimbridge, U.K. : Kuala Lumpur : International Waterfowl and Wetlands Research Bureau ; Asian Wetland Bureau.

1993 Vanuatu Account Compilers: Ernest Bani and David Esrom.

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Acknowledgments

Funding for the project was granted by the Australian Government and the Convention for the Protection of Natural Resources and the Environment of the South Pacific Region.

Technical review and other support to the project was provided by; Ms Georgina Usher (Australian Department of Environment), Dr Lew Young (Secretariat of the Ramsar Convention on Wetlands) and Dr Lars Dinesen (Scientific and Technical Review Panel of the Ramsar Convention).

Special thanks to the Ramsar Officer Oceania, Mr Vainuupo Jungblut (Secretariat of the Pacific Regional Environment Programme) for administrative and technical review support throughout the project.

This component of the larger project was implemented in collaboration with the Department of Environmental Protection and Conservation (DEPC), Vanuatu. Our special thanks to Director Mr Albert Williams, Vanuatu.

A number of other people provided review comments, collected data and information, or gave other assistance: Rolenas Baereleo, Molu Bolu, Lilly Fatdal, Mark Kalotap (DEPC); Mimoso Bethel (volunteer); and Zoe Ayong (Shefa Province).

1 Introduction

The Secretariat of the Pacific Regional Environment Programme (SPREP) is an intergovernmental organisation charged with promoting cooperation among Pacific islands countries and territories to protect and improve their environment and ensure sustainable development for present and future generations. For more information, see: www.sprep.org.

Wetlands are among the world's most productive (and threatened) ecosystems and the services that they provide to humanity are significant. In order to effectively conserve and manage wetlands, a first step is to document and understand their distribution and status through conducting detailed baseline wetland inventories. Across the Pacific region, The Directory of Wetlands in Oceania 1993 documented available information on the distribution, status and values of wetlands in Pacific Island Countries and Territories, however, much of this existing information needs updating.

A number of Pacific Island Countries are contracting parties to the Ramsar Convention on Wetlands and as such are obligated to formulate and implement national planning to promote the conservation of their Ramsar Sites and other wetlands within their jurisdiction. Such planning relies very much on the availability of comprehensive data on wetlands.

The aim of this project was to update wetland inventories for Kiribati, Palau and Vanuatu (Scott 1983) as a means of strengthening the baseline state of knowledge of wetlands in these countries. Such baseline information would be valuable for informing conservation decisions, raising awareness of the importance of wetlands, influencing public perception of wetlands, creating ongoing monitoring, revealing trends over time, identifying priority sites for conservation management (e.g. for designating Ramsar Sites or other types of Protected Areas) and as a tool for planning and implementing effective conservation interventions for wetlands, especially in light of the impacts of climate change.

This project activities to build national capacity to conduct future wetland inventory updates, as well as to be able to use information collated in the inventory process in national decision making. To facilitate this, collated data will be centralized and delivered to SPREP, which will act as the central depository and dissemination point.

Updating wetland inventories is a priority under the SPREP Regional Wetlands Action Plan 2011-2013.

Funds for the project were granted to SPREP from the Australian Government and through the Convention for the Protection of Natural Resources and the Environment of the South Pacific Region (Noumea Convention), to update wetland inventories.

SPREP contracted the team of Roger Jaensch and Doug Watkins to work with the appropriate Government agencies on the project. Roger led the updates for Palau and Vanuatu and Doug the update for Kiribati.

2 Vanuatu Overview

2.1 Compilers and scope of update

The introduction and overview for Vanuatu for the 1993 edition of *A Directory of Wetlands in Oceania* was compiled by Ernest Bani and David Esrom. This updated version was prepared by Donna Kalfatak and Roger Jaensch, with assistance from Zoe Ayong, Rolenas Baereleo and Lilly Fatdal, in January to May 2014.

This update retains essential information from the 1993 edition, updated where necessary, and introduces data that have become available subsequently. Consequently, the document has standalone status. Also, several new categories of information have been added to the scope of this introduction and overview.

Whereas the 1993 edition included 13 sites, one site – Lake Isiwu, beside an active volcano on Tanna Island – no longer exists, the retaining ash/soil having been washed away by a recent cyclone. Meanwhile, two new sites have been added from the numerous candidates, as permitted with the available time and resources for the update; other candidates are listed.

For the 2014 update of the national wetland inventory, the boundary of each site was defined following discussion between consultants and the national agency responsible for wetlands. It was based as far as possible on information in the original Directory (Scott 1993), which in many cases was open to wide interpretation. For some sites it was possible to expand the site to include additional wetland areas and wetland types, including marine types such as coral reefs, which were contiguous and hydrologically connected. This approach enabled ecologically integrated sites to be defined, which should assist management planning.

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status except in the case of listed Ramsar Sites. It was fully intended that these site boundaries would be subject to adequate discussion through consultation with landholders and other stakeholders. As time and resources available for the 2014 update were limited, the extent to which this was achieved by the national authorities was limited. The site boundary therefore should be regarded as provisional, subject to further discussion.

2.2 Geographical summary

Within the boundaries of the Republic of Vanuatu is an archipelago of about 80 islands between latitudes 13° and 21° South and longitudes 166° and 170° East (see map below). The islands lie in an arc that extends north-west to the Solomon Islands and New Guinea; other neighbouring countries include the Fiji Islands and New Caledonia, which is a territory of France. The two largest islands are Espiritu Santo (3,955 km²) and Malekula (2,041 km²); there are about 10 medium-sized islands and the remainder are much smaller: see maps below at the start of the Wetland site accounts. The capital, Port Vila, lies on Efate island near the centre of Vanuatu.

Area of land: 12,190 km².

2.3 Geological and geomorphic setting

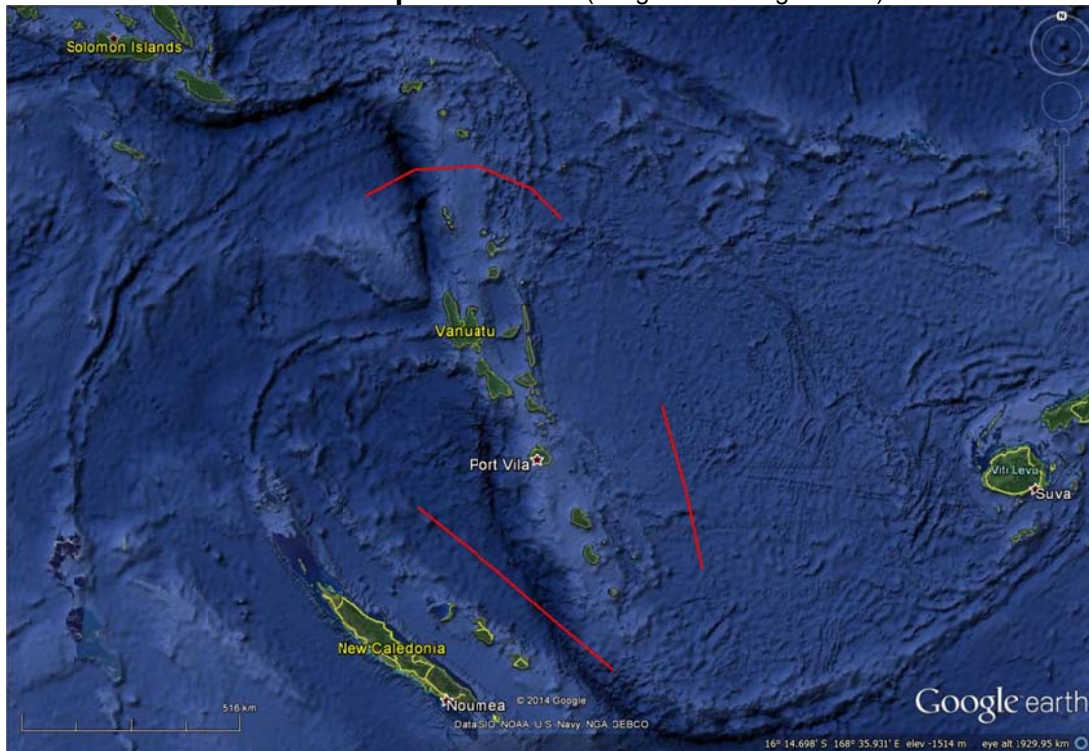
The islands of Vanuatu are oceanic, separated by deep ocean trenches from neighbouring land masses. They were formed by uplift and accumulation of volcanic and carbonate deposits, mainly during the Quaternary Period.

Active volcanos and other geothermal features exist on many of the islands – notably Vanua Lava, Gaua and Ambae – and significant eruptions occur occasionally. These islands have landforms, such as craters, and soils typical of volcanic situations but also exhibit erosion patterns, including some incised rivers, reflective of the unconsolidated substrate. Highest mountain peaks are on the islands of volcanic origin; the highest is Mt. Tabwemasana (1879 m) on Santo, one of the highest Pacific Island peaks outside New Guinea. Islands of oldest volcanic origin have highly weathered soils, often red in colour.

Some islands are partly or wholly limestone, derived from uplifted former coral reefs. Karst landforms are prominent, especially on Santo, and include jagged erosion relief in the uplands and solution sinkholes in the lowlands. Malekula has mostly limestone geology.

Whereas short rivers and numerous streams, some seasonal, drain many of the large and medium-sized islands, permanent and longer rivers are rarer; Vanuatu's longest river is the Jordan River, on Santo.

Location map of Vanuatu (Image from Google Earth)



2.4 Climate and natural disasters

Vanuatu has a humid tropical climate characterised by heavy rainfall and high temperatures. This shows little variation due to the oceanic setting but seasonality is more pronounced in the south. The wettest months are November to April (especially March) and the driest month is August, while mean annual rainfall varies from over 4,000 mm in the north, to around 2,500 mm in Efate and under 2,000 mm in the south. The orographic effects of high islands on rainfall are illustrated by Efate where rainfall may be 2,400-3,000 mm on the windward (south-east) side but half that on the leeward side. Mean annual temperature is about 25°C to 27°C with only a few degrees of variation between the months but temperatures have been trending upwards in recent decades.

Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; about 3 to 5 cyclones per decade are very destructive. There is no apparent trend in total numbers of cyclones or of severe cyclones in the South Pacific (1981-2007: Kuleshov *et al.* 2010). From 1940 to 2006, Vanuatu experienced 23 'wind storms', eight earthquakes and three major volcanic eruptions (King 2007).

Four volcanoes are active (Yasur, Lopevi, Ambrym, Gaua) and three are dormant or mostly so (Ambae, Gaua, Vanua Lava). The Vanuatu Geohazards agency maintains a website (<http://www.geohazards.gov.vu/>) with live updates on volcanic activity across the country.

2.5 Biogeographic regions

In terms of Freshwater Ecoregions of the World (FEOW: <http://www.feow.org/>; Abell *et al.* 2008), the **Vanuatu Freshwater Ecoregion** (<http://www.feow.org/ecoregions/details/819>) is the FEOW unit applicable to Vanuatu.

In terms of Marine Ecoregions of the World (MEOW: <http://worldwildlife.org/biome-categories/marine-ecoregions>; Spalding *et al.* 2007), Vanuatu, together with the Santa Cruz Islands, forms the **Vanuatu Marine Ecoregion** (<http://www.marineregions.org/gazetteer.php?p=details&id=21996>).

2.6 Vegetation

About 75% of the country is covered by evergreen tropical rainforest. On the larger mountainous islands, three major categories of vegetation can be readily identified: (a) evergreen tropical forests on lowland, wet, windward slopes; (b) semi-deciduous forests and fire-induced savannahs and grasslands on lowland, drier, leeward slopes; and (c) evergreen forests of upland and summit areas where the cooler, wetter and more humid climate results in a forest of smaller trees rich in epiphytes (Chambers 1992). There are about 900 species of flowering plants in Vanuatu, a comparatively low number compared with neighbouring island groups, and only 135 (15%) are endemic (these data may be out of date as additional species have been discovered). The fern flora, by contrast, is comparatively rich, with about 250 species known to occur (Chambers 1992).

An overview of vegetation of mangroves, freshwater marshes and swamp forests is given under the summary on wetland types (below) with further mention in applicable site accounts.

2.7 Wetlands of Vanuatu

Rivers

Not surprisingly, given the high topography and rainfall of most islands, rivers and streams are abundant in Vanuatu. The largest occur on Espiritu Santo and Malekula.

Most of the rivers are characterized by large and rapid fluctuations in flow regime coupled with generally steep gradients. Although of no great length, these rivers may carry large amounts of water during rainy periods. Many, such as the Teouma River on Efate and the Matenoi River on south Malekula, flow through spectacular and almost inaccessible limestone gorges for much of their length. The only extensive floodplain area in the country is formed by the rivers that drain the Tabwemasana Range of central Santo and flow north into Big Bay.

Some rivers, particularly in areas made up largely of raised reefs, e.g. eastern Santo, coastal Efate and the Torres Islands, flow only at times of heavy rainfall. On some islands, there is little or no surface water for all or much of the year because of the porous nature of the uplifted coralline limestone substrate.

Lakes

There are about 25-30 natural freshwater lakes in Vanuatu (Ambae, Ambrym, Efate, Epi, Espiritu Santo, Gaua, Maewo, Malekula, Tanna and Thion). Several of these are crater lakes, some within active volcanoes. Much the largest is Lake Letas (1,900 ha), on Gaua, which is the largest freshwater lake in the island Pacific outside of New Guinea. The caldera lakes of Ambae's active volcano Waivundolue, at over 1,300 m elevation, are the highest lakes in the South Pacific. Many of the other freshwater lakes occur in lowland areas and usually include some marsh vegetation; most are very small, some are seasonal.

Freshwater swamps

Freshwater swamps and swamp forests are generally small and few in number. They occur as fringing areas around lakes on Efate and Thion Island; in depressions on plateaus, e.g. on Efate, Epi, Maewo and Gaua; in extinct volcanoes such as Vanua Lava; or on floodplains such as those of the rivers entering Big Bay on Santo (Chambers 1992). The latter are the largest areas of swamp forest in Vanuatu and support a particularly rich and diverse swamp forest community dominated by species of *Hibiscus* and *Erythrina*. Patches of swamp forest on Efate are dominated by species of *Barringtonia* and *Pandanus*, while those on Malekula are dominated by species of *Hibiscus* and *Metroxylon*.

Coastal lagoons and inlets

A few brackish and saline lagoons, with relatively narrow tidal connections to the sea, occur in the coastal zone of some islands, e.g. on south Espiritu Santo, south-west Malekula, and north Efate. The largest of the brackish lagoons is Lake Nalema on east Epi. Vanuatu's largest closed saline lagoon, Ekasuvat ("Second") Lagoon near Port Vila on Efate, is now much disturbed by urban development.

Mangroves

Mangrove forests constitute the most extensive wetland vegetation in Vanuatu: estimates lie between 2,500 ha (FAO 2005) and 3,000 ha in the islands. Of this total, almost 2,000 ha of mangrove occurs on Malekula, mainly in two large areas along the east coast; elsewhere, mangroves occur as small stands or narrow belts along lagoon perimeters, sea shores and estuaries. Sizeable stands of mangrove occur on only nine of the 80 islands in the archipelago: Malekula (1,915 ha), Hiu (210 ha), Efate (100 ha), Emae (70 ha), Epi (60 ha), Vanua Lava (35 ha), Ureparapara (30 ha), Mota Lava (25 ha) and Aniwa (15 ha) (Lal and Esrom, 1990).

24 species of mangrove tree ('natongtong') have been recorded (Vanuatu MESCAL project, 2013). Typically, there are four recognizable zones: a landward fringe, now generally cleared by human activity; thickets of *Ceriops tagal* with the mangrove fern *Acrostichum aureum*; a *Rhizophora* spp. forest zone; and a seaward forest zone of *Avicennia marina*, occasionally with scattered *Sonneratia caeseolaris* and *Bruguiera* sp. In some localities, the stands of *Sonneratia* and *Bruguiera* spp. comprise an additional recognizable zone (Chambers 1988).

The human impact on mangroves in Vanuatu is mainly limited to subsistence activities, notably the harvest of mangrove wood to meet the energy needs of rural populations.

Conversion of mangroves to other uses has not yet occurred to any significant broad extent, though mangroves are occasionally cleared for easier access to the sea, some landward fringe has been converted to coconut plantations, and some mangroves have been cleared to allow for village construction. In the Port Vila area, tourism developments have involved the removal of small areas of mangroves (Chambers 1988; Lal and Esrom 1990).

Although the exploitation of mangroves on a traditional subsistence basis is allowed, there is a total ban on commercial logging in mangroves (FAO 2005). There is some community based management of aquatic resources of the mangroves and adjacent coral reefs, under the traditional land and sea tenure system. On special occasions, a partial or complete ban may be imposed on the harvesting of certain resources, e.g. in the Port Stanley area, local community chiefs often collectively ban the harvest of *Cardiosoma* crabs for commercial sales during the crab's breeding season, while continuing to allow subsistence use (Lal and Esrom 1990).

Seagrass beds

The seagrass communities of Vanuatu have been described by Chambers *et al.* (1990) who surveyed 60 sites from Aneityum in the south to Ureparapara in the north, and found seagrass beds in 39 of them. Nine species of seagrass were recorded, six of which were new records for Vanuatu. The most widespread species were *Thalassia hemprichii*, *Cymodocea rotundata*, *Halodule inermis*, *Enhalus acoroides* and *Halophylla ovalis*. Dense stands of seagrasses were located at 16 sites in shallow lagoons, bays and intertidal areas, in all instances where sand was the major or only substrate component. Most of the sites were rather small, but extensive seagrass beds were located on the comparatively wide intertidal areas around the Maskelyne Islands and along the south-east coast of Malekula.

Coral reef systems

Whereas coral reefs were not generally considered for the 1993 edition of the Directory (Scott 1993) and at the Government's request have not been specifically targeted for inclusion in the present update, they have been included where contiguous with or adjacent to existing important sites. For example, many of the sites in the 1993 edition (Scott 1993) which focus on mangrove wetlands, have extensive fringing-reef flats, patch-reefs and enclosed or surrounding shallow marine lagoons. Where appropriate, and subject to local endorsement, the boundaries of such sites have been redefined to extend seawards and include these marine wetlands. This is consistent with customary ownership of land and resources which extends to the outer seaward edge of the reefs in Vanuatu, and with an integrated approach to coastal zone management.

Coral reefs occur throughout the archipelago, encircling some islands, but discontinuously around recently-active land masses such as Santo, Malekula and Ambrym. They have been described in some detail in an inventory of the coral reefs of the world (UNEP/IUCN, 1988).

Other wetland types

Owing to the active volcanism in Vanuatu, hot springs and other geothermal wetlands occur on several islands, especially Efate, Vanua Lava and Gaua.

Surface wetlands such as sinkholes, and subterranean wetlands including streams and caves, occur in limestone karst landscapes, notably in eastern and southern Santo. Bouchet *et al.* (2011) investigated over 60 caves and several collapse features known locally as 'blue holes', some of which are important tourist and recreational attractions. Over 30 fishes, a dozen crustacean species and some invertebrates were documented in these karst wetlands.

2.8 Wetland fauna

Recent studies have boosted the numbers of freshwater fishes (67 species) and crustaceans (29) known from Vanuatu's streams (Keith *et al.* 2010). Five fishes are known to be endemic to Vanuatu: *Akihito vanuatu*; *Schismatogobius vanuatuensis*; *Sicyopterus aiensis*; *Stiphodon astilbos*; and *Stiphodon kalfatak*; most are found on three or more islands but *S. kalfatak* is known only from Santo (Keith *et al.* 2007, 2010). *Akihito* is a genus endemic to and named for Vanuatu (Watson *et al.* 2007; Keith *et al.* 2010). *S. aiensis* is harvested as a delicacy on Santo. Another seven species are known only from Vanuatu and New Caledonia but some are declining in New Caledonia (Keith *et al.* 2010).

Estuarine crocodiles *Crocodylus porosus* were still common in parts of Vanua Lava, northern Vanuatu, before 1972 with the largest specimen 5.5 m long (Bouchet *et al.* 2011). Numbers declined due to flooding effects of a 1972 cyclone and to hunting, such that a more recent estimate (Dickson 1981, cited in Bouchet *et al.* 2011) for Vanuatu was only 50 individuals. As the crocodile seems vulnerable to extinction in Vanuatu a fresh assessment of numbers is warranted. Marine turtles occur widely in Vanuatu; beaches are not extensive in the volcanic high islands but some turtle nesting sites for are known to local people and to community groups involved in monitoring.

Rather few species of waterbirds are resident in Vanuatu which is unsurprising given the relative scarcity of shallow freshwater habitat. Ducks are scarce and rails such as Purple Swamphen *Porphyrio porphyrio* and Spotless Crane *Porzana tabuensis* may be widespread but not conspicuous. Of some interest is the subspecies of Australasian Grebe *Tachybaptus novaehollandiae leucosternos* which is confined to Vanuatu and New Caledonia and is estimated to have a naturally low population in the islands' lakes (Wetlands International 2014). A few migratory shorebirds occur around the coast.

Dugong *Dugong dugon* occur in areas of seagrass associated with fringing flats and shallow bays of several of Vanuatu's islands.

2.9 Human population

Population: 264,652 (South Pacific Commission data, 2013).

Population growth rate (2012): 2.6%.

Distribution: 25% of people live in the two main urban centres, Port Vila and Luganville (IRG 2012).

Population density: 22 persons per square km (South Pacific Commission data, 2013) one of the lowest densities in the Pacific Islands; about 15 islands are uninhabited.

Languages: 110-120 (King 2007).

About 85% of the population of Vanuatu is dependent on traditional subsistence agriculture (slash-and-burn farming) for their livelihood, although this is often supplemented by reef fishing and occasionally also freshwater fishing. Cattle raising has become more prominent in recent decades. The remainder of the population lives in the urban centres of Port Vila on Efate and Luganville on Santo. Most of the population lives along the coast, and the interiors of many islands, particularly the larger, are virtually uninhabited. Thus although the overall population density is low, densities along the coast are often quite high. On some islands, this has resulted in problems of soil erosion associated with reduced fallow periods in the slash and burn cycle.

2.10 Land tenure system

In Vanuatu, land and water areas as far seaward as the outer edge of fringing reefs, and the natural resources therein, are in customary ownership. Other parties may establish lease arrangements with the customary owners, which is overseen by the Department of Lands. Ownership disputes are resolved by the Department's Land Tribunal. The tenure system has considerable implications in terms of opportunities and consultations for the process of declaring any form of protected or internationally-recognised wetland area.

2.11 Economy

Vanuatu is rich in natural resources but remains classified as a Least Developed Country. About 5,000 km² (41%) of Vanuatu's total land area is suitable for cultivation, but only about 30% of this area is currently cultivated. Climate and soil support plantations of copra, cocoa, coffee and a variety of other agricultural crops such as tubers, spices and fruits, as well as cattle farms. Limited use of agro-chemicals has created opportunities for export of 'organically grown' goods. There is considerable potential for forestry development, particularly in areas where agricultural development is limited. Significant potential also exists for the development of coastal and deep-sea fisheries in Vanuatu's Economic Exclusion Zone of 680,000 km². Mineral resources have been located on many islands, and there is potential for the exploitation of zinc, manganese, gold and raised coral limestone, as well as geothermal energy. The country's main exports are beef, cocoa, coffee, copra and kava (King 2007). Tourism and related services is the main foreign exchange earner, contributing 40% of GDP (in 2006 there were 68,000 visitors and 60,000 cruise ship visitors: King 2007), while in 2012 agriculture contributed 21% of GDP.

2.12 Pressures and threats to wetlands

The key drivers of environmental change in Vanuatu are a rapidly growing economy (after many years of inconsistent economic performance), a young population and rapid population growth, urban drift, land speculation, agricultural intensification, deforestation, inadequate fisheries and marine management, industry and trade, tourism, imported energy and transportation needs, extractive industries, and the global rise in greenhouse gas emissions (King 2007).

The World Risk Report in 2012 ranked Vanuatu as highest of 173 countries in its World Risk Index, due to high exposure to natural hazards and climate change coinciding with very vulnerable societies (Alliance Development Works 2012). This scenario has implications for Vanuatu's wetlands.

Although the freshwater wetlands are currently little disturbed by human activity, they are likely to come under increasing pressure as populations increase and the development of mining, forestry and agriculture proceeds. Because of their limited extent, swamp forests in particular are likely to come under threat. Agricultural pressures are already high on some islands, and with a growing population these pressures are likely to increase considerably in the coming decades. The inadequate disposal of various pollutants, including sewage and solid waste, is resulting in some contamination of coastal wetlands. Invasive species such as tree-smothering rope vine *Merremia* sp. are abundant on some islands of Vanuatu. At least three species of introduced fish occur in Santo: tilapia *Sarotherodon occidentalis*, guppy *Poecilia reticulata* and gambusia *Gambusia affinis* (Bouchet *et al.* 2011); some of these also occur elsewhere including Efate and Tanna. Introductions of Tilapia have been proposed in the context of food security.

For marine ecosystems, the key management issue is overharvest of marine resources (Government of Vanuatu 1999). Factors influencing this situation include: advent of new technologies and methods; increased population in coastal areas; decreased respect for traditional resource management systems; and disregard for controls brought in under fisheries legislation (Government of Vanuatu 1999).

The International Resources Group (2012) lists 20 recent, ongoing or under development projects related to climate change adaptation in Vanuatu.

Natural disasters such as cyclones can radically impact wetlands, especially in the coastal zone and former Lake Isivi on Tanna was destroyed since 1993 by erosion of its retaining structure as result of heavy rainfall. El Nino droughts can lead to fires in swampy wetlands.

2.13 Threatened wetland species

There is no formal list of threatened species in Vanuatu but some species are of conservation concern. Though not listed as globally threatened, in Vanuatu the estuarine crocodile *Crocodylus porosus* is now confined to a single site on Vanua Lava Island in the Banks Islands group and thus is vulnerable to extinction in this country. The dugong *Dugong dugon* occurs throughout the islands and remains relatively common. For both the Estuarine Crocodile and Dugong, Vanuatu is the easternmost limit of their extensive distributions in southern Asia and the Pacific.

Knowledge of marine turtles in Vanuatu is inadequate though greatly improved since 1993 through monitoring and other activities of community organisations such as Wan Smol Beg. Green turtle *Chelonia mydas*, hawksbill *Eretmochelys imbricata*, loggerhead *Caretta caretta* and leatherback *Dermochelys coriacea* occur and nest in the islands: all are globally threatened (IUCN Red List). However, as there are few large sandy beaches, breeding populations in Vanuatu may be small (Chambers 1992).

Other wetland associated species of conservation interest include three species of freshwater mollusc and the black flying-fox *Pteropus tonganus* and endemic white flying-fox *P. anetianus*, which often roost in mangroves.

2.14 Conservation measures

Considerable progress on wetland conservation has occurred in Vanuatu in the 20 years since the 1993 edition of the Directory. Dahl (1980) and others (TCSP 1990) had recommended a representative reserve system and highlighted some important wetlands such as Duck Lake. However, the situation did not change greatly until the mid-1990s when initiatives on 'conservation areas' supported by SPREP and GEF took effect. Conservation areas were not established as protected areas typical of European models; rather, they were set up in key areas of biodiversity where local land and resource owners agreed to meet conservation goals concurrent with maintaining sustainable livelihoods. National legislation (see below) prescribes the arrangements for conservation areas in Vanuatu and landholders can register them, giving controls on access and resource exploitation.

Some Conservation Areas (CAs) in Vanuatu include important wetlands identified in the 1993 edition of the Directory:

- Vathe CA: included a large part of the Jordan River Floodplains site.
- Amal – Crab Bay CA and Uri-Narong Marine CA: are parts of the Port Stanley, Bushmans Bay and Crab Bay site.
- A small conservation area is included in the Port Sandwich, Cook Bay and Maskelyne Islands site.

Other protected areas relevant to wetlands in Vanuatu:

- President Coolidge and Million Dollar Point: a marine reserve covering 100 ha off the coast of Espiritu Santo (under Fisheries Act).

In 1999 a National Biodiversity Strategy and Action Plan was produced for Vanuatu and this includes a number of items directly related to wetlands (Government of Vanuatu 1999). The Plan is presently undergoing review and update.

Public awareness of the importance and conservation of mangroves and other wetlands has been raised in Vanuatu over the past two decades through local meetings, radio features, posters, school curricula, and public theatre performances. These activities have been undertaken by government agencies, often on a project-funded basis, in partnership with community organisations.

There has been no systematic inventory of all wetlands across the entire area of Vanuatu but such an initiative would undoubtedly identify additional important wetlands, some of which may be suitable for informal or formal conservation measures.

Other conservation measures taken:

- The Fisheries Department monitors the harvest of marine resources. Turtles may be taken only for customary purposes, under a quota and permit system.
- Dugongs are not harvested intentionally.

2.15 Wetland area legislation

Considerable progress has occurred since 1993 in regard to enactment of legislation and in accession to international agreements, which are relevant to wetlands in Vanuatu. There is no legislation relating specifically and principally to wetland conservation in Vanuatu, but several Acts include or relate to wetlands:

Wild Bird Protection Regulation 1962: Makes it unlawful to kill, wound, capture or take the eggs of a number of named species of wild birds; and imposes a close season for Pacific Black Duck *Anas superciliosa pelewensis* and for some ten other species including other ducks.

Fisheries Act 1982: This Act requires the Director of Fisheries to prepare and keep under review plans for the management and development of fisheries in Vanuatu waters. The Act prohibits all fishing for marine mammals in Vanuatu waters, and also prohibits the use of explosives and poisons for fishing. It also provides that the Minister may declare 'any area of Vanuatu waters and the seabed underlying such waters to be a marine reserve'.

Forestry Act 1982: This establishes a buffer zone of up to 100 m either side of streams/rivers during forestry operations, and provides for conservation of land as an area or part of an area of particular scenic, cultural, historical or national interest.

National Parks Act (1993): Provides for declaration of national parks and nature reserves, though conservation areas are more popular with landholders.

Water Resources Management Act (2002): This legislation promotes the coordinated management of water resources and catchment areas at a national level, and calls for an inventory of water resources and the production of a National Water Development Plan. It prescribes riparian buffer zones of varied width (up to 50 m)

according to stream size. The Public Health Bill includes penalties for pollution of any wetland and for pollution or drainage in connection with water supply areas.

Environmental Protection and Conservation Act (2003, 2010) (CAP 283): Makes provision for environmental impact assessment and for registration of community conservation areas.

Legislation addressing threatened and endemic species is under development. A national environment policy is in draft form, but it does not yet specifically refer to wetlands.

Relevant international agreements to which Vanuatu has formally become a Contracting Party are:

- Convention on Biological Diversity (1993).
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (1996). This is supported in Vanuatu by the International Trade (Fauna and Flora) Act 1989.
- UN Convention to Combat Desertification (1998).
- World Heritage Convention.
- UN Framework Convention on Climate Change (1993).
- UNESCO Man and the Biosphere Programme.

Some additional agreements are under consideration, but Vanuatu already faces considerable challenges in servicing multiple conventions and agreements. Vanuatu has expressed interest in joining the Ramsar Convention but has experienced difficulties in securing necessary agreement among customary landholders and other local stakeholders on nomination of its first Ramsar site; attention has recently shifted from the Crab Bay site to Lake Letas as a potential candidate Ramsar site.

2.16 Organisations responsible for or otherwise involved with wetlands

a) Government of the Republic of Vanuatu

Department of Environmental Protection and Conservation (DEPC):

- DEPC is responsible for assessment of potential protected areas and management and administration of the country's natural environment. The Department is the country's focal point for local, regional and international environmental organizations, and is the agency responsible for CBD and CITES.

Department of Fisheries

- Responsible for the management and development of marine resources as spelt out under the Fisheries Act 1982.

Department of Forestry

- Responsible for the management and development of the country's forest resources; it is developing a flora database.

Department of Mines and Water Resources

- The Water Bureau is responsible for water protection, management and development to meet the needs of the people. It monitors water quality and discharge at several rivers as well as groundwater.

Department of Lands

- Maintains various geographic information systems for Vanuatu.

b) Non-governmental Organizations

Live and Learn is an NGO based in Australia and with a program in Vanuatu. It is involved in a 'ridge to reef' initiative that takes an integrated approach to catchment management.

Wan Smol Bag is an NGO in Vanuatu which uses theatre to promote environmental awareness. It coordinates a network for a monitoring program for turtle nesting throughout Vanuatu with local reporters on every major island. It also helps communities to establish local conservation areas.

Some NGOs that previously had offices in Vanuatu have subsequently relocated but maintain activities in Vanuatu. For example, the French research institute CIRAD (formerly ORSTOM) conducts research on mangroves and fisheries, the latter in collaboration with the Department of Fisheries, from Noumea.

2.17 Wetland research

Several major pieces of research have been conducted on the freshwater wetlands and biodiversity of Vanuatu since 1993. Previously, a number of isolated research activities had been reported (Baker 1929; Balfour-Browne 1939; Bregulla 1992; Jenkin 1929; Kimmins 1936; Lowndes 1928 and 1931; Mosely 1932; Salem 1959).

The National Museum of Natural History of Paris undertook several expeditions to Espiritu Santo in the past decade, publishing a large report on its findings (Bouchet *et al.* 2011). This provided a large boost to the knowledge of freshwater ecology on Santo and to Vanuatu generally, with – for example – descriptions of freshwater ecosystems and invertebrates at many sites across the island.

The Museum also spearheaded surveys of freshwater fishes and crustaceans on several islands of Vanuatu, in conjunction with DEPC. This led to compilation of an unpublished list and publication of a field guide of the freshwater species of Vanuatu (Keith *et al.* 2007; Keith *et al.* 2010).

Schabetsberger *et al.* (2013), in conjunction with DEPC, conducted a high-level investigation of eels *Anguilla* spp. on Gaua, satellite tracking their migration from Lake Letas to pelagic sites hundreds of kilometres distant.

Partnerships for East Melanesian Hotspots is an initiative focussed on documenting freshwater biodiversity and proposes future research, e.g. on Erromanga.

The GEF-funded project on Forestry and Protected Area Management will include several wetland areas including Lake Letas, Gaua.

Although providing a substantial baseline and documenting new species, there remains a need for surveys on other islands and for a wider scope of investigations on freshwater ecosystems of Vanuatu.

Some limited chemical analyses of water quality have been carried out by government agencies in the past. However, there is insufficient information available to plan development in such a way that the freshwater resources and human dependence upon these resources can be adequately safeguarded.

Some recent work has added to the existing body of knowledge on the mangroves of Vanuatu. Major items of research on mangroves are summarised as follows:

- Marshall and Medway (1976) described the mangrove community in Vanuatu.
- Scientists from the ORSTOM Mission on Efate carried out a variety of studies, including some inventory work using SPOT satellite imagery.
- Lal and Esrom (1990) conducted a study on the economics of mangrove utilization and management in Vanuatu.

- Chambers (1988) reported on the mangroves of Vanuatu for the UNDP/UNESCO Working Group Meeting on Mangroves in Apia in 1988.
- Gilman *et al.* (2006) included Vanuatu in their research on Pacific Island Mangroves in a changing climate and rising sea and determined a relative sea-level change rate of 1.0 mm per year.
- The MESCAL project (Mangrove Ecosystems for Climate Change Adaptation and Livelihoods) recently addressed mangrove ecosystems with the aims of developing awareness materials, documenting traditional knowledge and climate change adaptation and mitigation. Pascal and Bulu (2013) conducted an economic valuation of mangrove ecosystem services at Crab Bay (Malekula) and Eratap (Efate). Follow-up work is being developed through IUCN's regional program.

2.18 References

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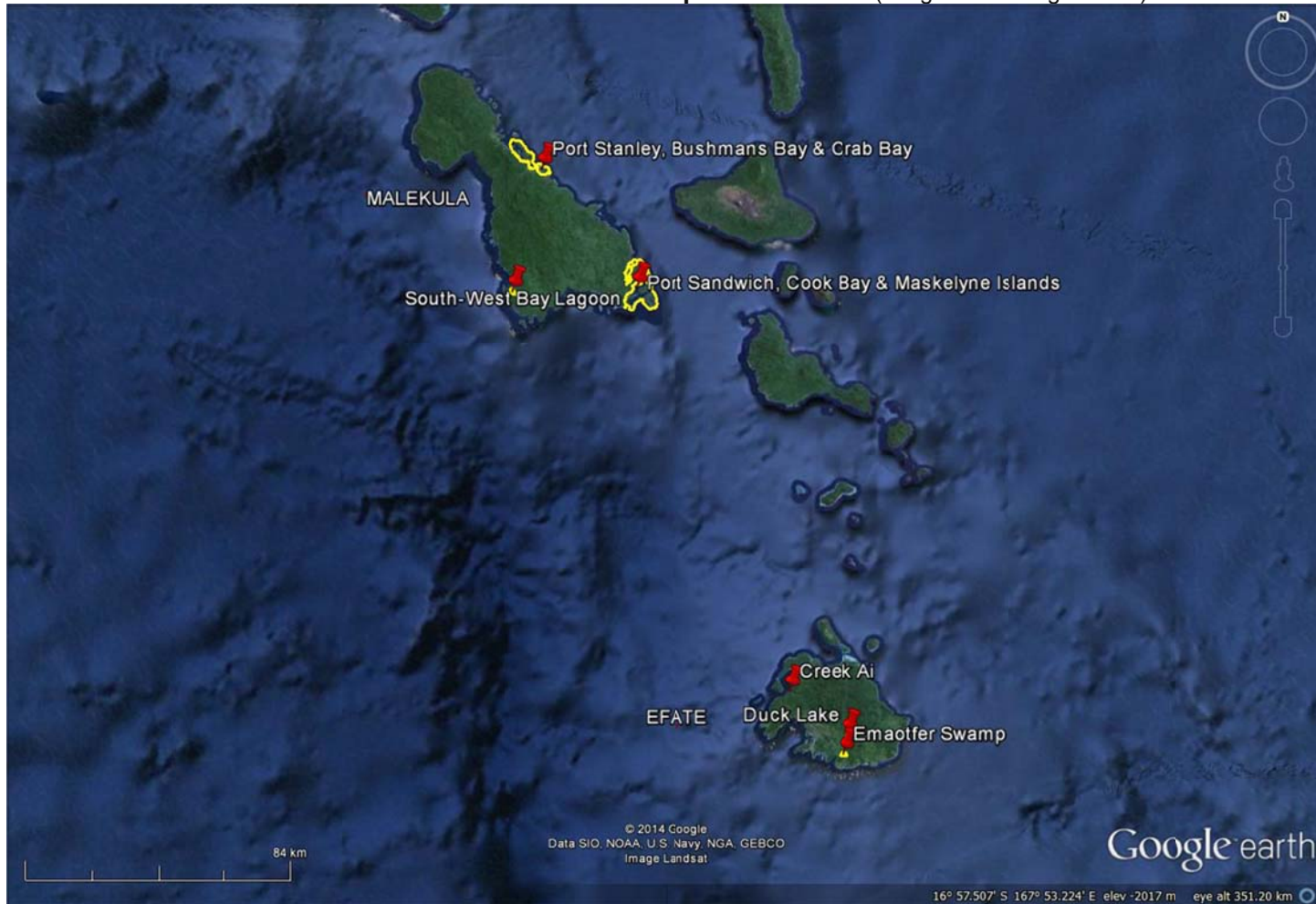
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2.19 Location maps of the inventoried wetland sites of Vanuatu

Location of inventoried wetland sites in the northern part of Vanuatu (Image from Google Earth)



Location of wetland sites in the southern part of Vanuatu (Image from Google Earth)



3 Wetland site accounts

3.1 Alligator River

A. Overview:

Alligator River wetland is a small tidal inlet in mangrove forest, important in Vanuatu for its population of estuarine crocodiles *Crocodylus porosus* and diversity of mangrove species.

B. Area, boundary and dimensions:

Area: 30 ha (polygon area using Google Earth Pro).

Boundary and dimensions: The site comprises the river channel upstream for about 2.6 km from the sea mouth, including about 50 m either side of the channel as a buffer zone. The main channel is generally about 10 metres wide, but widens to about 50 metres near its mouth; there are a few short side channels.

Note: with better resolution satellite imagery or aerial photographs it may be possible to better define the site boundary to include side creeks and all mangroves. Also, the upstream limit of the site is open to reconsideration.

C. Location:

Coordinates: 13°50'S, 167°32'E

The site is on the east coast of Vanua Lava Island in the Banks Islands group, northern Vanuatu; 439 km north of Port Vila and about 4.0 km north of Sola.

Province: Torba.

D. Site maps: See below.

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

E. Ramsar Wetland Types:

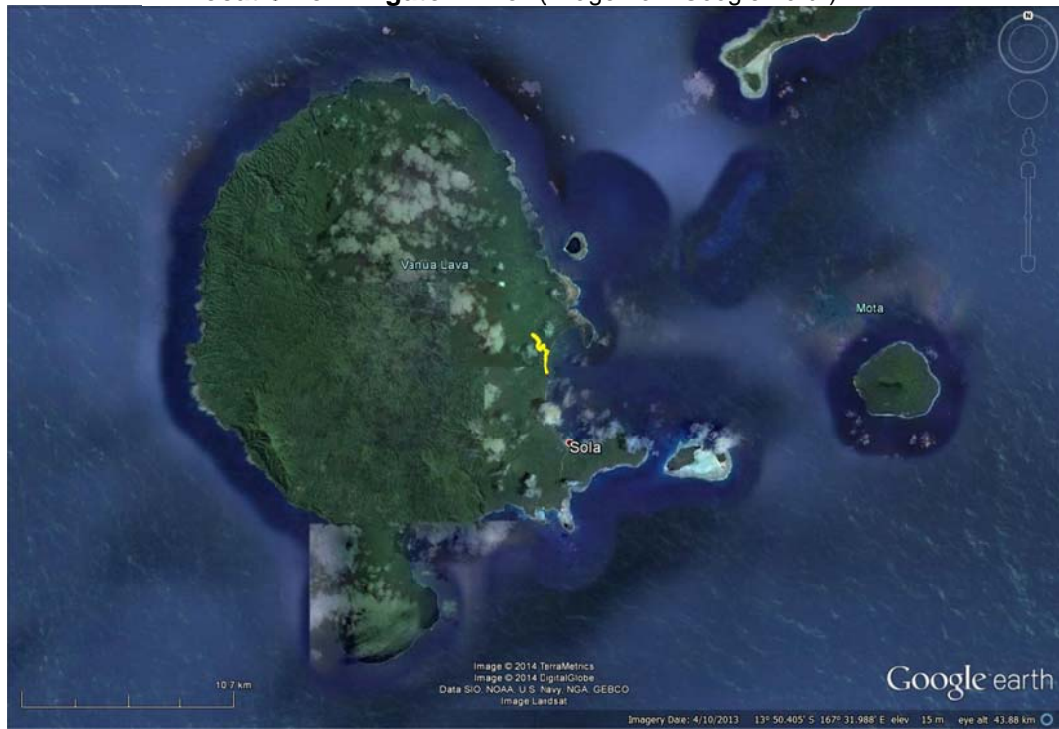
I: intertidal forested wetlands (mangroves).
F: estuarine waters.

F. Geomorphic setting:

Elevation: From sea level to slightly above.

Vanua Lava is a volcanic island with minor geothermal activity. Tuff, scoria and conglomerates occur in the interior and volcanic sediments at the coast. Alligator River site terminates beside an ocean beach of black sand.

Location of Alligator River (Image from Google Earth)



Alligator River: suggested site boundary (for discussion)
(Image from Google Earth)



Alligator River: suggested site boundary (for discussion)
(Image from Google Earth)



G. Biogeographic region: Vanuatu Marine Ecoregion (Spalding *et al.* 2007).

H. Climate:

The climate is humid tropical with a wet season extending from November to April. At nearby Sola, in 2009 and 2010 the annual rainfall was measured as between 4,500 and 5,000 mm and mean annual temperature was about 27°C with little monthly variation. Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil: Soil is of volcanic origin; the beach comprises black sand.

J. Water regime:

The Alligator River is a tidal inlet which meanders through a patch of mangrove forest. Field investigation is required to determine if there is freshwater stream inflow to the site.

K. Water chemistry: No information.

L. Biota:

Vegetation of the site is mangrove forest with a canopy at about 15-20 m. This site has the largest area of mangrove on Vanua Lava island. Vanua Lava has the highest diversity of mangrove tree species in Vanuatu.

The Alligator River still supports a tiny population of the estuarine crocodile *Crocodylus porosus*. Recent studies have shown that very few crocodiles remain, and breeding has apparently ceased (Chambers and Esrom 1989); an update from new field survey is required. This decline appears to have been caused by mortality from cyclones and hunting. The estuarine crocodile occurs in northern Vanuatu at the easternmost extremity of its enormous range.

M. Land use:

Some subsistence fishing involving a small number of people; subsistence agriculture in adjacent areas (distance from the site is not known). Presence of crocodiles may discourage greater use of the site for fishing.

N. Pressures and trends:

Minimal human population in the catchment; largely pristine.

Severe cyclones are known to have caused a decline in the crocodile population in the past, and may do so again.

O. Land tenure and administrative authority:

Land tenure: Customary ownership.

Administrative authority: The site is under the jurisdiction of the Department of Lands. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed? No, Vanuatu is not yet a Contracting Party.

Q. Ramsar Criteria met:

- Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
- Criterion 3. Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
- Criterion 4. Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

R. Justification for Ramsar Criteria met:

- Criterion 1: The site is a good representative example of two wetland types (F: tidal estuary; I: mangroves) found in the Vanuatu Marine Ecoregion.
- Criterion 3: The site is important to Vanuatu and thus the Vanuatu Marine Ecoregion because these northern islands have the greatest diversity of mangrove species in the country (Government of Vanuatu 1999), due to proximity to the Solomon Islands. Additional mangrove species for Vanuatu may be discovered at the site in the future. The site is important for maintaining crocodilians as a component of the biodiversity of the Vanuatu Marine Ecoregion.
- Criterion 4: The mangrove wetlands provide vital nursery habitat for fishes and crustaceans, possibly also juvenile crocodiles; this is one of the few such habitats, and the largest, in Vanua Lava.

Note that Criterion 2 potentially is met by the site because it supports the largest (and one of the few) populations of estuarine crocodile in Vanuatu. This species is not listed as threatened by IUCN in its Red List but is under consideration for inclusion in an official list of threatened species in Vanuatu.

S. Conservation and management status of the wetland:

No conservation measures for the site have been implemented. The Vanuatu NBSAP (Government of Vanuatu 1999) recommends conservation action to protect the mangroves of Vanua Lava, which includes Alligator River. The Biodiversity and Conservation Division of the Department of Environmental Protection and Conservation will review plans for the site in an upcoming update of the NBSAP. Previously (around 1993), there was a recommendation that Alligator River be protected as a Crocodile Reserve.

T. Ecosystem services:

Food supply: fish obtained on a subsistence basis for local communities.
Carbon sink: carbon is stored by the mangroves forest.

U. Current recreation and tourism: None.

V. Existing scientific research:

The former Environment Section in the Department of Physical Planning and Environment carried out a preliminary survey of the area in 1989 (Chambers and Esrom 1989).

W. Management plans and monitoring programs:

None implemented. Development of a local monitoring program and a management plan for crocodiles on Vanua Lava was proposed in the NBSAP (Government of Vanuatu 1999).

X. Current communication and public education programs: None.

Y. References cited:

- Chambers, M.R. and Esrom, D. 1989. The Status of the Estuarine Crocodile (*Crocodylus porosus* Schneider 1801) in Vanuatu. SPREP Topic Review. South Pacific Commission, Noumea, New Caledonia.
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Z. Compilers:

Original compilers (for 1993 edition): Ernest Bani and David Esrom.
Updated by: Donna Kalfatak and Roger Jaensch, May 2014.

3.2 Nagpen (Selva) River

A. Overview:

The Nagpen River site comprises a sterile river with distinctive water chemistry, draining a large area of sulphur springs.

Note: When referring to Alligator River and its mangroves, some sources call that site Selva or Silva River. As shown below, colours on the Nagpen River water suggest that the name Selva applies best to Nagpen River. Both rivers enter the sea near the same point.

B. Area, boundary and dimensions:

Area: 36.5 ha (polygon area using Google Earth Pro).

The boundary has been defined (2014) as the river channel upstream for about 5 km from the sea mouth, including about 50 m either side of the channel as a buffer zone. The site is separate from, and should not be confused with, nearby Alligator River.

Further investigation on the location of the sulphur springs may enable the site boundary to be expanded to include those springs. That would increase the importance of the site.

Note that the 1993 Directory indicated a site length of 10 km but the Google Earth image was of low resolution over the upper reaches of the river and the river could not be accurately mapped from that image above about 5 km.

C. Location:

Coordinates: 13°50'S, 167°31'E

On the central east coast of Vanua Lava Island in the Banks Islands group, northern Vanuatu; 438 km north of Port Vila and 3.8 km north-west of Sola. The mouth of Nagpen River is only 150 m south of the mouth of Alligator River.

Province: Torba.

D. Site maps: See below.

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

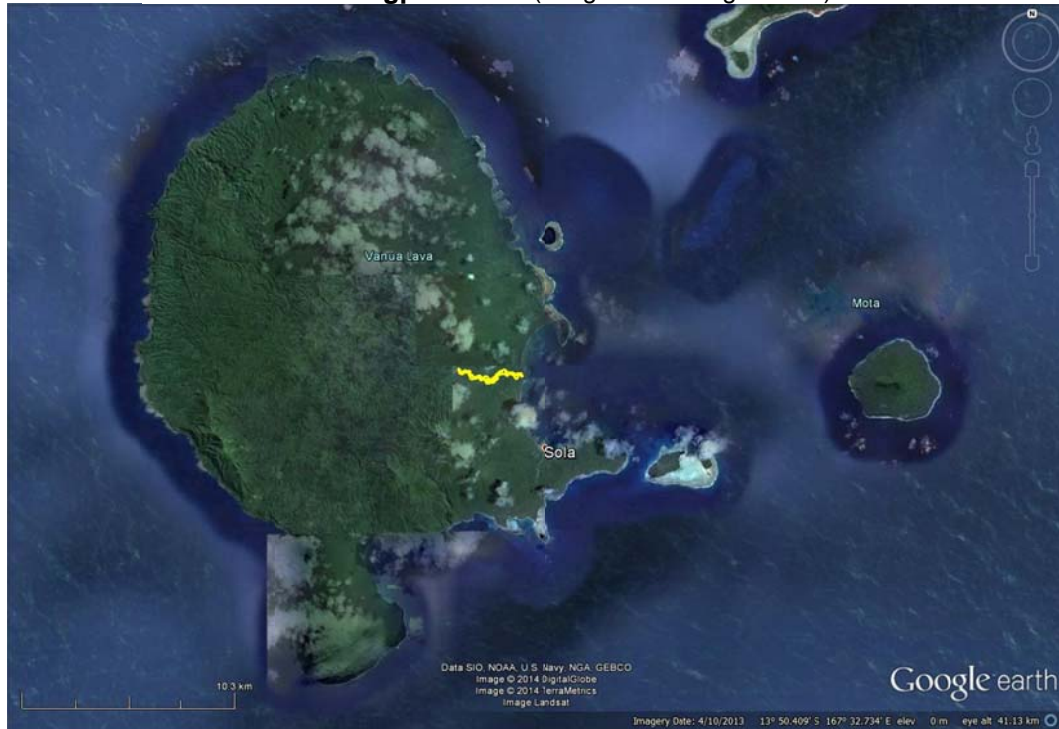
E. Ramsar Wetland Types:

M: permanent river.

I: Intertidal forested wetlands (mangrove swamps): a minor component.

Note: The additional wetland type "Zg: geothermal wetlands" would be added if sulphur springs are included in the site boundary.

Location of Nagpen River (Image from Google Earth)



Nagpen River: suggested site boundary (for discussion)
(Image from Google Earth)



Nagpen River: suggested site boundary (for discussion)
(Image from Google Earth)



F. Geomorphic setting:

Elevation: Sea level to 200 m (check on a topographical map).

Vanua Lava is a volcanic island with minor geothermal activity. Tuff, scoria and conglomerates occur in the interior and volcanic sediments at the coast.

G. Biogeographic region: Vanuatu Freshwater Ecoregion (Abell et al. 2008).

H. Climate:

The climate is humid tropical with a wet season extending from November to April. At nearby Sola, in 2009 and 2010 the annual rainfall was measured as between 4,500 and 5,000 mm and mean annual temperature was about 27°C with little monthly variation. Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil: Soil is of volcanic origin.

J. Water regime:

A small river, apparently 10 km in total length, draining some 500 ha of hot sulphur springs in the interior of Vanua Lava.

K. Water chemistry:

The river water has a very bitter taste, is highly acidic and appears to be almost sterile. It is a dark, peaty brown in colour and quite clear, except along the lower reaches of the river where there is a yellowish/brownish substance in suspension: this may be produced as a result of a chemical reaction occurring when fresh and saline waters mix near the river mouth. (Perhaps this is the origin of the name 'Selva' (= silver)?) Along the tidal reaches of the river, screw palm *Pandanus* sp. stems are stained an orange colour, presumably from sulphur precipitated out of the water.

L. Biota:

There are no submerged or emergent aquatic plants in the river. Vegetation along the banks of the lower reaches is dominated by *Pandanus* sp. and *tamanu Calophyllum* sp. The small tree *Hibiscus tiliaceus* also occurs here and becomes progressively commoner nearer the river mouth where it is the dominant species. Mangroves occur at the river mouth.

There are no fish in the river and very few invertebrates. Only a few insect larvae were observed during a brief survey of the river in 1989.

M. Land use:

None; subsistence agriculture in adjacent areas (distance from site is not known).

N. Pressures and trends:

Little or no human settlement or landuse in the catchment: human pressures unlikely to be significant. There was some prospecting for silver/lead/gold in the catchment in the 1970s-1980s but not recently.

O. Land tenure and administrative authority:

Land tenure: Customary ownership.

Administrative authority: The site is under the jurisdiction of the Department of Lands. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed? No, Vanuatu is not yet a Contracting Party.

Q. Ramsar Criteria met:

Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate bioregion.

R. Justification for Ramsar Criteria met:

Criterion 1: The site is a good representative example of a wetland type (M: permanent river) found in the Vanuatu Freshwater Ecoregion. It is a good and relatively rare example of a river fed mainly by geothermal sources and has distinctive water chemistry: the river is unusually sterile and it drains a large area of sulphur springs.

S. Conservation and management status of the wetland:

No conservation action taken or proposed.

T. Ecosystem services:

None identified; humans apparently do not directly use this river or its resources.

U. Current recreation and tourism: None.

V. Existing scientific research: No information.

W. Management plans and monitoring programs: None.

X. Current communication and public education programs: None.

Y. References cited:

Abell, R., Thieme M., Revenga C. et al. 2008. Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *BioScience* 58, 403–414.

Z. Compilers:

Original compilers (for 1993 edition): Ernest Bani and David Esrom.
Updated by: Donna Kalfatak and Roger Jaensch, May 2014.

3.3 Lake Letas

A. Overview:

The site comprises Lake Letas, a deep freshwater lake in a volcanic crater, and Solomul River, the lake's outflow river to the sea. The site is notable in the Pacific Islands context for the lake's size. It supports a large population of eels and several fishes endemic to Vanuatu and is a national tourist attraction.

B. Area, boundary and dimensions:

Area: 1,971 ha (polygon area using Google Earth Pro).

The site boundary follows the lake shore, then the outflowing Solomul River as far as its sea mouth, with all three distributary channels included. There is a buffer of about 50 m either side of the river channel. Siri Waterfall on Solomul River is included in the site. The lake is about 7 km by 2 km in surface dimensions and the river is about 7.3 km long.

C. Location:

Coordinates: Lake Letas: 14°16'S, 167°32'E.
Solomul River: 14°16'S, 167°34'E.

In the centre of Gaua (Santa Maria) Island in the Banks Islands, northern Vanuatu; 391 km north of Port Vila and about 7 km south-east of Avira.

Province: Torba.

E. Ramsar Wetland Types:

O: permanent lake (including waterfalls).
M: permanent stream.

The zone of wetland vegetation fringing the lake is too narrow to be recognised as a separate wetland type.

F. Geomorphic setting:

Elevation: The lake surface is situated at an altitude of 418 m. The outflow stream plunges 120 m over Siri Falls before it reaches sea level.

Gaua is the emerged top of a 3000 m high and 40 km wide stratovolcano. The lake is in a crater in the caldera of Mount Garet (altitude 979 m ASL), an active volcano. The caldera is about 8.5 km by 6.0 km in dimensions. Hot springs occur on the inner crater wall.

G. Biogeographic region: Vanuatu Freshwater Ecoregion (Abell *et al.* 2008).

D. Site maps:

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

Location of Lake Letas (Image from Google Earth)



Lake Letas: suggested site boundary (for discussion)
(Image from Google Earth)



Lake Letas: suggested site boundary (for discussion)
(Image from Google Earth)



Lake Letas; view across the lake to Mt Garet volcano (Photo: M. Tambets)



Siri Falls on Solomul River. Juvenile eels climb past the falls to reach the lake
(Photo: U. Sichowsky)



H. Climate:

The climate is humid tropical with a wet season extending from November to April. At Sola (45 km to the north on Vanua Lava), in 2009 and 2010 the annual rainfall was measured as between 4,500 and 5,000 mm and mean annual temperature was about 27°C with little monthly variation. Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil: Of relatively recent volcanic origin.

J. Water regime:

The lake is about 100 m deep based on recent soundings (D. Kalfatak pers. com.); earlier reports of depth of 360 m probably were in error, referring to imperial units (feet). A near-constant water level is maintained in the lake from the balance of subsurface inflows to the lake and stream outflow (P. Dovo pers. com.); given the high discharge rate it is assumed that there is a sufficient rate of groundwater inflow to the lake to maintain the lake level.

The outflow stream, Solomul River, plunges over Siri Waterfall, about 120 m high, before entering its lowland reaches; eventually it splits into three channels that enter the sea separately. Discharges at this bifurcation point were measured as 18, 0.9 and 6.1 cubic metres per second respectively, north channel to south; rates increase during heavy rain (Schabetsberger *et al.* 2013).

K. Water chemistry:

Lake water is fresh but not potable (D. Kalfatak pers. com.). The lake is constantly fertilised by inflow of nutrient-rich, warm volcanic springs; oxygen is available at the deepest point (Schabetsberger *et al.* 2013).

L. Biota:

Wetland trees including *Barringtonia racemosa* (P. Dovo pers. com.), reeds/sedges and aquatic plants occur in the lake margins. The lake is surrounded by dense equatorial cloud forest rich in epiphytes and *Hibiscus tiliaceus*.

Lake Letas has a large population of eels, considered to be among the largest in the South Pacific (Schabetsberger *et al.* 2009); it comprises at least two species, both catadromous: the giant mottled eel *Anguilla marmorata* and Pacific long-finned eel *A. megastoma*. The Pacific short-finned eel *A. obscura* occurs in lowland of the outflow river; another eel *A. reinhardtii* possibly also occurs in the site. Mature eels migrate to the ocean via Solomul River, predominantly during heavy rains and north-west winds between January and March. After falling tail-first over Siri Falls into the rocky plunge pool, the surviving eels rest before resuming travel onwards to the sea. Elvers return to the lake the same way, climbing mossy cliffs along the river near the waterfall. No other fishes are known to occur in the lake. The lake is very productive in terms of food for eels and invertebrates; more so than the lowland part of the outflow river (D. Kalfatak pers. com.). Stomachs of captured eels included molluscs.

Freshwater species in Lake Letas comprise the shrimps *Atyoides pilipes* and *Caridina typus*, the prawn species of *Macrobrachium lar* and the two eels. Freshwater species in the Solomul River and its three distributaries comprise 15 species of crustacean (including 5 *Macrobrachium* prawns and 4 species of *Caridina*) and 18 species of fishes including two endemics to Vanuatu (see item R) and 3 species of *Stiphodon* (Keith *et al.* 2007).

Reports of 'ducks' in the lake very likely refer also to Australasian Grebes *Tachybaptus novaehollandiae leucosternos*; further information and count data are needed.

Solomul River, showing extensive vine infestation (Photo: U. Sichowsky)



M. Land use:

The site is volcanically active with toxic sulphurous fumes routinely covering some areas and eruptions occurring from time to time. Consequently, there is little human use of the caldera including much of the lake catchment.

Some subsistence fishing for eels and prawns occurs in the lake, especially during visits by outsiders. Fishing often occurs in the lowland reaches of the Solomul River for eels, prawns and other fishes.

Along the lowest reaches of Solomul River there are some coconut plantations, gardens and cattle.

N. Pressures and trends:

There are no significant human impacts to the lake at present. In the 1980s, it was suggested that the lake could be used as a source of water for power generation to supply industrial developments proposed for the island; this has not been mentioned recently. Possible future introduction of ecologically-destructive Tilapia fish to the lake is a concern to DEPC.

Eruptions and other volcanic activity can impact the lake's character. For example, a small island in the lake favoured by waterbirds was damaged from an eruption in about 2008 and waterbird numbers subsequently decreased (P. Dovo pers. com.).

The outflow stream passes through some plantations near the coast but there is no substantial buffer between the plantations and some sections of the river.

O. Land tenure and administrative authority:

Land tenure: Customary ownership. The lake area is owned by many indigenous people of Gaua but the details have not been fully resolved in a legal context.

Administrative authority: The site is under the jurisdiction of the Department of Lands. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed?

No, Vanuatu is not yet a Contracting Party. However, Lake Letas is under consideration as a candidate Ramsar site if Vanuatu accedes to the Ramsar Convention.

Q. Ramsar Criteria met:

- Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
- Criterion 3. Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
- Criterion 4. Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
- Criterion 8: The streams, mangroves, lagoons and reefs of the site provide substantial stocks of fish and other marine resources on which local people depend.

R. Justification for Ramsar Criteria met:

- Criterion 1: The site is a good representative example of two wetland types found in the Vanuatu Freshwater Ecoregion: permanent freshwater lake (Type O); and permanent river (type M). It is the largest lake in Vanuatu, and the largest freshwater lake in the entire island Pacific outside of New Guinea.
- Criterion 3: The site is important for maintaining the biological diversity of the Vanuatu Freshwater Ecoregion because the outflow river system supports at least two of the freshwater fishes (*Schismatogobius vanuatuensis* and *Stiphodon astilbos*), that are endemic to Vanuatu.
- Criterion 4: The lake is a major refuge for eels (at least 2 species) in the Vanuatu Freshwater Ecoregion, and the outflow river forms a vital part of their migration route between breeding and non-breeding areas.
- Criterion 8: The site (lake and river) is important for supporting stocks of migratory eel, other fishes and freshwater prawns, which are harvested by local human communities.

Note: Procurement of count data on grebes occurring on the lake may allow testing against Criterion 6. The Australasian Grebe subspecies *Tachybaptus novaehollandiae leucosternos* is endemic to Vanuatu and New Caledonia and has a small population size (Wetlands International 2014). Relatively small numbers (a few tens, or less) might ensure Criterion 6 is met and such numbers are quite possible on this relatively large lake.

S. Conservation and management status of the wetland:

Lake Letas is on the tentative list for designation as a World Heritage Area and in the future may be nominated as a Ramsar Site. The Vanuatu NBSAP (Government of Vanuatu 1999) proposed some conservation measures for the site and the Tourism Council of the South Pacific identified Lake Letas as a suitable site for inclusion in Vanuatu's protected area system (TCSP, 1990). A Forest and Protected Area Management project funded by GEF through FAO is currently working with communities to establish Lake Letas and its forest vicinity as a conservation area.

T. Ecosystem services:

Food supply (subsistence): eels and prawns from the lake and outflow river are eaten by local people.

Recreation: a relatively small but possibly increasing number of tourists visit the lake and more people visit the waterfall (trekking to these places is apparently steep and slippery, which would deter some visitors).

U. Current recreation and tourism:

Occasional visits by tourists to the waterfall and/or lake occur; they are organised by the Tourism Office (Port Vila) and its local office. The Red Cross provides safety briefings and equipment due to possible volcanic activity; breathing masks must be carried in some areas of the catchment due to possible sulphur fumes. There are no facilities on the lake-side other than a canoe. Siri Falls is visited more often.

V. Existing scientific research:

A rapid biodiversity assessment was done by the Departments of Environment and Forestry in 1998 and a rapid assessment of plants was conducted by the Forestry Department in 2008. Surveys of fishes/eels and crustaceans were conducted in the lake and river in 2005 by the French National History Museum in collaboration with the Vanuatu Government (Keith *et al.* 2007).

An international team conducted research on eels in the site in 2012 and 2013 (Schabetsberger *et al.* 2013); this included limnological studies. Sixty-six eels of three species (up to 142 cm long) were caught and 7 were fitted with satellite transmitters; the project showed some eels migrating in the ocean for over 800 km to the north-east after leaving the Lake.

Fish surveys on Lake Letas (Photo: U. Sichowsky)



W. Management plans and monitoring programs:

The Forest and Protected Area Management Project (FPAMP), spearheaded by the Forestry Department and funded by GEF, will develop a management plan for the lake over the period 2013-2016. This may lead to some monitoring programs. Aspirations have been discussed with the local people and some socio-economic and wildlife surveys have been completed.

X. Current communication and public education programs:

A poster on the natural values of the lake was produced by the Landholders Conservation Initiative project of the Department of Environment in 2008 and distributed nationwide. Awareness of the importance of the lake was raised around Gaua as part of this project. The FPAMP project produced an awareness video of the lake in 2013, which was shown on national television.

Y. References cited:

- Abell, R., Thieme M., Revenga C. et al. 2008. Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *BioScience* 58, 403–414.
- Government of Vanuatu. 1999. National Biodiversity Conservation Strategy. Report of the Vanuatu National Biodiversity Strategy and Action Plan Project, 84 pp.
- Keith, P., Lord, C., Marquet, G., Gerbeaux, P. and Kalfatak, D. 2007. List of freshwater species recorded in the rivers of Vanuatu. Unpublished table of records.
- Schabetsberger, R., Drozdowski, G., Rott, E., Lenzenweger, R. and others 2009. Losing the bounty? Investigating species richness in isolated freshwater ecosystems of Oceania. *Pac Sci* 63: 153–179.
- Schabetsberger, R., Økland, F., Aarestrup, K., Kalfatak, D., Sichrowsky, U., Tambets, M., Dall’Olmo, G., Kaiser, R. and Miller, P. 2013. Oceanic migration behaviour of tropical Pacific eels from Vanuatu. *Marine Ecology Progress Series* Vol. 475: 177–190.
- TCSP. 1990. Guidelines for the Integration of Tourism Development and Environmental Protection in the South Pacific. Tourism Council of the South Pacific, Suva, Fiji.

Z. Compilers:

Original compilers (for 1993 edition): Ernest Bani and David Esrom.
Updated by: Donna Kalfatak and Roger Jaensch, May 2014.

3.4 Jordan River Lower Reaches and Floodplain Wetlands

A. Overview:

The site comprises the lower reaches of Jordan River entering Big Bay and a large area of freshwater marshes and swamp forest on associated near-coastal floodplain. It supports at least three of the freshwater fishes that are endemic to Vanuatu.

B. Area, boundary and dimensions:

Area: 3,335 ha (polygon area using Google Earth Pro).

The boundary corresponds closely to the boundary of the Vathe Conservation Area (VCA). This includes the lower reaches of the Jordan River (to about 10 km upstream) and floodplain eastwards to a prominent escarpment; the boundary returns along the coastline. Some western parts of the river bed may be outside the VCA boundary but the whole river bed is included in this inventory site.

In the future, the site boundary for the inventory could potentially be extended westwards to include more, or all, of the major rivers and floodplains draining into the south end of Big Bay; thus the site would become up to four times larger. (The original site description did not define the boundary in detail but the range of coordinates implied a site about 15 km wide and 8 km deep; however, there are few data on areas outside VCA.)

The dimensions of the site (VCA) are about 7 km east-west and 7 km north-south.

C. Location:

Coordinates (centre of VCA): 15°11 ' S; 166°56 ' E.

South of Big Bay, in north-central Espiritu Santo; 318 km north of Port Vila and about 44 km north-west of Luganville. The villages Matentas (Matantas) and Sara are in the site.

Province: Sanma.

Mouth of Matentas River, looking west along Big Bay (Photo: S. Maturin)



D. Site Maps: See below.

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

E. Ramsar Wetland Types:

Xf: Freshwater, tree-dominated wetlands (includes freshwater swamp forests).

Ts: Seasonal freshwater marshes and pools on inorganic soils (includes seasonally flooded meadows, sedge marshes).

M: Permanent rivers.

Tp: Permanent freshwater marshes and pools (ponds below 8 ha): a small area behind the beach near the river mouth.

Note: Some of the swamp forest may lie on peat substrate and thus be classed as a different wetland type: requires investigation.

F. Geomorphic setting:

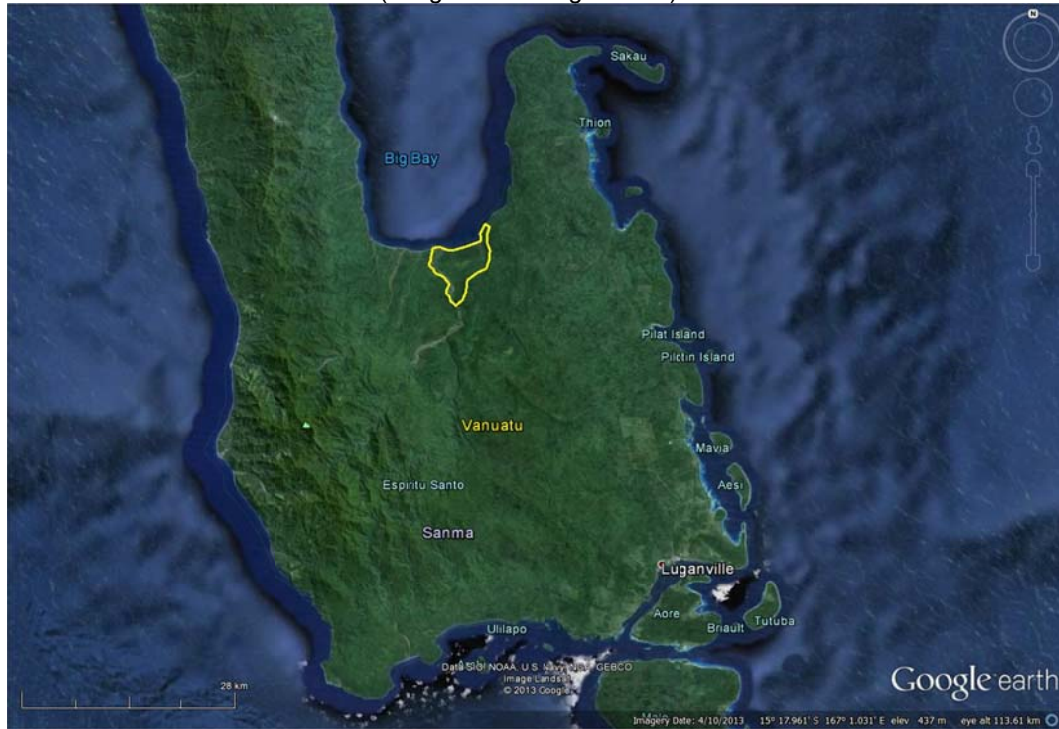
Elevation: Wetlands in the site (VCA) range from sea level to slightly above.

The Jordan River rises in the highest mountains of Espiritu Santo and moves from underlying volcanic geology to limestone geology along its course. Its bed is highly aggraded with sediment and thus it has a significant gradient along its entire course and has no estuary. Large boulders (basalt?) occur in the river bed. The escarpment on the east side of VCA is of limestone. A floodplain between the escarpment, river and coast supports swamp wetlands. The much smaller and shorter Matentas River enters the eastern part of the VCA.

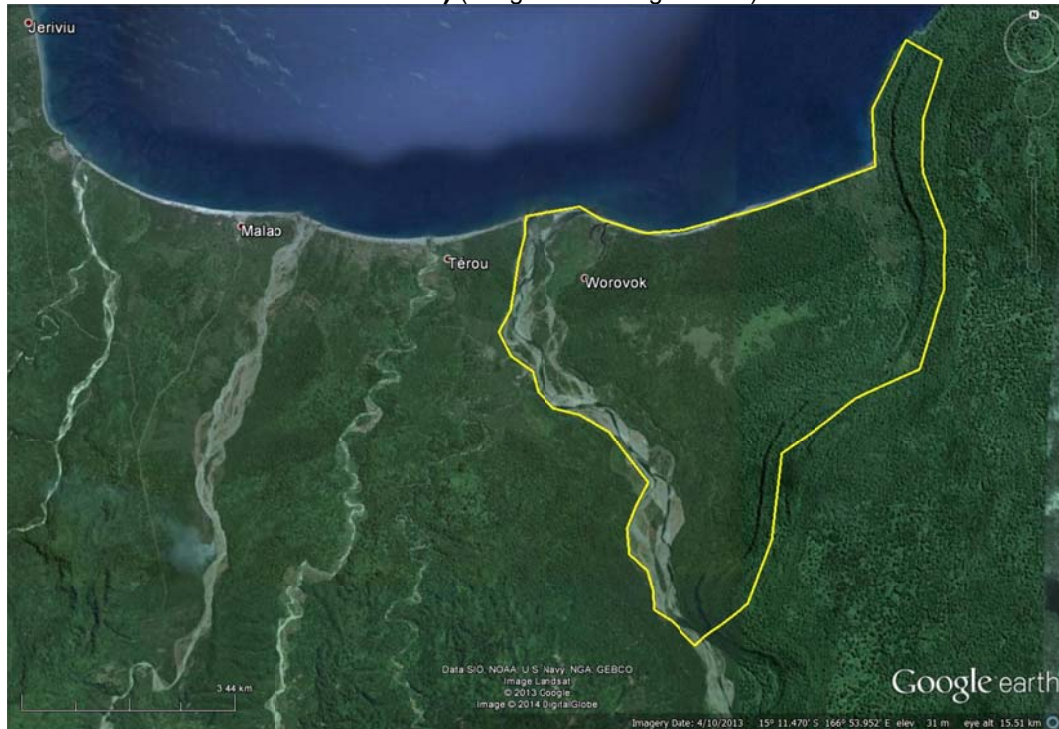
Jordan River, downstream view towards mouth (Photo: J. Terry)



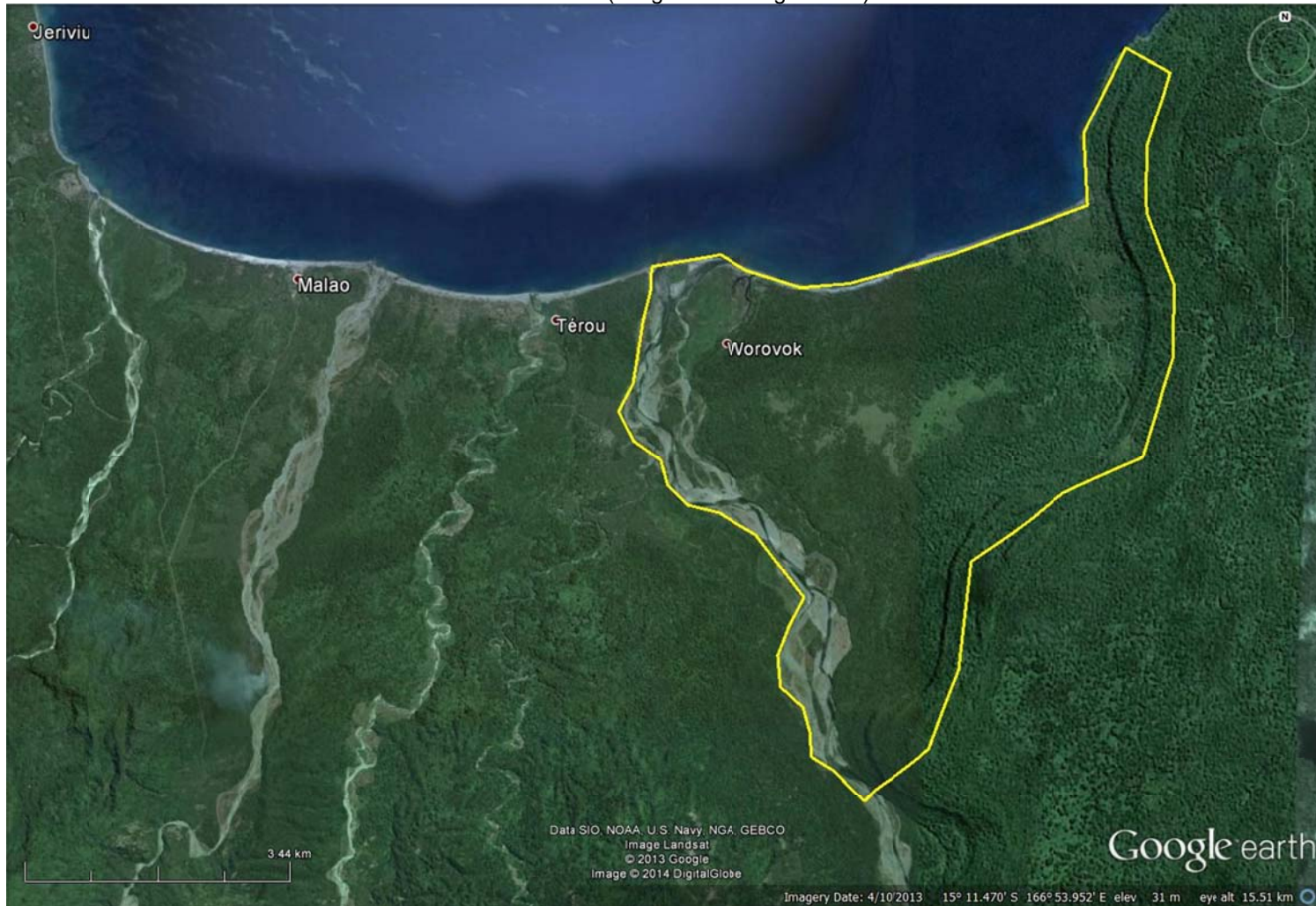
Location of Jordan River Lower Reaches and Floodplain Wetlands
(Image from Google Earth)



Jordan River; Lower Reaches and Floodplain: suggested site boundary (for discussion)
(Image from Google Earth)

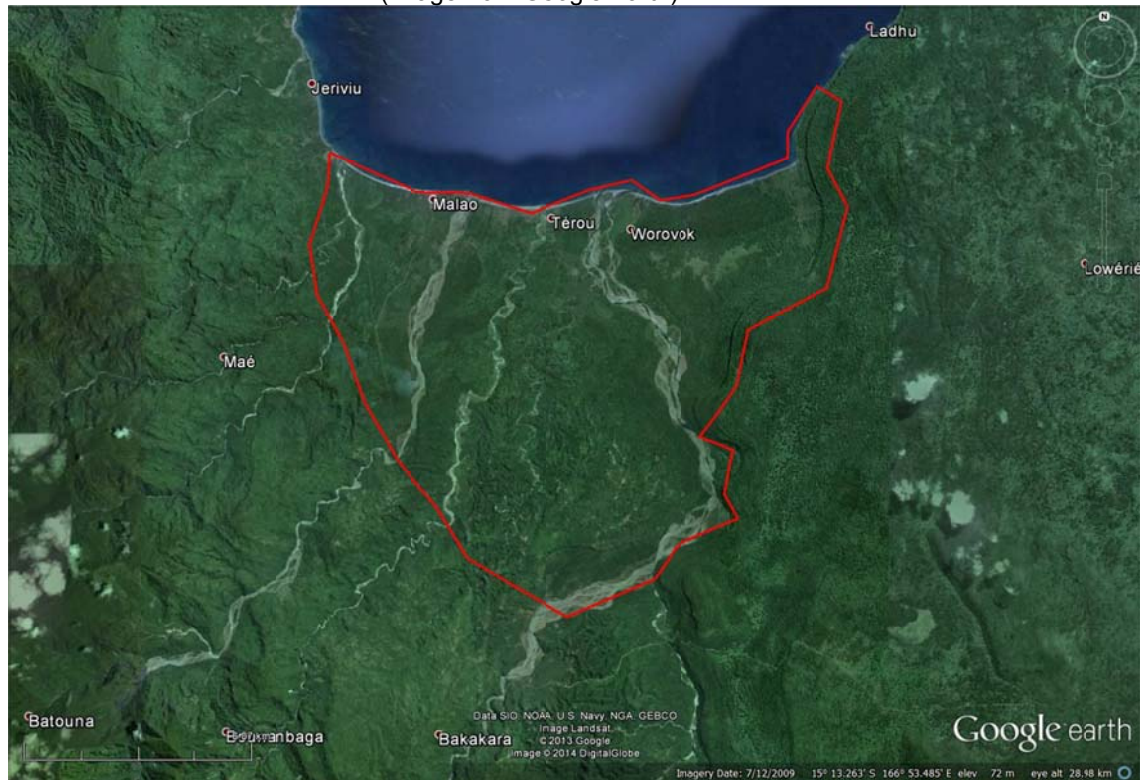


Jordan River; Lower Reaches and Floodplain: suggested site boundary (for discussion)
(Image from Google Earth)



Yellow line = inventory site boundary = boundary of Vathe Conservation Area

Potential extension of the inventory site boundary in the future
(Image from Google Earth)



Red line = potential extension of the inventory site boundary in the future.

G. Biogeographic region: Vanuatu Freshwater Ecoregion (Abell *et al.* 2008).

H. Climate:

The climate is humid tropical with a wet season extending from November to April. At Pekoa Airport near Luganville, in 2009 and 2010 the annual rainfall was measured as between 2,700 and 3,000 mm and mean annual temperature was about 25°C with monthly variation of only one or two degrees. Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil:

Alluvial deposits, including material of volcanic origin, underlie the Jordan River. Many of the swamp wetlands include decomposed organic matter, possibly classifiable as peat, in their substrate (L. Fatdal pers. com.) but this requires further investigation.

J. Water regime:

The Jordan River is a permanent river rising in the densely forested Tabwemasana Range to the south, which includes Vanuatu's highest mountain, Mount Tabwemasana (1,869 m). The river bed contains much sediment and the flow is fast. Apparently there is no tidal influx to the main river channel.

The floodplain east of the river contains seasonally inundated wetlands. The Matentas River is a much smaller stream, entering the sea against the escarpment. A number of other small streams occur on the floodplain but their regime is unknown.

Jordan River bed (Photo: J. Terry)



K. Water chemistry:

The Jordan River is freshwater. Freshwater swamps in the site are likely to have high organic content and thus may have a low pH.

L. Biota:

Swamp forest in the site is dominated by several trees: *Erythrina fusca*, *Barringtonia racemosa* and species of *Hibiscus*. Reeds, sedges, water lilies and other aquatic plants grow in the marshes, including in a pond behind the beach near the river mouth. Undisturbed humid tropical forest and cloud forest occur in the Jordan River catchment area to the south.

Dry swamp forest, Vatthe Conservation Area (Photo: S. Maturin)



Freshwater plants in a pond behind the beach (Photo: S. Maturin)



At least 21 species of crustaceans and 28 species of freshwater fishes occur in the site, based on surveys of the lower Jordan and Matentas Rivers (Keith *et al.* 2007). The fishes include three endemic to Vanuatu (see item R); the eel *Anguilla marmorata*; five species of *Microphis* and three species of *Kuhlia*. The crustaceans include seven species of *Macrobrachium* shrimp and five of *Caridina*. Other fishes in the Jordan River include bull sharks (D. Kalfatak pers. com., species not advised). The endangered coconut crab *Birgus latro*, a terrestrial species, occurs on the far NE coast of the VCA.

Waterbirds have been recorded in the site in small numbers; these include Purple Swamphen *Porphyrio porphyrio* and Eastern Reef Egret *Egretta sacra*.

The swamp forests are reported to be rich in bird life: about 80% of Vanuatu bird species are recorded from the VCA. Insectivorous bats roost in large numbers in caves on the escarpment.

M. Land use:

Within the site, subsistence fishing occurs in Jordan River, livestock grazing close to the villages, subsistence agriculture (gardening) in some areas, and coconut plantations in the far north-east of VCA. Land use has been zoned within the VCA.

Coconut plantations occur on the western side of the Jordan River, close to the river bank.

N. Pressures and trends:

Within the site, the invasive plant species *Merremia peltata* (a vine/creeper with large leaves) is widespread and has been partly controlled but remains a threat. A non-native plant described as 'water lettuce' occurs in some swamps near the river mouth and other changes to the vegetation are occurring there (L. Fatdal pers. com.). River bank erosion cliffs have occurred on the western bank of the River where coconut plantations exist and landslides cause soil to fall into the river. Cattle grazing causes soil compaction in some areas. A new village has established near the Jordan River mouth and water is harvested for drinking needs.

O. Land tenure and administrative authority:

Land tenure: customary ownership.

Administrative authority: The site is under the jurisdiction of the Department of Lands. Ownership questions are addressed by the Land Tribunal assisted by the island court.

Bank erosion, Jordan River (Photo: L. Fatdal)



P. Ramsar listed? No, Vanuatu is not yet a Contracting Party.

Q. Ramsar Criteria met:

Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

Criterion 3. Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

R. Justification for Ramsar Criteria met:

Criterion 1: The site is a good representative example of two wetland types found in the Vanuatu Freshwater Ecoregion: permanent river (wetland type M) and freshwater, tree-dominated wetlands (type Xf: includes freshwater swamp forests). The site has the largest area of swamp forest in the ecoregion and the only extensive floodplain.

Criterion 3: At least three of the freshwater fishes that are endemic to Vanuatu are known to occur in the site: *Schismatogobius vanuatuensis*, *Sicyopterus aiensis* and *Stiphodon astilbos* (Keith *et al.* 2007).

Note: It may be possible to compare the total number of freshwater fish species in Vanuatu and Santa Cruz Islands (thus in the applicable bioregion), with the number of such species (28) in Vathe CA. If that represents a significant proportion of the total then this is additional justification for Criterion 3.

It is possible that this site will meet additional criteria such as Criterion 4 (critical life stages) but more information is needed on how wetland animals use the site and the numbers of individuals involved.

Looking south-west across the floodplain forest (Photo: S. Maturin)



S. Conservation and management status of the wetland:

The site comprises the Vatthe Conservation Area (VCA), which was established in 2004. Vatthe CA is on the tentative list for World Heritage status.

T. Ecosystem services:

Food supply: The rivers and their floodplains support a rich subsistence fishery that has traditionally provided an important source of food for local people. Sustainable and regulated hunting of wild pigs and wild cattle occurs.

Water supply: Water for the eastern village (Matentas) is drawn from the Matentas River entering the sea nearby.

Tourism: Eco-tourism in VCA provides some income for local people.

Heritage: Some historical sites for European exploration lie in the VCA, e.g. DeQuiros Monument (an explorer who named Espiritu Santo). An old airstrip occurs in the NW of the site.

Carbon sink: The site's swamp forests act as a carbon sink.

U. Current recreation and tourism:

The VCA supports small-scale eco-tourism in harmony with the management plan. Accommodation is provided in Matentas village.

V. Existing scientific research:

Surveys of birds and plants were conducted in connection with establishment of the Conservation Area. In 2003, 2005 and 2007, surveys of freshwater biota led by French scientists were conducted in the site: in the eastern channel of the Jordan River 1.9 km upstream of the sea mouth; in the Matentas River near the sea mouth; and at two additional sub-sites (Keith *et al.* 2007).

W. Management plans and monitoring programs:

A management plan for VCA was registered in 2004 and a revision is near completion, for re-registration in 2014. The plan provides comprehensive zoning and rules. There is a non-fishing zone near the Jordan River mouth to protect fish stocks migrating into the river from the bay. A local management committee comprises local community members from two villages with people who have ownership of the area.

X. Current communication and public education programs:

Workshops and meetings on development of conservation areas in Vanuatu normally feature VCA as an example of an established and functioning conservation area.

Y. References cited:

- Abell, R., Thieme M., Revenga C. *et al.* 2008. Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *BioScience* 58, 403–414.
- Keith, P., Lord, C., Marquet, G., Gerbeaux, P. and Kalfatak, D. 2007. List of freshwater species recorded in the rivers of Vanuatu. Unpublished table of records.

Z. Compilers:

Original compilers (for 1993 edition): Ernest Bani.
Updated by: Donna Kalfatak, Lilly Fatdal and Roger Jaensch, May 2014.

3.5 Lake Wai Memea

A. Overview:

Lake Wai Memea is a small freshwater crater lake with some swamp vegetation.

B. Area, boundary and dimensions:

Area: 19.5 ha (polygon area using Google Earth Pro).

Boundary: the site boundary follows the rim of the crater in which the lake occurs.

C. Location:

Coordinates: 15°17'S, 167°59'E

The lake is at the extreme north-east tip of Ambae (Aoba) Island and is about 300 m long. It is 272 km north of Port Vila and lies 1.5 km east of Lake Wai Lembutaga and 350 m from the nearest ocean.

D. Site maps: See below.

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

E. Ramsar Wetland Types:

Tp: Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season.

Because the lake is under 8 ha in area it is not classed as a lake.

F. Geomorphic setting:

Elevation: 100 m.

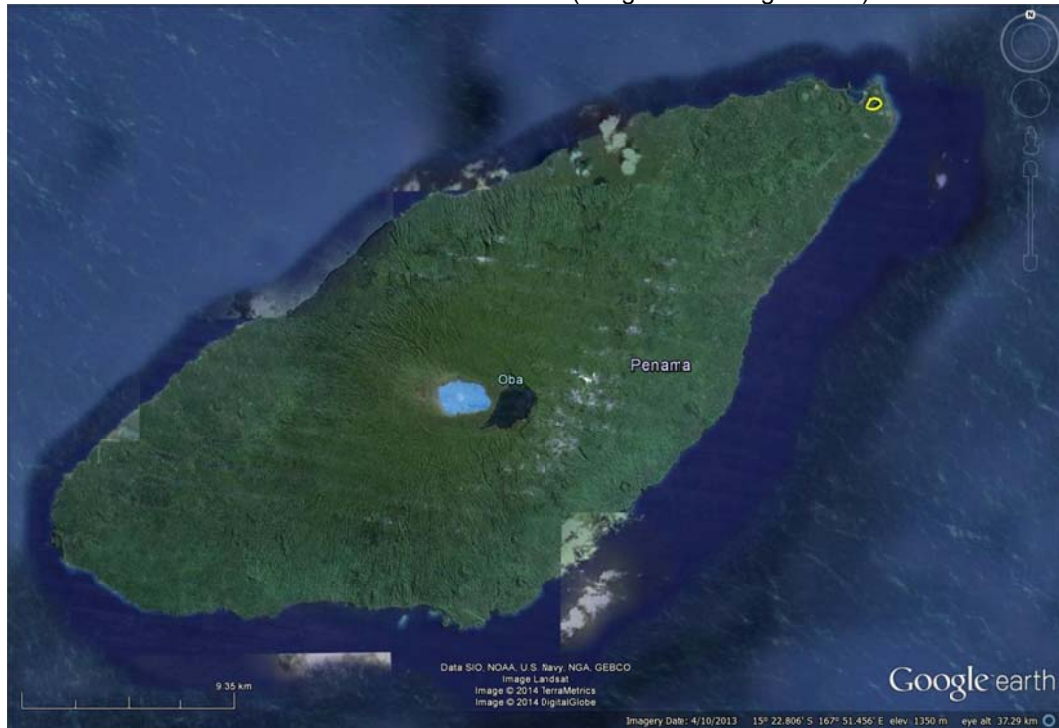
Lake Wai Memea is a permanent freshwater pond/lake formed in one of the eight interlocking craters near the north-eastern tip of Ambae Island. The crater is considered by Bullard (1962) to be a typical example of a phreatic cone where explosions resulting from the contact of hot lava with cold water have resulted in the accumulation of a rampart of cinders and ash in a wide ring around a large explosion crater.

G. Biogeographic region: Vanuatu Freshwater Ecoregion (Abell *et al.* 2008).

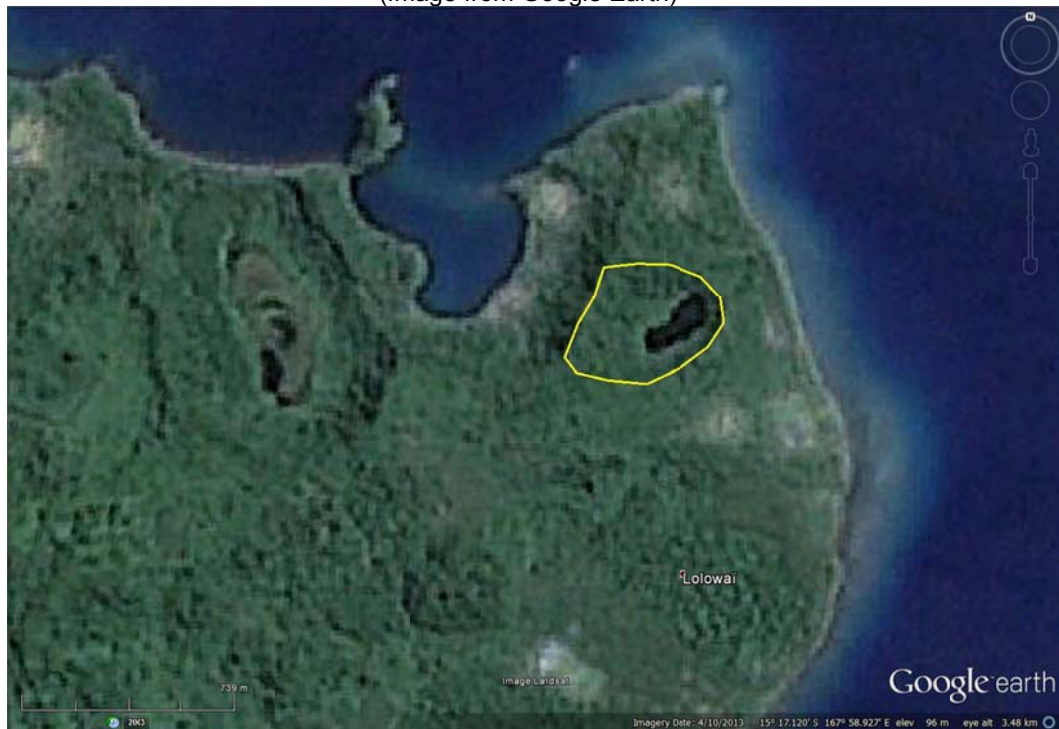
H. Climate:

The climate is humid tropical with a wet season extending from November to April. At Pekoa Airport near Luganville (85 km across land and sea, to the west), in 2009 and 2010 the annual rainfall was measured as between 2,700 and 3,000 mm and mean annual temperature was about 25°C with monthly variation of only one or two degrees. Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

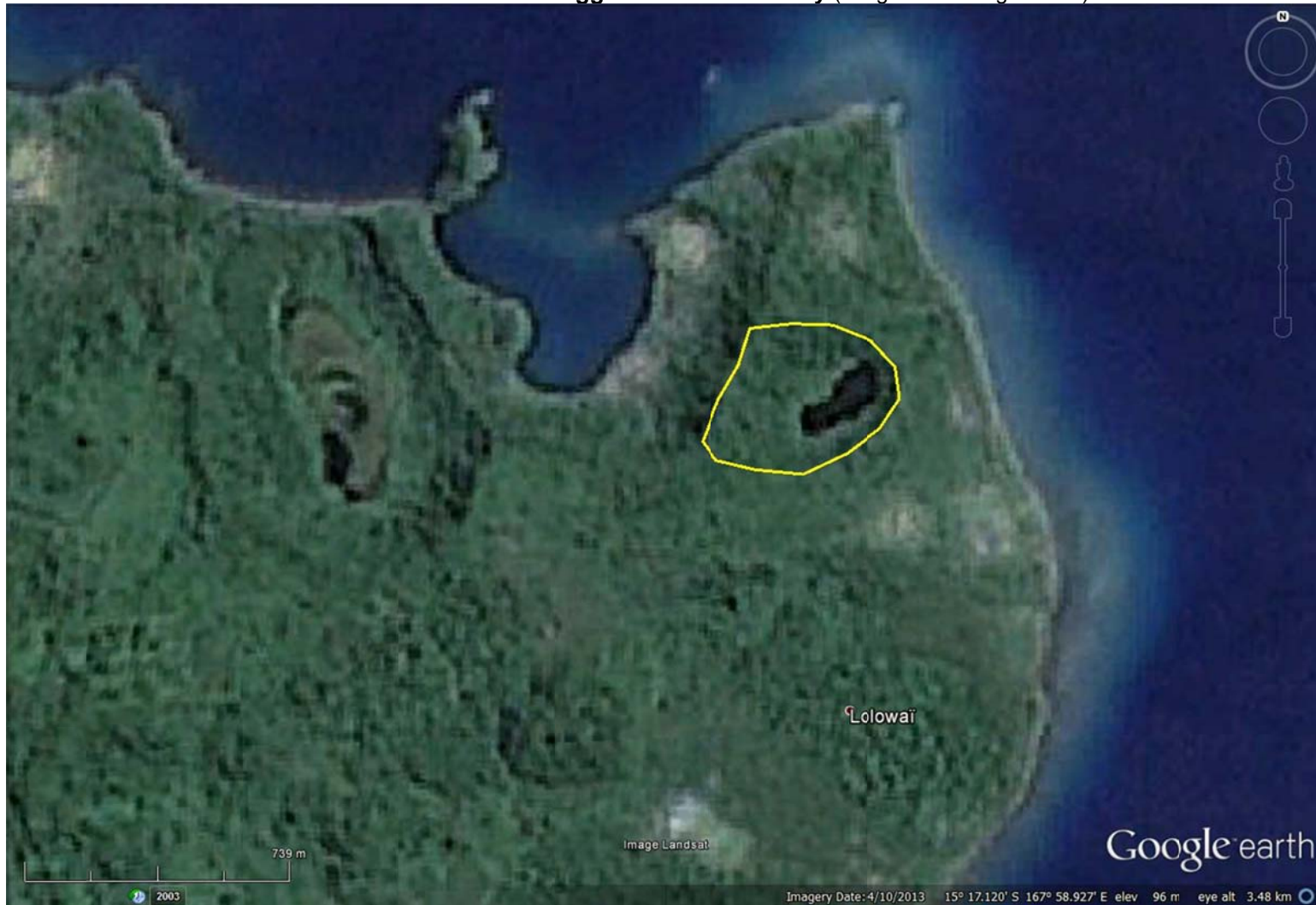
Location of Lake Wai Memea (Image from Google Earth)



Lake Wai Memea: suggested site boundary (for discussion)
(Image from Google Earth)



Lake Wai Memea: suggested site boundary (Image from Google Earth)



I. Soil: Soil is of volcanic origin.

J. Water regime:

The lake is permanent and is supplied only by local rainwater. There is no information on any outflow connection, surface or underground, to the sea but this seems less likely than in lakes elsewhere on limestone geology.

K. Water chemistry: Fresh water.

L. Biota:

Areas of open water are bordered by swamp vegetation with *Hibiscus tiliaceus* and sago palm *Metroxylon* sp. There are stands of nipa palm *Nypa fruticans* to the north of the lake, apparently within the site boundary; this is an unusual phenomenon as *Nypa* normally grows in intertidal situations such as estuaries.

According to the 1993 edition of the Directory, the lake is important for a subspecies of the Australasian Grebe *Tachybaptus novaehollandiae leucosternos*; ongoing occurrence can be inferred from recent oral interviews with local people (Z. Ayong pers. com.). No grebes were detected in a site visit to the lake in late April 2014 and local people advised that the 'wild duck' (possibly grebe) population is decreasing slowly (Z. Ayong pers. com.).

M. Land use:

The lake is used for water supply, hunting and fishing. Subsistence farming occurs in surrounding areas; the site is surrounded by human settlements and subsistence gardens, some gardens being as close as 50m from the lake boundary.

N. Pressures and trends:

The lake supports a large population of fish introduced in the 1960s; fishing occurs infrequently (Z. Ayong pers. com.). There is a considerable amount of hunting in the area, which may threaten local wildlife populations. Water has been pumped from the lake to Lolowai Hospital and the wider community in Saratamata (Penama Province HQ) (Z. Ayong pers. com.).

O. Land tenure and administrative authority:

Land tenure: Customary ownership.

Administrative authority: The lake is under the control of the Local Government Council.

P. Ramsar listed? No. Vanuatu is not yet a Contracting Party to the Convention.

Q. Ramsar Criteria met:

Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

R. Justification for Ramsar Criteria met:

Criterion 1: The site is a good representative example of a wetland type found in the Vanuatu Freshwater Ecoregion: permanent freshwater marshes/pools and ponds (Type Tp). It is a good example of a freshwater crater lake/pond in a phreatic cone.

Note: Procurement of count data on grebes occurring on the lake may allow testing against Criterion 6. The Australasian Grebe subspecies *Tachybaptus novaehollandiae leucosternos* is endemic to Vanuatu and New Caledonia and has a small population size (Wetlands International 2014). Relatively small numbers (a few tens, or less) might ensure Criterion 6 is met and such numbers are quite possible on this lake.

S. Conservation and management status of the wetland: No information.

T. Ecosystem services:

Water supply: The lake is a source of good quality water, unaffected by any siltation problems; it constitutes a water supply for the surrounding communities, schools, a hospital and the local government centre. Supply is sometimes halted due to equipment failure, as occurred in early 2014 (Z. Ayong pers. com.).

Recreation: The site is popular for recreational fishing.

U. Current recreation and tourism:

The site has considerable potential for outdoor recreation. Tourists sometimes visit the lake when sailing boats moor at Lolowai Harbour but this is not systematically managed.

V. Existing scientific research: No information.

W. Management plans and monitoring programs:

There is no proper management in place to protect and monitor the lake. Visits by tourists inside the lake boundary, though infrequent, do not necessarily have the approval of the relevant customary land owner (Z. Ayong pers. com.).

X. Current communication and public education programs: No information.

Y. References cited:

- Abell, R., Thieme M., Revenga C. *et al.* 2008. Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *BioScience* 58, 403–414.
- Bullard, F.M. 1962. *Volcanoes in History, in Theory Eruption*. University of Texas Press.
- Wetlands International 2014. *Waterbird population estimates; 5th edition*. Online at <http://wpe.wetlands.org/> accessed 27 March 2014.

Z. Compilers:

Original compiler (for 1993 edition): Ernest Bani and David Esrom.
Updated by: Donna Kalfatak, Zoe Ayong and Roger Jaensch, May 2014.

3.6 Lake Wai Lembutaga

A. Overview:

Lake Wai Lembutaga is a small, freshwater crater lake with extensive beds of papyrus sedge.

B. Area, boundary and dimensions:

Area: 69.5 ha (polygon area using Google Earth Pro).

The site boundary follows the rim of the crater in which the lake occurs. The lake is about 700 m long.

C. Location:

Coordinates: 15°17'S, 167°58'E

Near the north-east tip of Ambae (Aoba) Island; the lake is 273 km north of Port Vila and 1.5 km west of Lake Wai Memea.

D. Site maps: See below.

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

E. Ramsar Wetland Types:

Tp: Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season.

Although the lake basin is over 8 ha in area, it is mostly marsh (papyrus sedge *Cyperus papyrus*) which is Type Tp; the dominance of papyrus was confirmed during a site visit in late April 2014 (Z. Ayong pers. com.). The remaining small area of open water is under 8 ha and thus is also Type Tp.

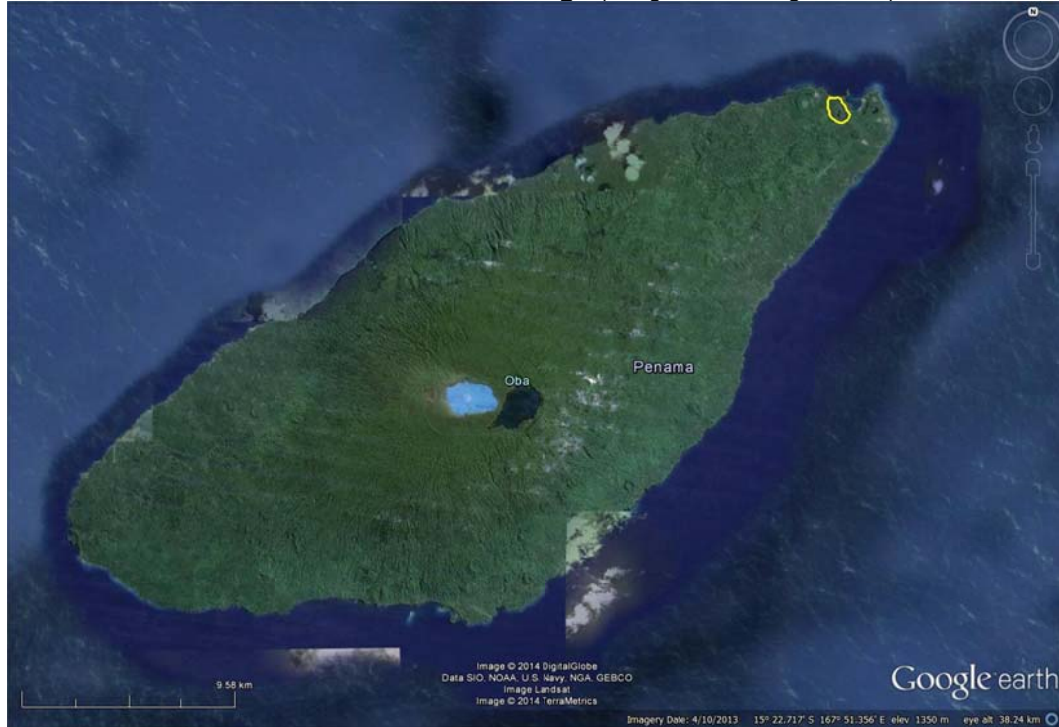
F. Geomorphic setting:

Elevation: 2 m.

Lake Wai Lembutaga is a permanent freshwater lake formed in a phreatic explosion crater near the eastern end of Ambae Island. The cone or tuff ring contains a crater about 914 metres in diameter with steep walls up to 91 metres in height. This type of structure is considered by Bullard (1962) to be typical of phreatic cones where explosions resulting from a contact of hot lava with cold water have resulted in the accumulation of a rampart of cinders and ash in a wide ring round a large explosion crater. The lake is situated in one of the eight interlocking craters of this type at the eastern end of the island (Bullard 1962; Ward 1970).

G. Biogeographic region: Vanuatu Freshwater Ecoregion (Abell *et al.* 2008).

Location of Lake Wai Lembutaga (Image from Google Earth)



Lake Wai Lembutaga: suggested site boundary (for discussion)
(Image from Google Earth)



Lake Wai Lembutaga: suggested site boundary (for discussion) (Image from Google Earth)



H. Climate:

The climate is humid tropical with a wet season extending from November to April. At Pekoa Airport near Luganville (85 km across land and sea, to the west), in 2009 and 2010 the annual rainfall was measured as between 2,700 and 3,000 mm and mean annual temperature was about 25°C with monthly variation of only one or two degrees. Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil: Soil is of volcanic origin.

J. Water regime:

The lake is permanent. There is no obvious connection to the sea although seepage of fresh water on the shores of nearby Lolowai Harbour is locally attributed to this lake (Z. Ayong pers. com.).

K. Water chemistry: Fresh water.

L. Biota:

Two-thirds or more of the lake surface is covered with papyrus *Cyperus papyrus*, based on a Google Earth image dated October 2013 and confirmed by a site visit in late April 2014 (Z. Ayong pers. com.). Papyrus is not an indigenous plant of Vanuatu and thus must have been introduced to the lake. The vegetation around the lake is secondary forest communities and shrubs.

According to local sources, fish were introduced to the lake by the first people to start gardening near the lake; as these were saltwater fishes, several reintroductions were made before populations of fish persisted (Z. Ayong pers. com.).

According to the 1993 edition of the Directory, the lake is important for a subspecies of the Australasian Grebe *Tachybaptus novaehollandiae leucosternos*. A brief site visit in late April 2014 confirmed at least 20 waterbirds, possibly grebes, were present on the north side of the lake (Z. Ayong pers. com.).

M. Land use:

Some hunting and fishing still occurs in the lake and during rainy weather (presumably, unsuitable for boating at sea) 'wild duck' are hunted on the lake (Z. Ayong pers. com.).

Subsistence agriculture and forestry plantation occur in surrounding areas; gardening is as close as 5 m and plantations are about 300 m from the lake edge (Z. Ayong pers. com.). Cattle ranching occurred in the past but is no longer active.

N. Pressures and trends:

In the past, excessive use of water for domestic supply (neighbouring high school) and road construction along the escarpment towards the coast, put pressure on the lake; present water use is only for adjacent gardens (Z. Ayong pers. com.). Mud has flowed into the lake from roadworks nearby. Native forests nearby have been cleared for forestry plantations. Subsistence agriculture occurs as close as 5m from the lake edge; 'water taro' has been introduced from Maewo Island to gardens on the 'lake plain' (Z.

Ayong pers. com.). Garbage is being dumped by surrounding communities into a ravine in the lake's catchment slope.

O. Land tenure and administrative authority:

Land tenure: Customary ownership. Adjacent areas are leased to Vureas High School (a Government school).

Administrative authority: The site is under the jurisdiction of the Department of Lands. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed? No. Vanuatu is not yet a Contracting Party to the Convention.

Q. Ramsar Criteria met:

Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

R. Justification for Ramsar Criteria met:

Criterion 1: The site is a good representative example of a wetland type found in the Vanuatu Freshwater Ecoregion: permanent freshwater marshes/pools and ponds (Type Tp). The lake differs in its geological origins from other crater lakes on the island.

Note: Procurement of count data on grebes occurring on the lake may allow testing against Criterion 6. The Australasian Grebe subspecies *Tachybaptus novaehollandiae leucosternos* is endemic to Vanuatu and New Caledonia and has a small population size (Wetlands International 2014). Relatively small numbers (a few tens, or less) might ensure Criterion 6 is met and such numbers are quite possible on this lake.

S. Conservation and management status of the wetland:

The Provincial Government has been trying to form a community group to look after the lake but this has not yet been successful, partly due to communication difficulties (Z. Ayong pers. com.). Consequently, there is no management plan or strategy for the lake.

T. Ecosystem services:

Water supply: previously used by a nearby Junior Secondary School.
Cultural values: the lake has some cultural significance to the local people

U. Current recreation and tourism:

Tourists sometimes visit the lake when sailing boats moor at Lolowai Harbour but this is not systematically managed.

V. Existing scientific research: No information.

W. Management plans and monitoring programs: No information.

X. Current communication and public education programs:

There is no communication or public education program for the site. Knowledge of the site is carried only at the individual or family level. There has been some discussion about water quality impacts of soil washing into the lake from roadworks adjacent to the site.

Y. References cited:

- Abell, R., Thieme M., Revenga C. *et al.* 2008. Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *BioScience* 58, 403–414.
- Bullard, F.M. 1962. *Volcanoes in History, in Theory Eruption*. University of Texas Press.
- Ward, A.J. 1970. Evolution of Aoba Caldera Volcano, New Hebrides. Francesco Gianni and Figli, Napoli, Italy. Reprinted from *Bulletin Volcanologique*, Tome XXXIV,1.
- Wetlands International 2014. Waterbird population estimates; 5th edition. Online at <http://wpe.wetlands.org/> accessed 27 March 2014.

Z. Compilers:

Original compiler (for 1993 edition): Ernest Bani.
Updated by: Donna Kalfatak, Zoe Ayong and Roger Jaensch, May 2014.

3.7 Ambae Caldera Lakes

A. Overview:

The Ambae Caldera Lakes comprise a caldera lake and two crater lakes surrounded by dense virgin forests at high altitude within the active volcano of Ambae Island.

B. Area, boundary and dimensions:

Area: Lake Manaro Ngoru, 15 ha; Lake Vui, 150 ha; Lake Manaro Lakua, 170 ha.
Total area of site: 1,025 ha. (Polygon areas using Google Earth Pro).

The boundary of the site follows the outer rim of the craters containing the lakes.

C. Location:

Coordinates:

Lake Manaro Ngoru	15°23'S, 167°48'E
Lake Vui	15°23'S, 167°50'E
Lake Manaro Lakua (Gesa)	15°23'S, 167°51'E

In the centre of Ambae (Aoba) Island in northern Vanuatu; 264 km north of Port Vila.
Distance to the coast from either side of the site is about 6-7 km.

Province: Torba

D. Site maps: See below.

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

E. Ramsar Wetland Types:

O: permanent lake.
Zg: geothermal wetlands.

F. Geomorphic setting:

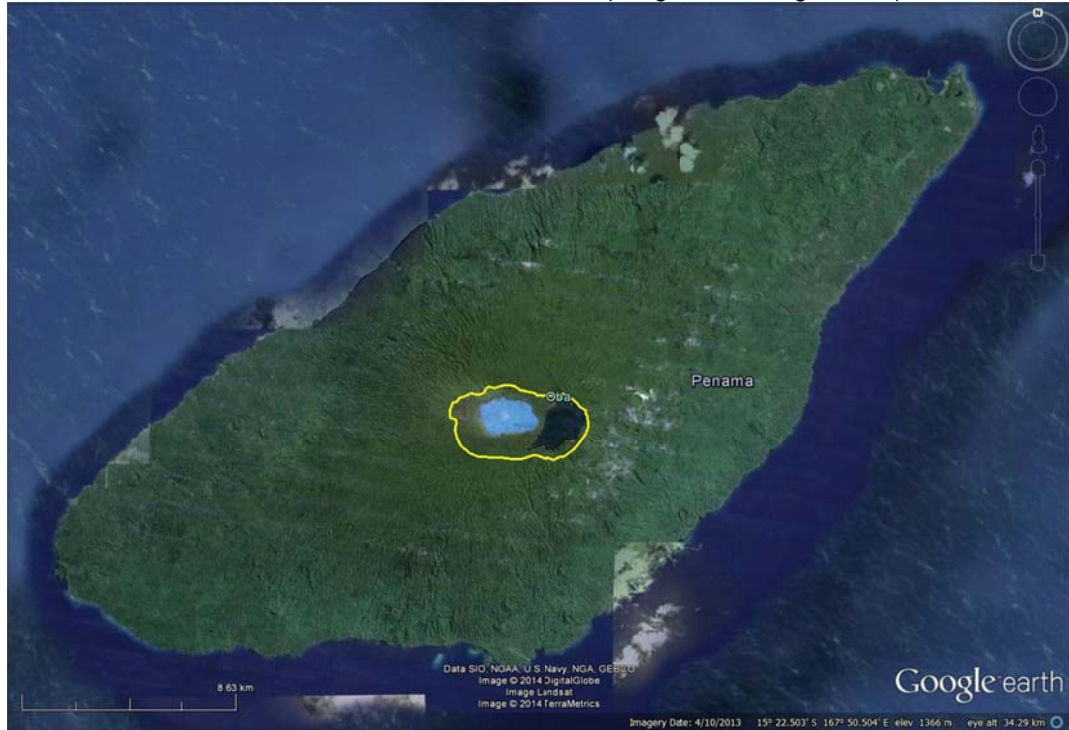
Elevation:

Lake Manaro Ngoru	1,391 m
Lake Vui	1,340 m
Lake Manaro Lakua	1,397 m
Summit of crater rim	1,496 m

Lake Vui and Lake Manaro Ngoru are situated in young craters formed within the inner caldera. It is not certain if Lake Vui, the larger of the two, was formed within the summit crater of a broad cone filling the centre of the inner caldera or in a third and smaller caldera (Ward, 1979). The Manaro Ngoru crater has a floor one kilometre in diameter, which at times is covered by a temporary lake surrounded by a low rampart of pyroclastics abutting against the caldera wall along its western margin. It probably represents an explosion crater. Lake Manaro Lakua lies in a third crater, to the east of Lake Vui. The presence of well-sorted, bedded, commonly cross-bedded tuffs deposited in or reworked by Lake Manaro Lakua indicates that the water once stood 100-150 metres above its present level. The tuffs occur in islands and along the crater walls.

Conversely, a fringe of partly submerged trees along the western edge of the lake shows that it recently stood at a lower level (Ward, 1970). Thermal areas exist on the southeast side of Lake Manaro Lakua and on the bed of Lake Vui. These include hot springs, geysers and fumaroles.

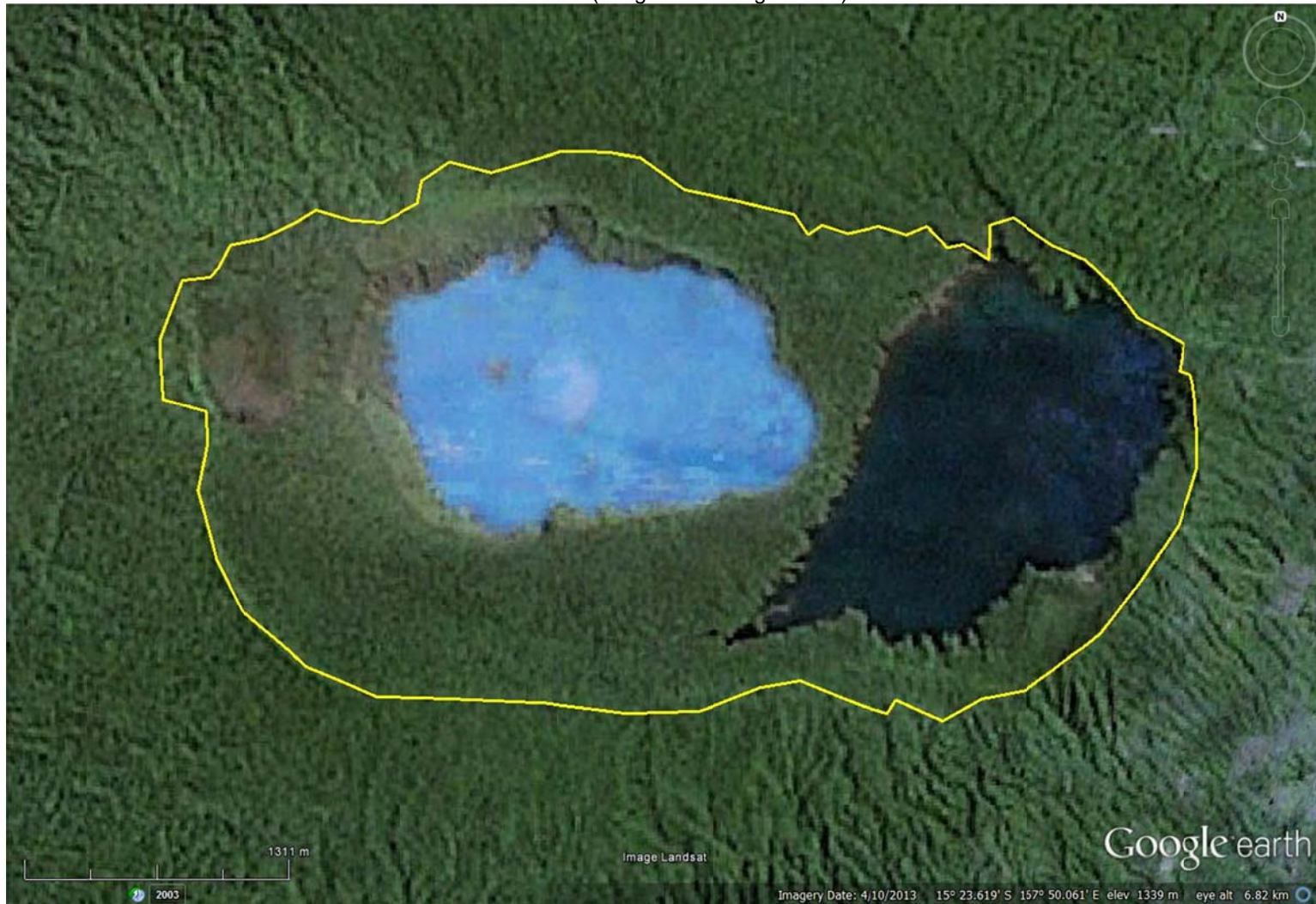
Location of Ambae Caldera Lakes (Image from Google Earth)



Ambae Caldera Lakes: suggested site boundary (for discussion)
(Image from Google Earth)



Ambae Caldera Lakes: suggested site boundary (for discussion)
(Image from Google Earth)



G. Biogeographic region: Vanuatu Freshwater Ecoregion (Abell *et al.* 2008).

H. Climate:

The climate is humid tropical with a wet season extending from November to April. At Pekoa Airport near Luganville (70 km across land and sea, to the west), in 2009 and 2010 the annual rainfall was measured as between 2,700 and 3,000 mm and mean annual temperature was about 25°C with monthly variation of only one or two degrees. Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil: Soil is of volcanic origin.

J. Water regime:

Lake Manaro Ngoru is dry most of the time; Lakes Vui and Manaro Lakua are dry for about half of the year and inundated for the other half of the year (local advice to Z. Ayong, April 2014). Also see: Geomorphologic setting.

K. Water chemistry:

The water of Lake Vui has a bitter taste and a distinctive green colour. Similar discolouration is often seen in the sea around Vanuatu where fumaroles occur on the summits of submarine volcanoes.

L. Biota:

No information is available on the aquatic vegetation.

The lakes are surrounded by dense, pristine, montane rain forest with endemic orchids and a very rich flora. A recent investigation discovered three new species of orchids for Vanuatu, *Agrostophyllum cf. torricellense*, *Dendrobium kietaense* and *Bulbophyllum microrhombos*, and a species of *Peristylus* unknown to science (Wheatley 1989). This forest gives way to moss forest above 1,350 m.

According to the 1993 edition of the Directory, Lake Manaro Lakua is an important site for the Australasian Grebe *Tachybaptus novaehollandiae leucosternus* and green frogs; these animals still occur at the site (Z. Ayong pers. com.). There are no fish in the lakes.

M. Land use:

There is no land use at the site because of its high altitude, with villages being located near the coastline; there are no permanent residents near the site (Z. Ayong pers. com.).

N. Pressures and trends: No threats from human activity at present.

O. Land tenure and administrative authority:

Land tenure: Customary ownership.

Administrative authority: The site is under the jurisdiction of the Ambae/Maewo Local Government Council and the Department of Lands. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed? No. Vanuatu is not yet a Contracting Party to the Convention.

Q. Ramsar Criteria met:

Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

R. Justification for Ramsar Criteria met:

Criterion 1: The site is a good representative example of wetland types found in the Vanuatu Freshwater Ecoregion: permanent freshwater lake (wetland type O) and geothermal wetlands (Zg). These three interesting crater lakes in a region of thermal activity are the highest lakes in the island Pacific outside of New Guinea.

Note: Procurement of count data on grebes occurring on the lakes may allow testing against Criterion 6. The Australasian Grebe subspecies *Tachybaptus novaehollandiae leucosternos* is endemic to Vanuatu and New Caledonia and has a small population size (Wetlands International 2014). Relatively small numbers (a few tens, or less) might ensure Criterion 6 is met and such numbers are quite possible on this relatively large lake.

S. Conservation and management status of the wetland:

Government, local government centres and customary land owners have discussed the possibility of declaring the area Public Land and establishing a protected area, but a conclusion has not been reached. The lakes were identified as a site suitable for protection by the Tourism Council of the South Pacific (TCSP, 1990).

T. Ecosystem services:

Spiritual/Cultural values: The lakes are of considerable cultural importance to the people of Ambae who believe that spirits of the dead reside there. Taboo stones are present in Lake Manaro Gesa and weapons of two mythical characters are said to be concealed in the bottom of this lake (Z. Ayong pers. com.).

U. Current recreation and tourism:

There is a greater level of tourist visitation to this site than to Lakes Wai Memea and Lembutaga (Z. Ayong pers. com.).

V. Existing scientific research:

The lakes were surveyed by the Department of Mines, Minerals and Rural Water Supply in 1969 and by the Department of Physical Planning and Environment in 1988. Monitoring is conducted at the three lakes by the Vanuatu Meteorological and Geohazards Department (VMGD).

W. Management plans and monitoring programs: No information.

X. Current communication and public education programs:

The Vanuatu Meteorological and Geo-hazards Department occasionally conducts awareness activities for the residents of Ambae.

Y. References cited:

- Abell, R., Thieme M., Revenga C. *et al.* 2008. Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *BioScience* 58, 403–414.
- TCSP. 1990. Guidelines for the Integration of Tourism Development and Environmental Protection in the South Pacific. Tourism Council of the South Pacific, Suva, Fiji.
- Ward, A.J. 1970. Evolution of Aoba Caldera Volcano, New Hebrides. Francesco Gianni and Figli, Napoli, Italy. Reprinted from *Bulletin Volcanologique*, Tome XXXIV, 1.
- Wetlands International 2014. Waterbird population estimates; 5th edition. Online at <http://wpe.wetlands.org/> accessed 27 March 2014.
- Wheatley, J. 1989. Report of the Ambae Caldera Expedition.

Z. Compilers:

Original compiler (for 1993 edition): Ernest Bani.
Updated by: Donna Kalfatak, Zoe Ayong and Roger Jaensch, May 2014.

3.8 Port Stanley, Bushman Bay and Crab Bay

A. Overview:

The site is a complex of mangrove forests, tidal lagoons, coral reef flats and associated salt marshes and mudflats in three bays along the north-east coast of Malekula Island. It is important for subsistence fisheries and has one of the two largest stands of mangroves in Vanuatu.

B. Area, boundary and dimensions:

Area: 4,132 ha. As originally described, the site included 963 ha of mangrove forest.

The boundary of the site starts at the jetty at Litslits village, follows the high water mark southwards almost to Sarmette village; then returns northwards along the outer edge of the coral reef flats to the northern tip of Uri Island; thence across the bay back to Litslits. The site therefore includes large parts of Port Stanley (bay) and Bushman Bay, the Amal – Crab Bay Conservation Area, the Narong Marine Conservation Area, and various islands and minor bays.

Note: Coordinates in the original 1993 Directory account showed the site extending 5-8 km northwards to beyond the northern end of Port Stanley. However, due to the small area of mangrove and considerably more urban development in that sector, that part has now been excluded.

The largest contiguous stand of mangroves (560 ha) occurs in the Port Stanley embayment and along the shores of the adjoining Botun Bay. There are a further 72 ha on the island of Uri and 24 ha on the island of Taikata, at the entrance to Port Stanley bay. Farther south-east along the coast, there is a large patch of mangroves totalling 275 ha along the north-east coast of Bushman Bay (25 ha) and along the entire coast of the adjoining Crab Bay (250 ha).

C. Location:

Coordinates: Site limits:	16°05'-10'S, 167°26'-33'E
Port Stanley	16°06'S, 167°27'E
Bushmans Bay	16°09'S, 167°30'E
Crab Bay	16°10'S, 167°31'E

On the north-east coast of Malekula Island, 198 km north of Port Vila and 3-16 km south-east of Lakatoro.

Province: Malampa. (Central Area Council, Malekula)

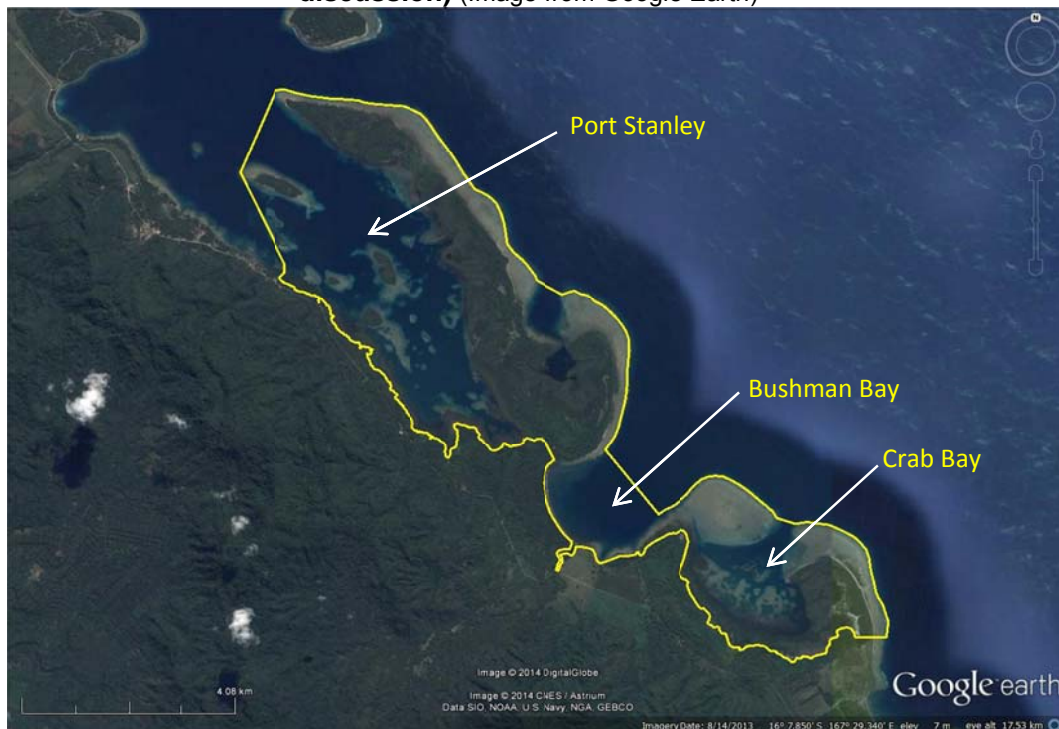
D. Site Maps:

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

Location of Port Stanley, Bushman Bay and Crab Bay
(Image from Google Earth)



Port Stanley, Bushman Bay and Crab Bay: suggested site boundary (for discussion) (Image from Google Earth)



Port Stanley, Bushman Bay and Crab Bay: suggested site boundary (for discussion)
(Image from Google Earth)



E. Ramsar Wetland Types:

- A: Permanent shallow marine waters.
- I: Intertidal forested wetlands (mangrove swamps).
- F: Estuarine waters.
- G: Intertidal mud, sand or salt flats.
- E: Sand shores.
- H: Intertidal marshes; includes salt marshes.
- B: Marine subtidal aquatic beds (sea-grass beds, tropical marine meadows).
- C: Coral reefs.

Crab Bay mangroves (Photo: D. Kalfatak)



F. Geomorphic setting:

Elevation: Sea level.

The Port Stanley – Crab Bay area is situated on a coralline reef platform. Port Stanley and Crab Bay are sheltered from the ocean by peninsulas and include small islands whereas Bushman Bay is open to the ocean.

G. Biogeographic region: Vanuatu Marine Ecoregion (Spalding *et al.* 2007).

H. Climate:

The climate is humid tropical with a wet season extending from November to April. At Lamap (45 km to the south-east) in 2009, 2010 and 2012 (= recent years of complete records), the mean annual rainfall was measured as 2,317 mm whereas an older (1993) source gives average annual rainfall of 1,638 mm at Port Stanley. Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil:

Sediments in the bays are of volcanic/alluvial origins. Sand on beaches is of coralline origin.

J. Water regime: No information.

K. Water chemistry:

The site is dominated by marine salt water. Freshwater inflows directly to the site occur through at least two creeks: the larger, entering Bushman Bay, and a smaller creek entering just south of Litslits.

L. Biota:

The site contains one of the two largest stands of mangroves in Vanuatu. Three zones have been identified in the mangrove vegetation: an inner zone of *Ceriops tagal* thickets with mangrove fern *Acrostichum aureum*; a *Rhizophora* forest zone dominated by *R. mucronata* and *R. stylosa*; and a seaward forest zone of *Avicennia marina* with a few scattered *Sonneratia caeseolaris* and *Bruguiera* sp.

Seagrass beds occur in Port Stanley.

The mangroves support a diverse invertebrate and fish fauna including numerous species of molluscs, crustaceans, polychaetes and finfish. Of the 20 or so crustaceans recorded from the area, only the crabs *Cardiosoma hirtipes* and *Scylla serrata* are regularly harvested for local consumption and export to Port Vila. The Crab Bay component of the site is known for its high abundance of crabs.

There is still an apparently healthy population of dugong *Dugong dugon* in the area. A species of flying fox (*Pteropus* sp. endemic to Vanuatu) occurs in the mangroves.

Waterbirds using the site include Whimbrel *Numenius phaeopus*, (especially in the Conservation Area beside Uri Island), smaller shorebirds and Striated (Mangrove) Heron *Butorides striata* and Eastern Reef Egret *Egretta sacra*.

M. Land use:

Subsistence fishing and collection of invertebrates (crabs, bivalves, cone-shaped shellfish) occurs. Harvesting of mangroves for building materials, livestock fencing and fuel wood. Ecotourism has started. Further details under item T.

In adjacent areas, coconut and cocoa plantations, cattle grazing and subsistence agriculture occur and limestone is quarried for road building.

N. Pressures and trends:

Minor impacts have occurred or are occurring in localised areas. There is some encroachment into mangroves by the small human settlements scattered throughout the area. A commercial wharf was built in the area in 1987 at Litslits for inter-island trading vessels; this involved the building of a causeway through the mangroves in Port Stanley bay and clearing of two or three hectares. Discharge of wastewater into the bay from the urban area is a concern. Some mangrove is cut in the channel at Uri Island to optimise water flow.

O. Land tenure and administrative authority:

Land tenure: Customary ownership, including mangroves and reef flats. Some small areas are leased, including in Crab Bay. The village on Uri island is included in the site.

Administrative authority: Jurisdiction of mangrove areas is subject to proposed amendments to Vanuatu legislation but involves the Department of Lands, Department of Fisheries, Department of Forestry and Department of Environment. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed? No. Vanuatu is not yet a Contracting Party to the Convention.

Q. Ramsar Criteria met:

- Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
- Criterion 4. Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
- Criterion 8: The streams, mangroves, lagoons and reefs of the site provide substantial stocks of fish and other marine resources on which local people depend.

R. Justification for Ramsar Criteria met:

- Criterion 1: The site is a good representative example in the Vanuatu Marine Ecoregion of an integrated system comprising several coastal wetland types: coral reefs (Type C), marine lagoons and bays (Type A), seagrass beds (Type B) and mangrove forest (Type I). The site includes one of the two largest areas of mangrove in Vanuatu.
- Criterion 4: The site includes mangrove forests that are vital nursery areas for marine animals (fishes, prawns) and seagrass areas that are vital feeding areas for turtles and dugongs.
- Criterion 8: The extensive wetlands of the site support stocks of fish and other marine resources that local people depend on for their own consumption and for some income.

S. Conservation and management status of the wetland:

Conservation measures taken:

- Amal – Crab Bay Conservation Area (ACBCA) (area = over 150 ha?).
- Uri Marine Conservation Area (160 ha); established in 1991.

Sixteen villages (about 1500 people) have collaborated to protect the ACBCA: 14 on the main island and two on smaller islands including Uri. ACBCA started as the Amal-Krabbei Tabu Eria in 2002 in response to overharvest of land crab *Cardiosma carnifex* following transition to a cash economy in Vanuatu in the 1990s. It has been supported through the International Waters Project (2003), project activities of agencies such as Fisheries (2003; shellfish spawning), training of community volunteers (5 methods of baseline data collection), and the MESCAL project (Mangrove Ecosystem for Climate Change and Livelihoods) of IUCN. It is managed by a committee, which has set visitor fees and rules (enforceable by the police) and extended the regulations effective to 2016.

The Resource Management Initiative of the Amal-Crab Bay Community won the Equator Prize in 2006. This recognised achievements in: an increase in coastal resources (400% increase in land crab sales 2005-2010); an enhanced evidence base for the mangroves; improved local management capacity; ecotourism infrastructure (visitor information centre); and national and international recognition. Learning from ACBCA has impacted policy in Vanuatu and regionally.

One family on Uri Island has established the Uri Marine Conservation Area, within which collection or damage of all marine resources is prohibited under traditional rules.

Mangrove forests are protected from commercial exploitation by the Government. Local community chiefs can apply closures on hunting and fishing in the mangroves if considered appropriate.

There is some interest, especially among the Litslits community, in additional protected areas within this large wetland site.

T. Ecosystem services:

Nursery for commercial and subsistence fisheries. In Crab Bay there are 300 fishermen from 160 households (Pascal and Bulu 2013). Mangrove crabs caught in the mangroves of the site are sold to restaurants in Port Vila and Luganville, though rather few households are involved.

Food supply: fish and other marine food; a source of protein for local people.

Materials: timber for door and fence posts, house rafters, garden stakes.

Fuelwood: from the mangroves.

Medicines: traditional, from mangroves.

Coastal protection from storms.

Nutrient cycling: food chain support.

Carbon sink: sequestration by mangrove forests and sea grass.

Mangrove ecosystems in Crab Bay (137 ha) in 2012 produced an economic value of Vatu 53 M (min. 36 M, max. 70 M) (= USD 586,000), equivalent to USD 4300 per ha per year (Pascal and Bulu 2013). The principal ecosystem services in economic terms were the value of carbon sequestered (71%) and proteins from subsistence fishery (17%).

U. Current recreation and tourism:

Visits by small numbers of tourists are made to both Conservation Areas; there is an information centre in the ACBCA. Yachts moor in Crab Bay where there is a deep water access point to the land. Visitors pay fees to the committee of the ACBCA.

V. Existing scientific research:

- The MESCAL project (German Government funded via IUCN) conducted research at ACBCA including a study on the economic valuation of mangrove ecosystem services (e.g. Pascal and Bulu 2013).
- Crab Bay was a site included under the GEF International Waters program (via SPREP).
- Several other surveys and studies have been carried out in the area, particularly with respect to the species composition of the mangroves and utilization of mangrove resources.

W. Management plans and monitoring programs:

A management plan for ACBCA was launched in 2013. Some monitoring is included in the plan, especially on resource use. The MESCAL project has supported the management planning process; including accurate surveying of the boundary of the ACBCA. A project to assist local people to self-monitor harvest and selling of crabs is being supported by Japan (JICA).

X. Current communication and public education programs:

National, provincial and community level awareness campaigns have been conducted in regard to mangrove (natongtong) in Vanuatu. A general poster has been disseminated. A video was produced under the GEF International Waters project, for Amal – Crab Bay site. Workshops were conducted with all 16 communities involved in the ACBCA and copies of the management plan and other publications have been distributed. A pilot environmental education project for local schools has been supported by JICA and the Provincial Government.

Y. References cited:

Pascal, N. and Bulu, M. 2013. Economic Valuation Of Mangrove Ecosystem Services In Vanuatu: Case Study of Crab Bay (Malekula Is.) and Eratap (Efate Is.). Final report to IUCN MESCAL project, 147 pp.

Spalding M.D., Fox H.E., Allen G.R., Davidson N., Ferdaña Z.A., Finlayson M., Halpern B.S., Jorge M.A., Lombana A., Lourie S.A., Martin K.D., McManus E., Molnar J., Recchia C.A., Robertson J. 2007. Marine Ecoregions of the World: a bioregionalization of coast and shelf areas. *BioScience* 57: 573-583.

Z. Compilers:

Original compilers (for 1993 edition): Ernest Bani and David Esrom.
Updated by: Donna Kalfatak and Roger Jaensch, May 2014.

3.9 Port Sandwich, Cook Bay and the Maskelyne Islands

A. Overview:

The site is a complex of mangrove forests, tidal lagoons, coral reef flats and associated salt marshes and mudflats at the south-east end of Malekula Island and in the adjacent Maskelyne Islands. It is important for subsistence fisheries and has one of the two largest stands of mangroves in Vanuatu.

B. Area, boundary and dimensions:

Area: 7,004 ha (polygon area using Google Earth Pro).

The site comprises four connected components: all of Port Sandwich, which is a deep embayment south-west of Lamap; Cook Bay and Gaspard Bay and associated islands; the nearby Maskelyne Islands; and a connecting strip of coast from Lamap south through Dravai village to Doucere Point. Among the numerous included islands are Sakao, Metai, Maskelyne and Vulal Islands. Mangroves and other coast within the site are included up to the high water mark.

There are three main areas of mangrove: Port Sandwich (175 ha), the coast south of Lamap (262 ha) and the Maskelyne Islands (420 ha). In the Port Sandwich area, there are 25 ha of mangroves at the mouth of the Lasopenamor River on the west side of the bay, 35 ha in the southwest corner of the bay, and 120 ha in the estuary of the Sandwich River. The area south of Lamap includes 130 ha of mangroves along the coast from Lamap to Doucere Point, there are 32 ha in the innermost portion of Cook Bay, and 100 ha along the coast opposite Lembong and Awi in the Maskelyne Islands. Mangroves in the Maskelyne Islands cover 420 ha.

Note: Estuaries and swamp forests associated with Port Sandwich embayment should be included in the site boundary but Google Earth imagery of that area was obscured by cloud. Larger scale maps are needed.

C. Location:

Coordinates: Limits of site: 16°25' -16°33'S, 167°46' -167°51'E
 Port Sandwich 16°26'S, 167°46'E
 Cook Bay 16°31'S, 167°47'E
 Maskelyne Islands 16°31'S, 167°50'E

Clustered around the south-eastern tip of Malekula Island, 147 km north of Port Vila.

Province: Malampa. (South Malekula Area Council)

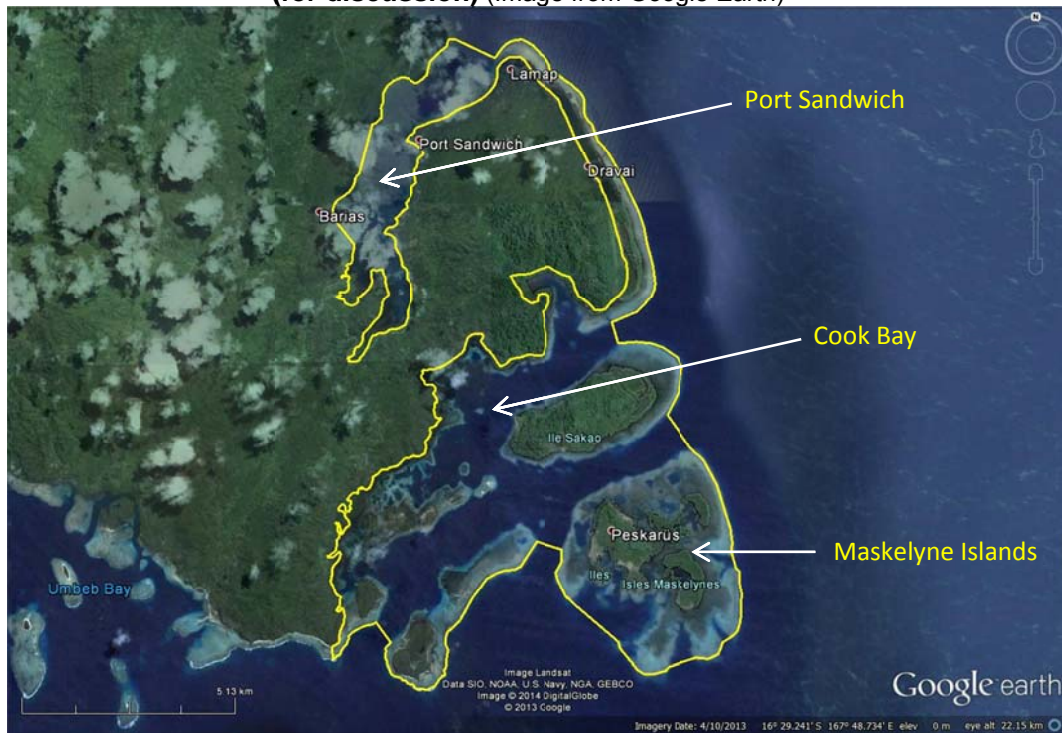
D. Site maps: See below.

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

Location of Port Sandwich, Cook Bay and the Maskelyne Islands
(Image from Google Earth)



Port Sandwich, Cook Bay and Maskelyne Islands: suggested site boundary
(for discussion) (Image from Google Earth)



Note: some western parts of Port Sandwich have been imprecisely mapped due to cloud cover on the satellite image preventing interpretation and delineation.

Port Sandwich, Cook Bay and Maskelyne Islands: suggested site boundary (for discussion) (Image from Google Earth)



E. Ramsar Wetland Types:

- A: Permanent shallow marine waters.
- B: Marine subtidal aquatic beds (sea-grass beds, tropical marine meadows).
- C: Coral reefs.
- E: Sand, shingle or pebble shores.
- F: Estuarine waters.
- G: Intertidal mud, sand or salt flats.
- H: Intertidal marshes; includes salt marshes.
- I: Intertidal forested wetlands; includes mangrove swamps.

F. Geomorphic setting:

Elevation: Sea level.

The Maskelynes are a group of small coral islands and reef platforms.

G. Biogeographic region: Vanuatu Marine Ecoregion (Spalding *et al.* 2007).

H. Climate:

The climate is humid tropical with a wet season extending from November to April. At Lamap in 2009, 2010 and 2012 (= recent years of complete records), the mean annual rainfall was measured as 2,317 mm whereas an older (1993) source gives average annual rainfall of 1,987 mm for this area. The mean annual temperature is 26°C (1993 Directory). Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil: Coralline and estuarine sediments.

J. Water regime: No information.

K. Water chemistry:

The site is dominated by marine salt water. Freshwater inflows directly to the site occur through at least two creeks: Lasopenamor River and Sandwich River, both entering Port Sandwich bay.

L. Biota:

The site contains one of the two largest stands of mangroves in Vanuatu. Mangrove forest has three recognizable zones: an inner *Ceriops tagal* zone; a *Rhizophora* forest zone dominated by *R. mucronata* and *R. stylosa*; and a seaward forest zone of *Avicennia marina* with some *Sonneratia caeseolaris*. The sago palm (*Metroxylon* sp.) occurs amongst the coconut plantations along the landward edge of the mangroves.

In the Maskelyne Islands, 66 species of finfish belonging to 32 families are regularly caught in the mangrove areas, and 29 of these are found exclusively within the mangroves. Common species include mullets (Mugilidae), rabbit fish (Siganidae) and goat fish (Mullidae).

The mangroves support a rich invertebrate fauna dominated by molluscs, crustaceans and polychaetes. Of the 20 or so crustaceans, only the crabs *Cardiosoma hirtipes* (which has a good population) and *Scylla serrata* are regularly harvested.

There is still an apparently healthy population (more than 10 animals) of dugong *Dugong dugon* in the area, especially around Sakao (Malampa Province officer, pers. com.). Two species of flying fox, *Pteropus tonganus* and *P. anetianus*, occur in the mangroves.

Apparently, turtles nest on sand beaches of Siof Island, within the south-west part of the site (Malampa Province officer, pers. com.).

M. Land use:

Subsistence fishing (fish, shellfish) and harvesting of mangroves for building materials and fuelwood, occur within the site.

Surrounding areas support coconut plantations, cattle grazing and subsistence agriculture.

N. Pressures and trends:

In the Maskelyne Islands, villages are located within the mangrove forests. The population of the largest island, Koulivou, is about 1,000 (1989 National Census estimates), giving a population density of 313 people per sq.km. This is one of the largest population densities in Vanuatu and some 20 times the national average. As the population continues to grow, more and more mangrove is being cleared for residential areas.

There is a strong tradition among local people of this area for harvest of turtles for special occasions but nationally this now requires issue of a permit from the Fisheries Department.

O. Land tenure and administrative authority:

Land tenure: Customary ownership; some small areas are leased. The village of Peskarus on the Maskelyne Islands is included in the site. Some land on the main island of Malekula within the site is owned by people from Peskarus.

Administrative authority: Jurisdiction of mangrove areas is subject to proposed amendments to Vanuatu legislation but involves the Department of Lands, Department of Fisheries, Department of Forestry and Department of Environment. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed? No. Vanuatu is not yet a Contracting Party to the Convention.

Q. Ramsar Criteria met:

- Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
- Criterion 4. Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
- Criterion 8: The streams, mangroves, lagoons and reefs of the site provide substantial stocks of fish and other marine resources on which local people depend.

R. Justification for Ramsar Criteria met:

- Criterion 1: The site is a good representative example in the Vanuatu Marine Ecoregion of an integrated system comprising several coastal wetland types: coral reefs (Type C), marine lagoons and bays (Type A), seagrass beds (Type B) and mangrove forest (Type I). The site includes one of the two largest areas of mangrove in Vanuatu.
- Criterion 4: The site includes mangrove forests that are vital nursery areas for marine animals (fishes, prawns) and seagrass areas that are vital feeding areas for turtles and dugongs.
- Criterion 8: The extensive wetlands of the site support stocks of fish and other marine resources that local people depend on for their own consumption and for some income.

S. Conservation and management status of the wetland:

A small Conservation Area exists on reef flat to the north-east of Peskarus. A small Conservation Area has been proposed for the west end of Sakao Island.

As elsewhere in Vanuatu, mangrove forests are protected from commercial exploitation by the Government. Local community chiefs can apply closures to the exploitation of the mangrove resources if considered appropriate.

T. Ecosystem services:

Nursery for commercially harvested marine resources: the mangroves serve as vital nursery and feeding grounds for a variety of inshore and marine invertebrates and fishes important in the commercial and subsistence fisheries. Mangrove crabs caught in the mangroves of the site are sold to restaurants in Port Vila and Luganville, though rather few households are involved. There is also a small scale commercial fishery servicing these markets.

Food supply: the mangroves and their fishery resources constitute an important source of food for the local people, and are vitally important in maintaining the livelihood of the inhabitants of the Maskelyne Islands. Sixty-six species of fish are caught regularly in the Maskelynes mangroves (David and Cillaurren 1988). *Cardiosma* crabs and *Terebralia* molluscs are highly valued by local people in the Maskelynes.

Fuel wood, timber: an average of 15-24 bundles of mangrove wood per month per household is burned as fuelwood in the Maskelynes (unpublished and undated paper by Tari, T. and Naviti, W.).

Medicines: traditional, from mangroves.

Coastal protection: the mangrove fringe provides protection against coastal erosion and reduces storm damage during the frequent cyclones that affect this area.

Nutrient cycling and food chain: the mangroves provide a source of nutrients for a diversity of food chains.

Carbon sink: mangrove forests, sea grass.

U. Current recreation and tourism: Tourism is not a major activity at this site.

V. Existing scientific research:

Several surveys and studies have been carried out in the area, particularly with respect to the species composition of the mangroves and utilization of mangrove resources.

W. Management plans and monitoring programs:

A UNDP project on climate change adaptation may start in 2014 in Malekula, possibly at this site.

X. Current communication and public education programs:

National, provincial and community level awareness campaigns have been conducted in regard to mangrove (natongtong) in Vanuatu. A general poster has been disseminated.

Y. References cited:

Spalding M.D., Fox H.E., Allen G.R., Davidson N., Ferdaña Z.A., Finlayson M., Halpern B.S., Jorge M.A., Lombana A., Lourie S.A., Martin K.D., McManus E., Molnar J., Recchia C.A., Robertson J. 2007. Marine Ecoregions of the World: a bioregionalization of coast and shelf areas. *BioScience* 57: 573-583.

David, G. and Cillaurren, E. 1988. A survey of village subsistence fishing in Vanuatu. Paper presented at the 26th Congress of the International Geographical Union, Sydney, Australia, 21-26 August 1988.

Z. Compilers:

Original compilers (for 1993 edition): Ernest Bani and David Esrom.
Updated by: Donna Kalfatak and Roger Jaensch, May 2014.

3.10 South-west Bay Lagoon (Tisri Lagoon)

A. Overview:

Tisri Lagoon is a tidal lagoon with a narrow connection to the sea and it includes a small area of mangrove forest.

B. Area, boundary and dimensions:

Area: 194 ha (polygon area using Google Earth Pro).

The boundary of the site follows the high water mark of the lagoon and the sea-connecting channel, to the sea mouth. The lagoon and channel is about 2.8 km long and the lagoon is up to about 1.0 km wide. The lagoon includes three islands, one near the start of the channel and two others supporting mangroves.

C. Location: See below.

Coordinates: 16°30'S, 167°26'E

On the south-west coast of Malekula Island, 165 km north of Port Vila, between the villages of Lamango and Lebinwen.

Province: Malampa.

D. Site maps: See below.

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

E. Ramsar Wetland Types:

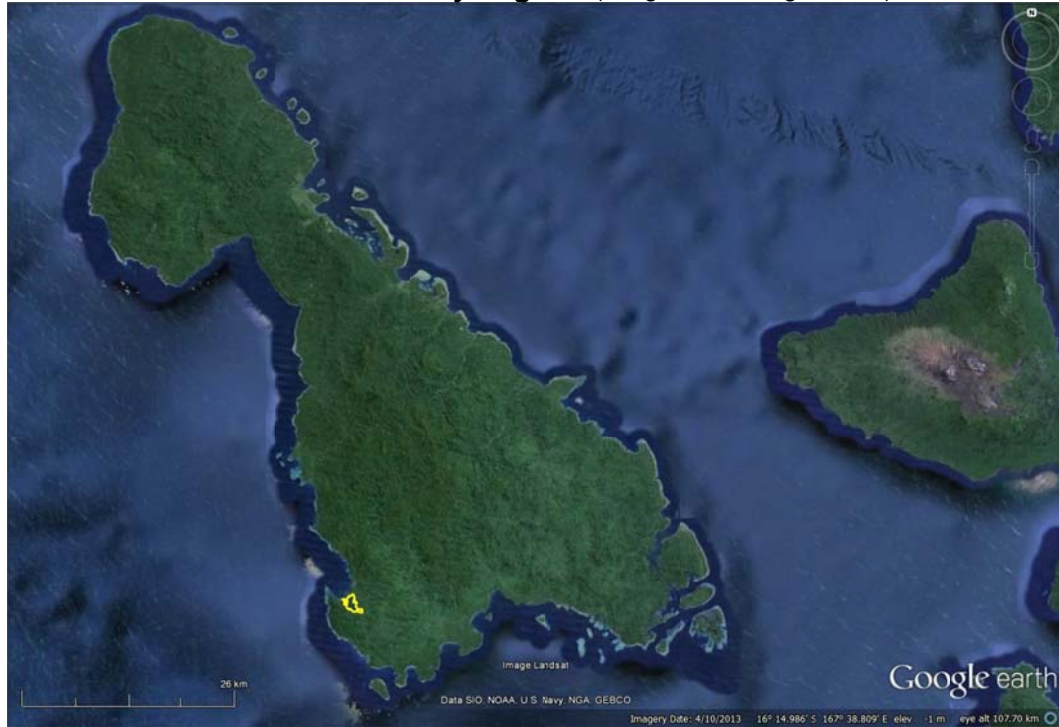
J: Coastal brackish/saline lagoons with at least one relatively narrow connection to the sea.

F: Estuarine waters.

G: Intertidal mud, sand or salt flats.

I: Intertidal forested wetlands (mangrove swamps).

Location of South-west Bay Lagoon (Image from Google Earth)



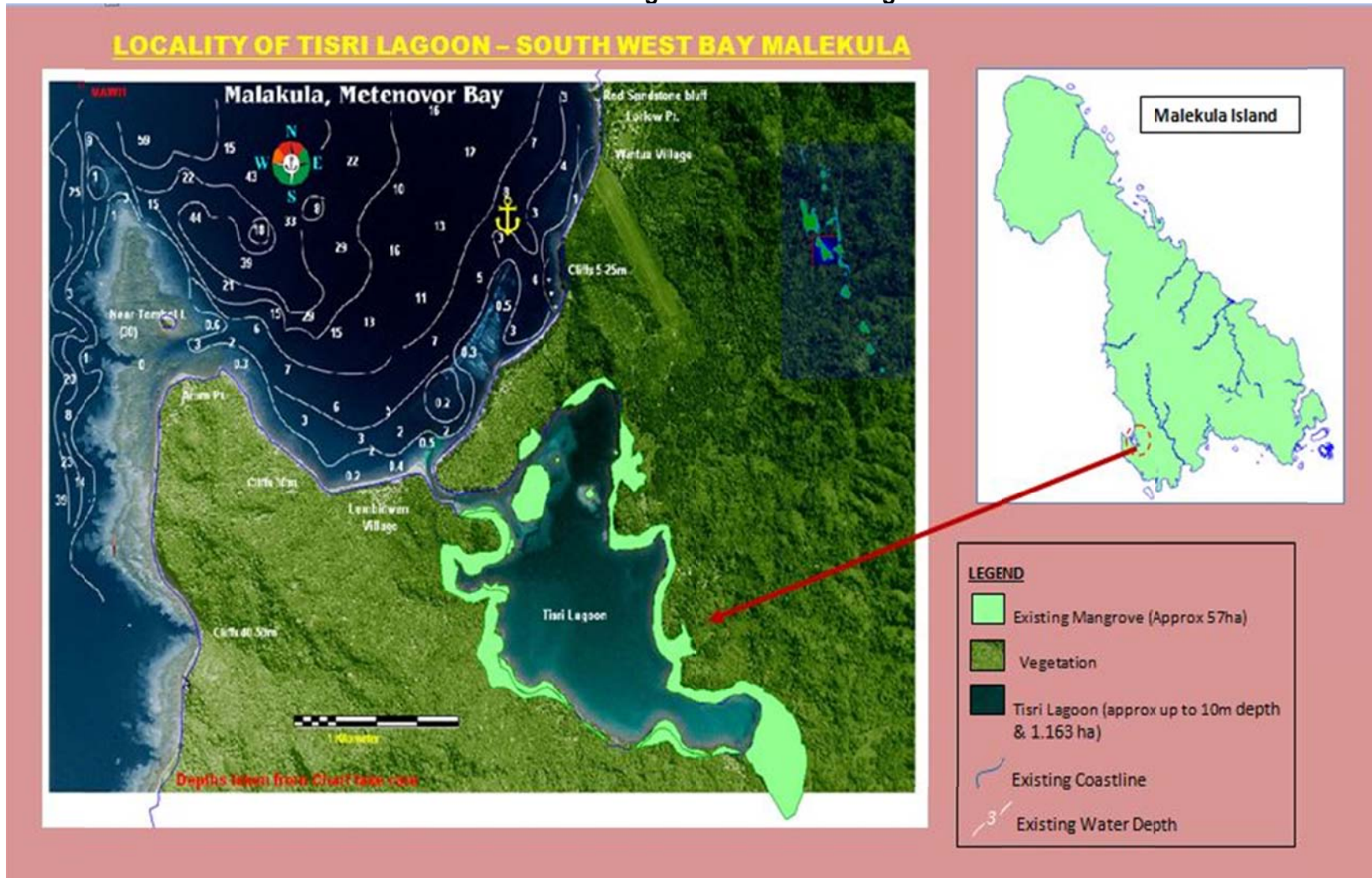
South-west Bay Lagoon: suggested site boundary (for discussion)
(Image from Google Earth)



South-west Bay Lagoon: suggested site boundary (for discussion)
(Image from Google Earth)



Location of mangroves within Tisri Lagoon



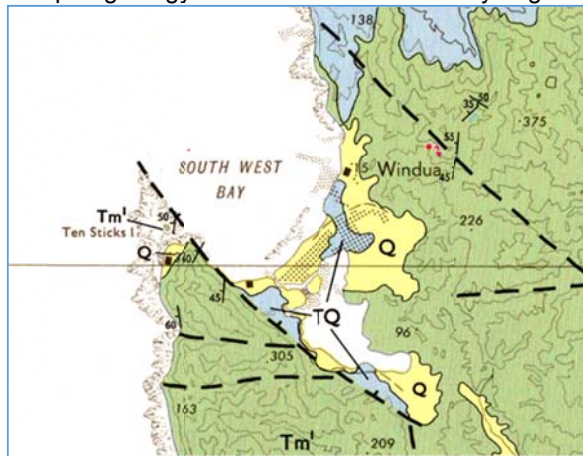
F. Geomorphic setting:

Elevation: Sea level.

The lagoon is separated from the sea by land about 300 m wide. The connecting channel is 550 m long and 50-100 m wide.

South-West Bay Lagoon lies between 2 parallel faults trending in a north-west – south-easterly direction; this makes the Lagoon orientation structurally controlled. The predominant volcanic geology (green on the map below) is from the Lampumbu volcanic breccia of Late Miocene age. Pockets of limestone (blue on the map) are situated on the sides of the lagoon.

Map of geology and soils: South-West Bay Lagoon



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G. Biogeographic region: Vanuatu Marine Ecoregion (Spalding *et al.* 2007).

H. Climate:

The climate is humid tropical with a wet season extending from November to April. At Lamap (40 km to the east) in 2009, 2010 and 2012 (= recent years of complete records), the mean annual rainfall was measured as 2,317 mm; an older (1993 Directory) source gives average annual rainfall of 1,900 mm for the South-west Lagoon area – rainfall is typical lower on western (leeward) sides of the Vanuatu islands. The mean annual temperature for the South-west Lagoon area is 28°C (1993 Directory). Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil:

Alluvial deposits of recent formation cover the estuarine zone (yellow colour in the map under Geomorphic setting, above).

J. Water regime:

The lagoon is tidal, connected to the sea by a channel. There appears to be no major freshwater creek entering the lagoon and the surrounding catchment is relatively small but the high annual rainfall would ensure significant freshwater input.

Tidal range: no information.

K. Water chemistry:

Water in the lagoon is saline to brackish, being least saline in the wettest months of the year.

L. Biota:

Mangrove vegetation occurs around much of the lagoon shores. It is dominated by *Rhizophora seilala*, *R. stylosa*, *R. apiculata*, *R. lamarcki*, *R. samoensis*, *Ceriops tagal* and *Avicennia marina*. Other mangrove species found at the lagoon include: *Sonneratia alba*, *Bruguiera gymnorrhiza*, *Dolichandrone spathacea*, *Heritiera littoralis*, *Acrosticum speciosum* and *Excoecaria agallocha* (R. Baereleo pers. com.).

The mangroves support a rich invertebrate fauna dominated by molluscs, crustaceans and polychaetes, as well as numerous fishes such as mullets (Mugilidae).

A brief inspection in late April 2014 identified Reef Heron *Egretta sacra* and 'ducks' at the Lagoon and apparently pelicans (presumably Australian Pelican *Pelecanus conspicillatus*) sometimes visit the site (R. Baereleo pers. com.).

Dugong (*Dugong dugon*) occur in the bay (Chambers *et al.*, 1989); also hawksbill turtle *Eretmochelys imbricata* (R. Baereleo pers. com.).

M. Land use:

A village (Lembinwen) is situated beside the beach at the mouth of the lagoon.

The lagoon supports subsistence fishing (reef fish, molluscs) and the harvesting of mangroves for building materials (house posts) and fuelwood. The streams that flow into the lagoon also support water taro cultivation close to the lagoon. Communities from Lembinwen use the lagoon as an easy means of access by canoe to their gardens which are situated behind the lagoon (R. Baereleo pers. com.).

Some of the area surrounding the lagoon has been cleared.

N. Pressures and trends:

Pressures identified at the lagoon include overfishing, which has resulted in the decrease of fish stocks; however, since a taboo area was set up in 2013, fish stocks have rapidly increased in the taboo area (see below). Communities remain permitted to fish in some areas inside the lagoon. Coconut plantations along coastal sides of the lagoon contribute to mud being washed into the lagoon. Some local people are concerned at the use of chemicals to control weeds at the lagoon (R. Baereleo pers. com.).

O. Land tenure and administrative authority:

Land tenure: Customary ownership.

Administrative authority: Jurisdiction of mangrove areas is subject to proposed amendments to Vanuatu legislation but involves Department of Lands, Department of

Fisheries and Department of Forestry and Department of Environment. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed? No. Vanuatu is not yet a Contracting Party to the Convention.

Q. Ramsar Criteria met:

- Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
- Criterion 4. Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
- Criterion 8: The streams, mangroves, lagoons and reefs of the site provide substantial stocks of fish and other marine resources on which local people depend.

R. Justification for Ramsar Criteria met:

- Criterion 1: The site is a relatively rare example, in the in the Vanuatu Marine Ecoregion, of a coastal lagoon with narrow connection to the sea (Type J), and is a good representative example of mangrove forest (Type I) – it is the only significant stand of mangroves on the west coast of Malekula Island.
- Criterion 4: The site includes mangrove forests that are vital nursery areas for marine animals (fishes, prawns).
- Criterion 8: Local people depend on the fish/shellfish resources for their own consumption and income and the wetlands of the site provide stocks for many of these resources.

S. Conservation and management status of the wetland:

Village chiefs and owners of land in the lagoon area have established and manage two taboo areas ('erias') in the lagoon, as shown on the map below. Community members use different nets to fish in areas that are not taboo.



T. Ecosystem services:

Food supply: the mangroves and lagoon and their fisheries resources constitute an important source of food for the local people, and are vitally important in maintaining the livelihood of the inhabitants of the area.

Fuel-wood, timber: for use by local people.

Nutrient cycling and food chain: the mangroves provide a source of nutrients for a diversity of food chains.

Medicines: traditional, from mangroves.

Carbon sink: mangrove forests.

U. Current recreation and tourism:

Alo Lodge is one the lodges at Southwest Bay, which provides tours into the lagoon.

Features of the tour include: witnessing a custom ceremony; visiting old Libinwen Village; visiting a waterfall; visiting the mangroves; and fishing with bow and arrows (R. Baereleo pers. com.).

V. Existing scientific research: No information.

W. Management plans and monitoring programs:

There are two taboo areas in the lagoon, with management plans set and enforced locally through traditional chiefly systems.

X. Current communication and public education programs:

None specific to the wetland

Y. References cited:

Spalding M.D., Fox H.E., Allen G.R., Davidson N., Ferdaña Z.A., Finlayson M., Halpern B.S., Jorge M.A., Lombana A., Lourie S.A., Martin K.D., McManus E., Molnar J., Recchia C.A., Robertson J. 2007. Marine Ecoregions of the World: a bioregionalization of coast and shelf areas. *BioScience* 57: 573-583.

Z. Compilers:

Original compilers (for 1993 edition): Ernest Bani and David Esrom.

Updated by: Donna Kalfatak, Rolenas Baereleo and Roger Jaensch, May 2014.

3.11 Duck Lake (Emaotul)

A. Overview:

A small freshwater lake with associated swamp vegetation and some fringing swamp forest, surrounded by degraded lowland tropical rain forest.

B. Area, boundary and dimensions:

Area: 76.3 ha (polygon area using Google Earth Pro).

The boundary of the site corresponds closely to the high water mark of the lake and its fringing wetland vegetation. The lake is about 1.3 km long and 0.6 km wide.

C. Location:

Coordinates: 17°44'S, 168°25'E

Duck Lake is 10 km east-north-east of Port Vila, on the island of Efate.

Province: Shefa.

D. Site maps: See below.

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

E. Ramsar Wetland Types:

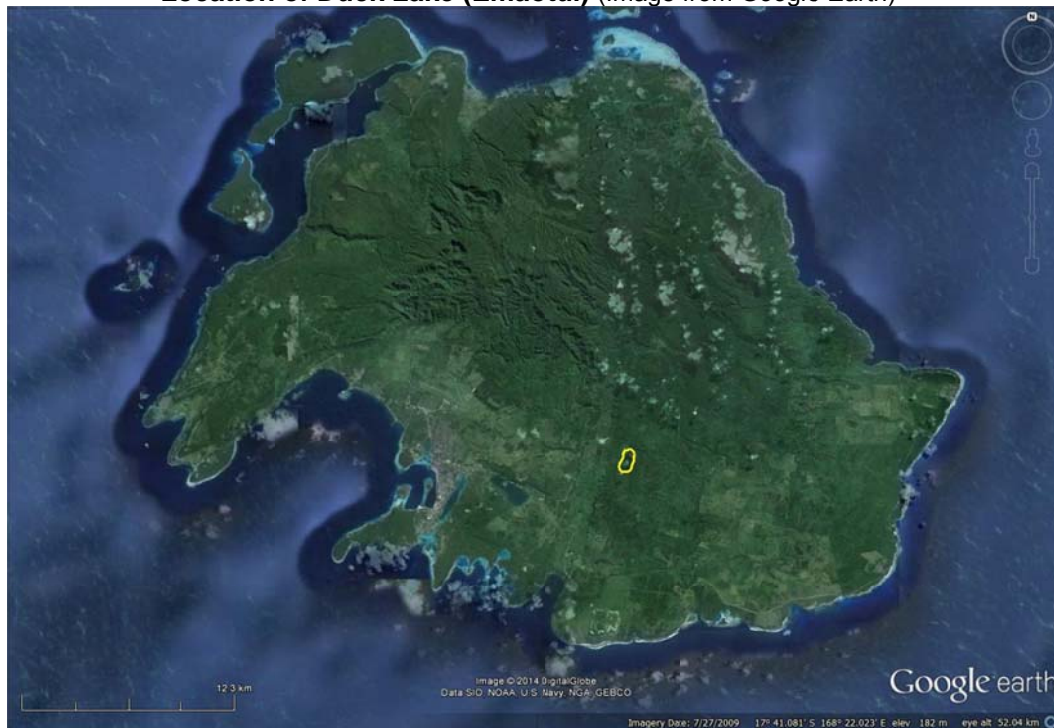
O: permanent lake.

Note: The swamp forest vegetation seems to form only a narrow fringe around the lake shore; otherwise, if more extensive, it should be added as a wetland type at this site (and the site boundary possibly modified and area re-calculated).

View of Duck Lake from south-west side (Photo: R. Jaensch)



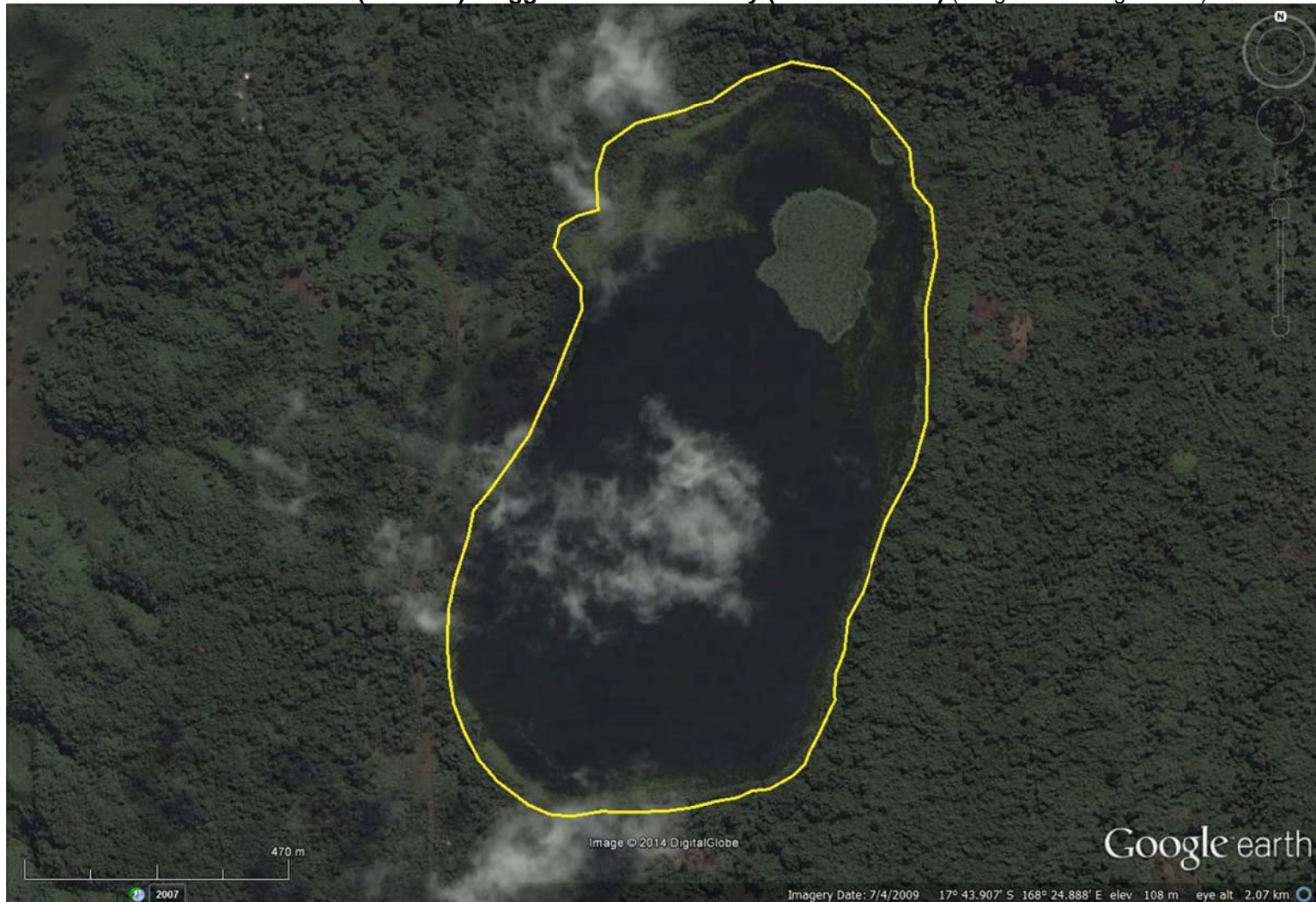
Location of Duck Lake (Emaotul) (Image from Google Earth)



Duck Lake (Emaotul): suggested site boundary (for discussion)
(Image from Google Earth)



Duck Lake (Emaotul): suggested site boundary (for discussion) (Image from Google Earth)



F. Geomorphic setting:

Elevation: 119 m.

The lake is situated on a raised limestone plateau above the Teouma Valley.

G. Biogeographic region: Vanuatu Freshwater Ecoregion (Abell *et al.* 2008).

H. Climate:

The climate is humid tropical with little seasonal variation in rainfall, although November to April are slightly wetter than the other months. At Bauerfield Airport near Port Vila (11 km to the west), from 2009 to 2012 the average annual rainfall was 2,353 mm and mean annual temperature was about 25°C with monthly variation of only one or two degrees. (Older sources (1993 Directory) state the average annual rainfall in this area as 2,270 mm.) Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil: Soil around the lake's western edge is red-brown and of volcanic origin.

J. Water regime:

Water is permanent and fresh; no information on depth or variation in depth. The lake is situated between the Teouma and Rentapao rivers, but apparently there is no surface inflow or outflow.

K. Water chemistry: Fresh water.

L. Biota:

The lake has some fringing grassy swamps at the east and west ends and fringing swamp forest with *Barringtonia* sp., *Hibiscus* sp. and *Pandanus* sp. Most of the lake is open water but a fringe of varied width in the open lake is covered by lilies: lotus *Nelumbo nucifera* and *Nymphaea* and *Nymphoides* spp.. The wetland is surrounded by degraded lowland tropical forest and shrubbery, and there is an area of sago palms *Metroxylon* spp. and *Phragmites* reeds nearby.

Waterbirds using the lake include Australasian Grebe *Tachybaptus novaehollandiae leucosternos* (see R below), Pacific Black Duck *Anas superciliosa* and Hardhead *Aythya australis*. Surrounding forests are rich in bird life.

M. Land use:

Local people take water lilies from the lake and sell at markets in Port Vila. It is not yet known whether or not some of the lilies were introduced to the lake for this purpose.

Some of the adjacent areas are cleared (south-west side). Surrounding areas are leased for logging, subsistence farming and cattle grazing. Several rural houses are close to the lake.

Roots of *Panadanus* at the edge of Duck Lake (Photo: R. Jaensch)



Lotus and lilies on the surface of Duck Lake (Photo: R. Jaensch)



N. Pressures and trends:

The introduced fish *Gambusia* sp. occurs in the lake. The status of various lilies in the lake – native or introduced – requires clarification.

The surrounding forest was much affected by logging; logging operations caused some disturbance to wildlife and provided easy access, encouraging increased land clearance for agriculture. There have been several proposals to expand cattle grazing in the area.

Proposals to establish a pig farm and a poultry farm near the lake were rejected by the Government.

O. Land tenure and administrative authority:

Land tenure: The lake is under customary ownership, although there was previously some dispute as to who the rightful owners were. Some areas are under lease arrangement.

Administrative authority: The site is under the jurisdiction of the Department of Lands. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed? No, Vanuatu is not yet a Contracting Party to the Convention.

Q. Ramsar Criteria met:

Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

R. Justification for Ramsar Criteria met:

Criterion 1: The site is a good representative example of a wetland type found in the Vanuatu Freshwater Ecoregion: permanent freshwater lake (wetland type O). It is probably the best example of a non-volcanic freshwater lake in Vanuatu and the whole ecoregion.

Note in relation to Criterion 6: On a brief visit to the lake on 16 January 2014, around 100 Australasian Grebe *Tachybaptus novaehollandiae* were counted on the lake (R. Jaensch pers. obs.). The population of this species in Vanuatu and New Caledonia is considered to be of subspecies *leucosternos* which has an estimated population size of 100-500 birds across these two island systems (Wetlands International 2014). On this one occasion in January 2014, Duck Lake therefore supported at least 1% of this estimated population size. This may be sufficient evidence to show that Criterion 6 is met by the lake and given that some local people refer to grebes as ducks, it is likely that grebes do occur there regularly. However, it would be advisable to conduct more systematic surveys of the numbers of grebes on lakes across Vanuatu and New Caledonia to better define the estimated population size and determine if numbers at 1% levels occur regularly at sites such as Duck Lake.

S. Conservation and management status of the wetland:

No protection has been secured for the site.

Dahl (1980) proposed the establishment of a reserve at Duck Lake and Rentapao Valley to protect the lake, freshwater swamp, swamp forest and surrounding lowland rain forest. The Tourism Council of the South Pacific identified the lake as a suitable site for protection (TCSP, 1990).

T. Ecosystem services:

Water supply: An important water supply for the local people (collection by hand). The lake also plays an important role, presumably via groundwater, in maintaining water supplies in the Teouma and Rentapao Rivers during the dry season.

U. Current recreation and tourism:

The lake has considerable potential for outdoor recreation and tourism because of its easy access and close proximity to Port Vila. Access to the water edge is through private property and permission is required from the owners; the edge may be reached via a 100 m unmade path across a fenced cattle-grazing area, from a rough unsealed public road.

V. Existing scientific research: No information.

W. Management plans and monitoring programs: None.

X. Current communication and public education programs: None.

Y. References cited:

- Abell, R., Thieme M., Revenga C. *et al.* 2008. Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *BioScience* 58, 403–414.
- Dahl, A.L. 1980. Regional Ecosystems Survey of the South Pacific Area. SPC Technical Paper No. 179. South Pacific Commission, Noumea, New Caledonia.
- TCSP. 1990. Guidelines for the Integration of Tourism Development and Environmental Protection in the South Pacific. Tourism Council of the South Pacific, Suva, Fiji.
- Wetlands International 2014. Waterbird population estimates; 5th edition. Online at <http://wpe.wetlands.org/> accessed 27 March 2014.

Z. Compilers:

Original compilers (for 1993 edition): Ernest Bani and David Esrom.
Updated by: Donna Kalfatak and Roger Jaensch, May 2014.

3.12 Emaotfer Swamp

A. Overview:

Emaotfer Swamp is a freshwater swamp in the southern lowlands of Efate, consisting of tall emergent sedges surrounded by dense low swamp forest. Initial investigations suggest that the swamp may include peat deposits.

B. Area, boundary and dimensions:

Area: 192 ha (polygon area using Google Earth Pro).

The site boundary follows the high water mark of the swamp; where surrounding areas have been cleared, the wetland boundary seems to be indicated by the outer edge of the swamp forest. The swamp has narrow arms in the south-west and south-east; the limit of the boundary of the south-east arm is arbitrary and could be extended farther to the east. The site is about 2.0 km long and 1.0 km wide.

C. Location:

Coordinates: 17°47'S, 168°24'E

The swamp is 10.5 km south-east of Port Vila, on the island of Efate.

Province: Shefa.

D. Site maps: See below.

The site boundary shown in this update serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

E. Ramsar Wetland Types:

Xp: Forested peatlands (peat swamp forests).

U: Non-forested peatlands (includes shrub or open bogs, swamps, fens).

Note: These determinations are provisional and require confirmation through systematic investigation of the site.

Peat is partly decomposed organic matter such as derived from trees, shrubs or sedge communities growing in swamps. Type U refers to the inner part of the swamp where sedges dominate; Type Xp refers to the densely wooded and seasonally inundated margins although it is possible that there is less peat in the margins and that Type Xf applies there (freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils).

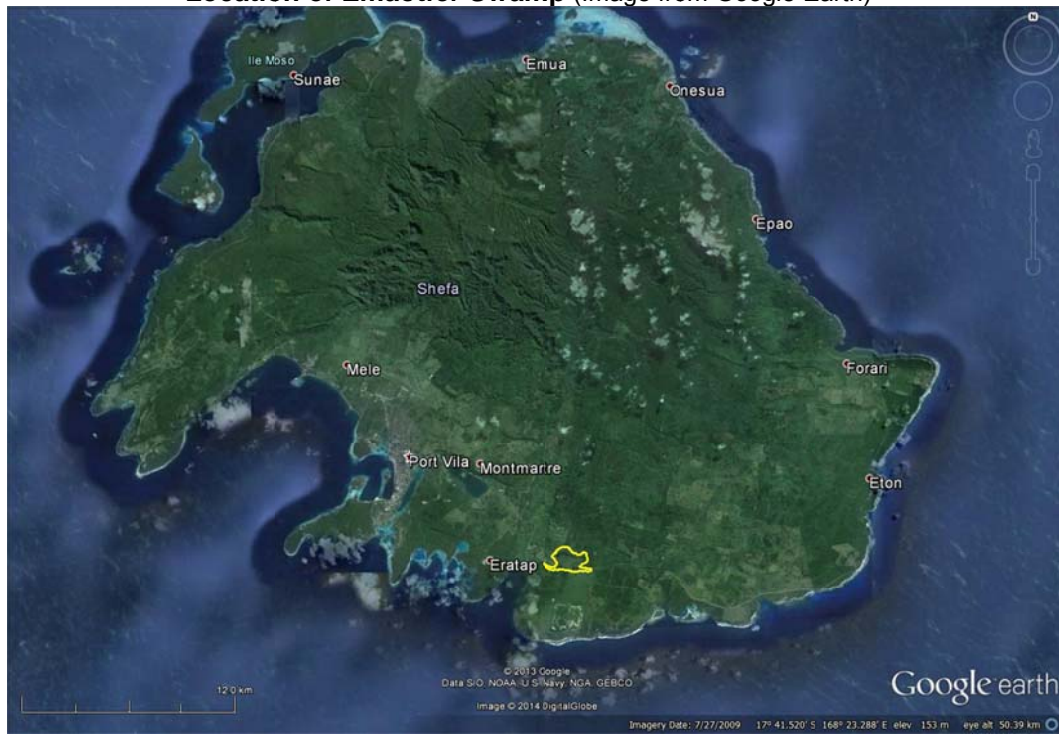
F. Geomorphic setting:

Elevation: 20 m.

The swamp is situated in a broad shallow depression, possibly but not obviously connected hydrologically via surface flows to coastal rivers to the west and east.

G. Biogeographic region: Vanuatu Freshwater Ecoregion (Abell *et al.* 2008).

Location of Emaotfer Swamp (Image from Google Earth)



Emaotfer Swamp: suggested site boundary (for discussion)
(Image from Google Earth)



Emaotfer Swamp: suggested site boundary (for discussion)
(Image from Google Earth)



Tree thickets (Barringtonia?), Emaotfer Swamp, with swollen bases

(Photo: R. Jaensch)



Gahnia sedge, at edge of sedge beds, Emaotfer Swamp (Photo: R. Jaensch)



H. Climate:

The climate is humid tropical with little seasonal variation in rainfall, although November to April are slightly wetter than the other months. At Bauerfield Airport near Port Vila (13 km to the north-west), from 2009 to 2012 the average annual rainfall was 2,353 mm and mean annual temperature was about 25°C with monthly variation of only one or two degrees. (Older sources (1993 Directory) state the average annual rainfall in this area as 2,270 mm.) Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil:

Preliminary inspection of the north-east edge of the swamp by D. Kalfatak and R. Jaensch on 16 January 2014 led to the conclusion that the wetland may contain some accumulated peat (partly decomposed organic matter derived from the swamp vegetation), principally underlying the permanently wet, sedge dominated interior of the swamp. Local people indicated that the soft substrate in mid-swamp may be chest deep, with less than a metre of free water on top. However, the substrate in outermost parts of the swamp may be inorganic/mineral soil.

J. Water regime:

The swamp seems to be perched between two river systems: Teouma River 2 km to the west and another river 4 km to the east. A small creek, apparently tidal, terminates abruptly 200-400 m from the western edges of the swamp: local people advised that there is no surface outflow connection to this creek; however, a subterranean connection seems possible. No specific inflow channel to the swamp is apparent but a long shallow watercourse extending at least 3 km eastwards from the south-east arm of the swamp may direct floodwater into (or out of?) the swamp at times of high rainfall. Further investigation of the swamp's hydrology is a high priority to enhance understanding of its functioning and to identify potential connection corridors for freshwater fauna.

The water level fluctuates according to the wet and dry seasons. According to local advice which matches high water marks on trees examined by D. Kalfatak and R. Jaensch on 16 January 2014, water levels in the swamp may rise by up to 1.5 m following heavy rainfall.

There are small pool-like areas of open water near the outer edges of the sedge-covered interior of the swamp but most of the swamp is vegetated.

K. Water chemistry:

Water in the wetland is fresh. Due to the high organic content it is possible that the pH is low.

L. Biota:

The fringing and broad swamp forest areas are dominated by *Barringtonia* and *Erythrina* species. Trees were up to 7 m tall and in dense thicket-like formation in an area investigated by the compilers in 2014. Swollen bases of trunks indicate adaptation of trees to extended periods of inundation.

The original site account indicated that the swamp vegetation includes the sedges *Cyperus difformis* and *Lepironia articulata* which are widespread species in Oceania. These plants were not evident from the inner wooded edge of the site during a brief inspection by D. Kalfatak and R. Jaensch on 16 January 2014, whereas many large plants of 'saw sedge' *Gahnia* sp. were conspicuous. (It is possible that the other sedges dominate farther into the swamp.) Minor components of the flora noted on the 2014 visit included many 'lilies' *Nymphoides* sp. and a few *Nymphaea* sp., knotweed *Persicaria* sp., and various other forbs.

According to local people, Purple Swamphen *Porphyrio porphyrio* occurs in the swamp; other rails such as Spotless Crane *Porzana tabuensis* are also likely to occur in the

dense swampy habitat. There is probably not enough open water for substantial numbers of ducks or grebes.

Scattered *Pandanus* and lowland forest occur in surrounding areas. The invasive vine-creeper *Merremia* has covered large areas of surrounding vegetation.

M. Land use:

There is no land use within the site, apart from some, probably opportunistic, fishing of introduced fish in the swamp by local people.

Gardens, some overgrown, and cattle grazing occur in some of the surrounding areas.

N. Pressures and trends:

Part of the swamp was burnt late in 2013 (A. Williams pers. com.) and this was evident in the distance during a brief inspection by D. Kalfatak and R. Jaensch on 16 January 2014. Fires in peat deposits should be avoided because the fires release stored carbon and destroy a scientifically important pollen record of past vegetation and climates.

Fish have been introduced to the lake and people attempt to catch them (DEPC).

O. Land tenure and administrative authority:

The wetland is under customary ownership.

Administrative authority: The site is under the jurisdiction of the Department of Lands. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed? No, Vanuatu is not yet a Contracting Party to the Convention.

Q. Ramsar Criteria met:

Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

R. Justification for Ramsar Criteria met:

Criterion 1: Based on preliminary investigations of wetland type, the site may be considered a good representative example of two wetland types found in the Vanuatu Freshwater Ecoregion: U: Non-forested peatlands (includes shrub or open bogs, swamps, fens) and Xp: Forested peatlands (peat swamp forests). If confirmed, the swamp would be significant as containing the only known examples of peat wetlands in the bioregion; further investigations may reveal other examples in Vanuatu but there are few possibilities of substantial size. As a peatland, the site would be potentially of great scientific interest for research into past climates based on the record of pollen from plants of previous eras, preserved in the peat.

S. Conservation and management status of the wetland:

No conservation measures have been taken or proposed.

T. Ecosystem services:

Carbon sink: the swamp vegetation and the assumed (possibly substantial) deposit of peat within the swamp serve as a carbon sink.

U. Current recreation and tourism:

None; the site is relatively inaccessible to the public.

V. Existing scientific research:

Apparently, a French research team took some core samples from the swamp substrate.

W. Management plans and monitoring programs: None.

X. Current communication and public education programs: None.

Y. References cited:

Abell, R., Thieme M., Revenga C. *et al.* 2008. Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *BioScience* 58, 403–414.

Z. Compilers:

Original compiler (for 1993 edition): Ernest Bani.
Updated by: Donna Kalfatak and Roger Jaensch, May 2014.

3.13 Lake Isiwi

A. Overview:

This was formerly a freshwater volcanic lake at the base of Yasur Volcano, Tanna island. As the result of exceptional heavy rainfall associated with a cyclone, the volcanic landform retaining the lake water was washed away and the lake no longer exists.

B. Area, boundary and dimensions:

Area: formerly 225 ha; now nil.

C. Location:

Coordinates: 19° 31'S, 169° 26'E

The lake was formerly at the base of Yasur Volcano, on the island of Tanna.

Province: Tafea

N. Pressures and trends:

The lake was subject to natural forces causing significant change, prior to its extinction. For example, landslides caused by Cyclone Uma in 1967 partially filled the lake with debris and silt. Date of the final destruction of the lake was post-1993.

Z. Compilers:

Original compiler (for 1993 edition): Ernest Bani.

Updated by: Donna Kalfatak and Roger Jaensch, May 2014.

3.14 South-east Santo Blue Holes

This is a **NEW** site, not previously listed in the 1993 Directory.

A. Overview:

The site is a suite of six karst sink-holes containing ponds known locally as 'blue holes' and that outflow via short streams to the sea. The blue holes are important as among the best examples of their type in Vanuatu; they support endemic invertebrates and are valued for tourism.

B. Area, boundary and dimensions:

Area: six separate ponds, each less than 1.0 ha in area (total area about 5 ha).

The boundary of the site is defined as the ponds (blue holes) and immediate vicinity at each of the points listed below (Location). The blue holes are in pairs about 1.5 km apart and the three pairs are about 8.5 km apart, roughly in a linear arrangement. Ponds are up to 50 m in diameter. A much more northerly pair of blue holes (Vatvatel and Vatvateur), 30 km beyond the Nanda Blue Holes, is not included in this site.

C. Location:

Coordinates:

Nanda 2 Blue Hole	15°18'S, 167°10'E
Nanda 1 Blue Hole	15°18'S, 167°10'E
Matevulu 2 Blue Hole	15°22'S, 167°10'E
Matevulu 1 Blue Hole	15°23'S, 167°10'E
CIRAD Blue Hole	15°26'S, 167°12'E
Suranda Blue Hole	15°27'S, 167°12'E

The blue holes are located on the south-east coast of Espiritu Santo island, 288 km north of Port Vila and from 7 km north-east to 24 km north of Luganville.

Province: Sanma.

D. Site maps: See below.

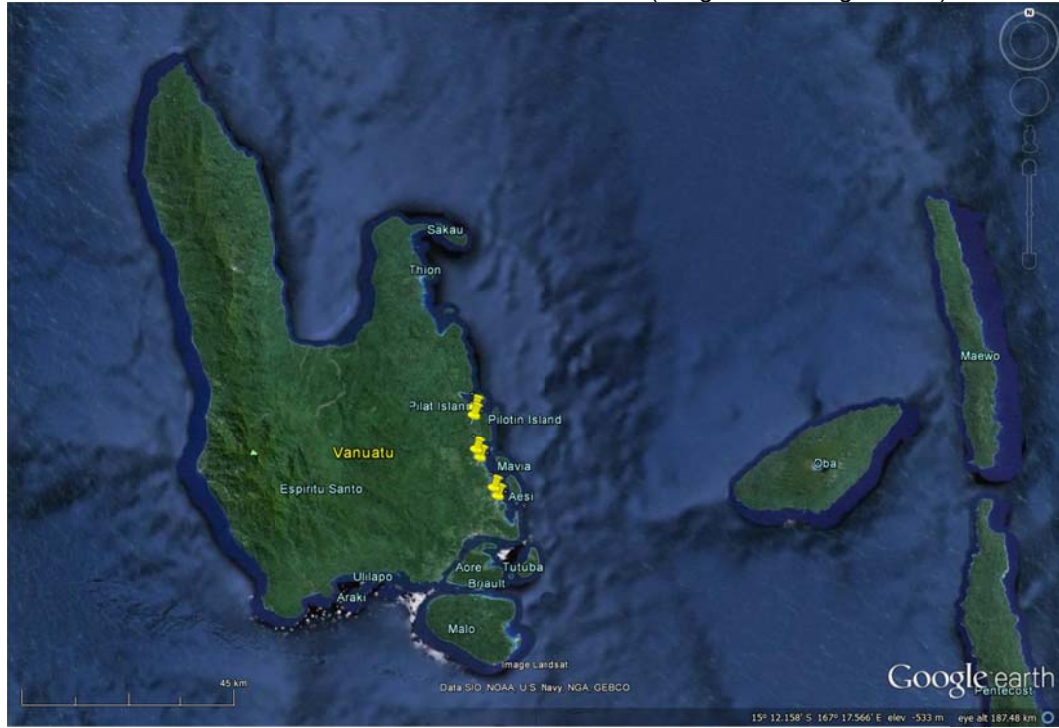
The site components in the maps serve to define the scope of information in the site account; their inclusion has no legal status as this is provisional and subject to further discussion.

E. Ramsar Wetland Types:

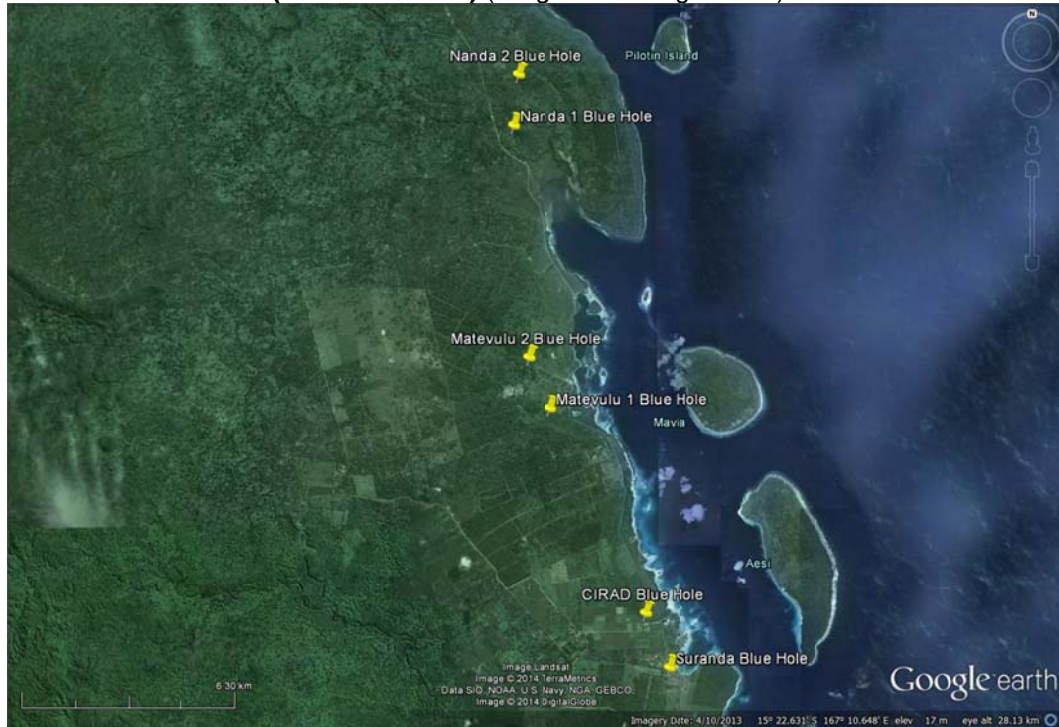
Zk (b): Karst and other subterranean hydrological systems, inland.

Note: The outflow streams (Type M: permanent streams) are not presently included in the site boundary or description but for reasons of ecological connectivity their inclusion should be considered.

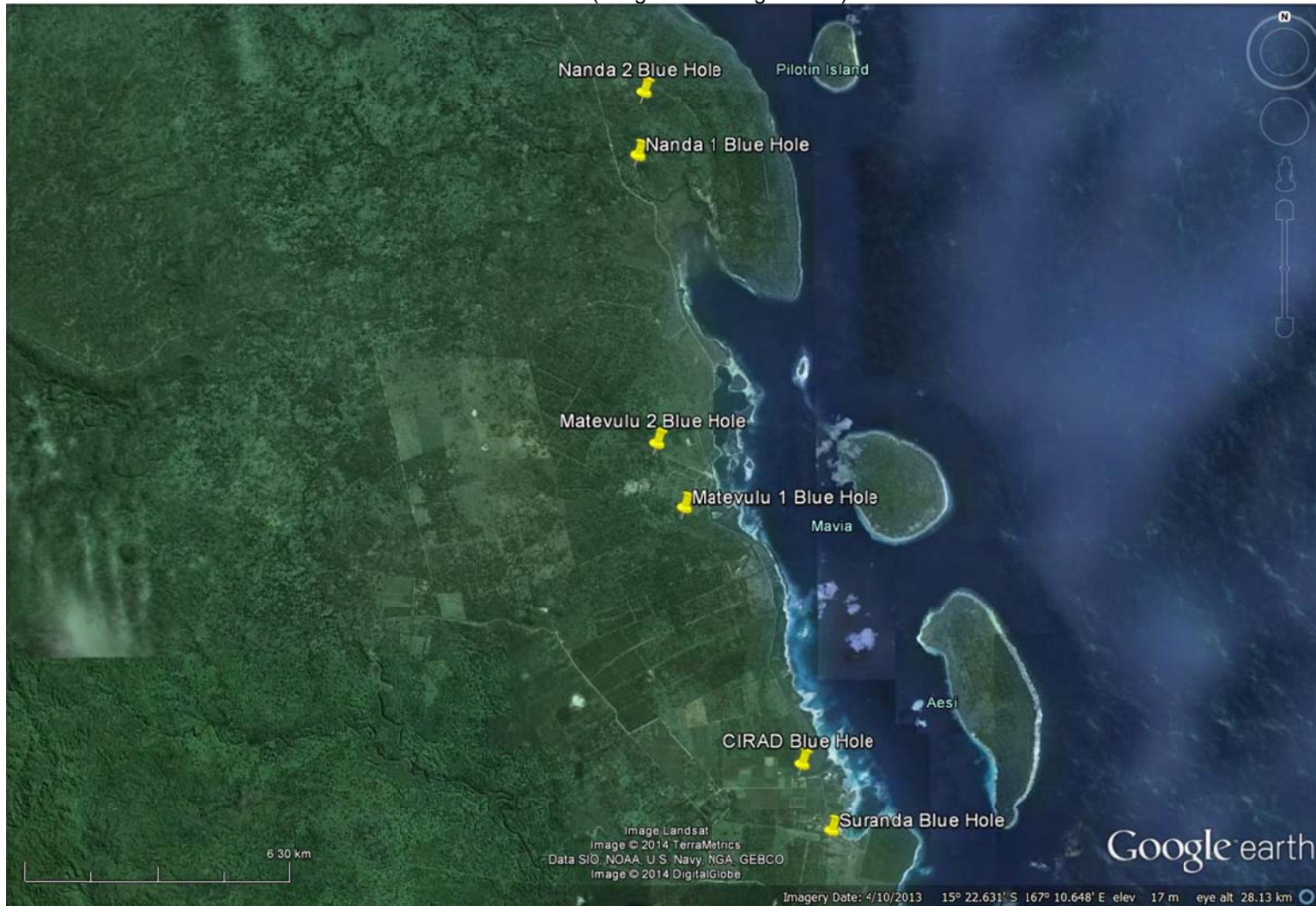
Location of South-east Santo Blue Holes (Image from Google Earth)



South-east Santo Blue Holes: components to be included in the site (for discussion) (Image from Google Earth)



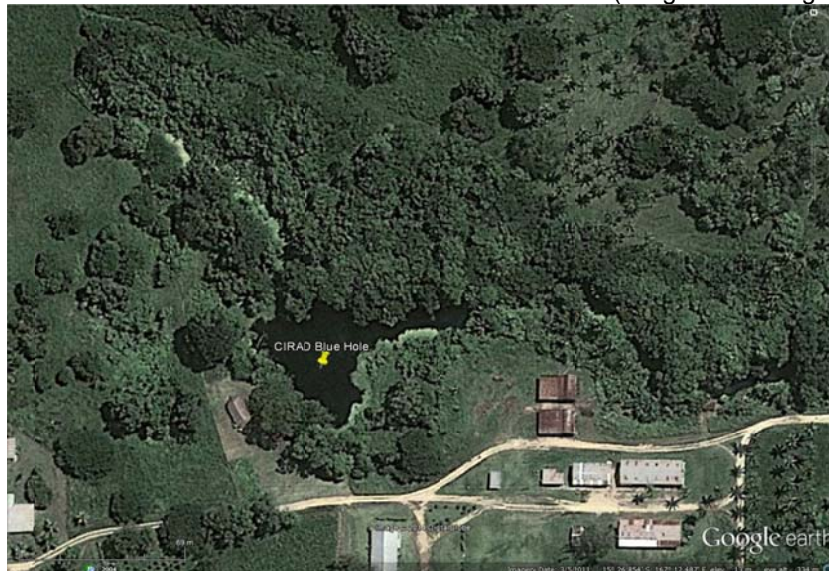
South-east Santo Blue Holes: components to be included in the site (for discussion)
(Image from Google Earth)



South-east Santo Blue Holes: detail of Nanda 1 Blue Hole. (Image from Google Earth)



South-east Santo Blue Holes: detail of CIRAD Blue Hole. (Image from Google Earth)



F. Geomorphic setting:

Elevation: close to sea-level.

The blue holes are situated in the extensive limestone karst region of eastern Espiritu Santo island. As subterranean karst streams and groundwater approach the coast the fresh water is forced upwards by the wedge of saline marine groundwater pressing landwards, resulting in a series of freshwater springs close to the coast. These springs are especially evident in sink-holes (dolines) known locally as 'blue holes' due to the deep blue colour of the clear water emerging from springs in the base of the sink-holes. Water outflows from these holes to the nearby coast via permanent streams.

G. Biogeographic region: Vanuatu Freshwater Ecoregion (Abell *et al.* 2008).

H. Climate:

The climate is humid tropical with a wet season extending from November to April. At Pekoa Airport (6 km south of the southernmost pair of blue holes) near Luganville, in 2009 and 2010 the annual rainfall was measured as between 2,700 and 3,000 mm and mean annual temperature was about 25°C with monthly variation of only one or two degrees. Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil: The soil presumably is derived from limestone geology.

J. Water regime:

A French research team intensively surveyed four of the holes and found they were up to 19 m deep (Nanda = 13 m deep; Matevulu 1 = 19 m; CIRAD = 6.5 m) (Bouchet *et al.* 2011).

K. Water chemistry: Fresh water with a turquoise (blue) hue.

L. Biota:

The open water of the ponds supports abundant plants, fish and aquatic invertebrates. A species of subterranean amphipod is endemic to Nanda Blue Hole and the freshwater hermit crab *Clibanarius fonticola* is endemic to Nanda and Matevulu blue holes (Bouchet *et al.* 2011; Keith *et al.* 2007). Surunda Blue Holes supports at least 5 species of invertebrates and 4 fishes; some blue holes support more than 10 freshwater fishes (Bouchet *et al.* 2011; Keith *et al.* 2007). Matevulu 2 Blue Hole has some water plants growing from its eastern side, where the outflow creek is situated.

M. Land use:

Many of the blue holes are popular tourist destinations.

Surrounding areas in many cases are used for agriculture and cattle grazing and in some cases, small urban areas. Forest surrounds some of the blue holes.

N. Pressures and trends:

Unless tourism is managed carefully the blue holes could become degraded by trampling around the margins and dropping of rubbish. Algal blooms have occurred in one blue hole and could occur in other holes, altering the oxygen balance in the water.

A recent inspection of the Matevulu blue holes (by DK) revealed some clearing of vegetation around Matevulu 2 Blue Hole and some gardening on its eastern side. The landowner of Matevulu 1 Blue Hole reported regular swimming and picnicking at this site by nationals, especially over the weekends, but dropping of rubbish has become a problem.

Adequate buffer zones should be established around each blue hole.

O. Land tenure and administrative authority:

Land tenure: The land in which the blue holes are located is under customary ownership.

Administrative authority: The site is under the jurisdiction of the Department of Lands. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed? No, Vanuatu is not yet a Contracting Party to the Convention.

Q. Ramsar Criteria met:

- Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
- Criterion 3. Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

R. Justification for Ramsar Criteria met:

- Criterion 1: The site is a good representative example of a wetland type found in the Vanuatu Freshwater Ecoregion: karst subterranean wetlands (inland) (Type Zk (b)). These are apparently the best examples of this type of wetland in the ecoregion.
- Criterion 3: A species of amphipod and a species of hermit crab are endemic to these blue holes (see Biota); thus the site meets criterion 3 by contributing significantly to the biodiversity of the ecoregion.

S. Conservation and management status of the wetland:

No specific protection measures have been enacted at the site.

The landowner of Matevulu 1 Blue Hole has shown considerable interest in having the area protected; this was identified during a recent site visit (by DK) and Sanma Province has been informed and will work with the owner on this.

T. Ecosystem services:

- Water supply: a reliable source of fresh water for local people.
- Tourism and recreation: the blue holes are increasingly valued for tourism and recreation, including for international visitors (swimming, canoeing, diving).

U. Current recreation and tourism:

The Blue Holes are a popular tourism attraction in Santo. The two Matevulu blue holes have regular day tours. Platforms and traditional shelters are built over the sides of the two blue holes for swimming activities. Kayaking takes place at Matevulu 2 Blue Hole, where tourists kayak from Oyster Island Resort to the blue hole and back to the resort.

V. Existing scientific research:

In 2006 a sub-set of the blue-holes was intensively studied by a French research team (Bouchet *et al.* 2007).

W. Management plans and monitoring programs: None.

X. Current communication and public education programs:

No information. The landowners primarily use these blue holes for tourist activities and generating income but no awareness-raising has been carried out on their importance for biodiversity and as distinctive wetland types. Sanma Province was made aware of the importance of these blue holes and the need for protection by the Department of Environmental Protection and Conservation during the updating of the Vanuatu wetland site accounts.

Y. References cited:

- Abell, R., Thieme M., Revenga C. *et al.* 2008. Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *BioScience* 58, 403–414.
- Bouchet, P., Le Guyader, H. and Pascal, O. (eds.) 2011. *The Natural History of Santo*. National Museum of Natural History of Paris. 569 pp.
- Keith, P., Lord, C., Marquet, G., Gerbeaux, P. and Kalfatak, D. 2007. List of freshwater species recorded in the rivers of Vanuatu. Unpublished table of records.

Z. Compilers:

Original compilers: Donna Kalfatak and Roger Jaensch, May 2014.

3.15 Creek Ai

This is a **NEW** site, not previously listed in the 1993 Directory.

A. Overview:

A permanent stream emerging from forested limestone catchment on the north-west coast of Efate; the type locality for a freshwater fish species that is endemic to Vanuatu.

B. Area, boundary and dimensions:

Area: about 50 ha.

The boundary of the site is defined as the channel of Ai Creek from its sea mouth upstream for about 2.4 km, with a 50 m buffer zone on both sides of the channel.

Note: Alternatively, the boundary could extend farther upstream or be the entire catchment of Ai Creek.

C. Location:

Coordinates: 17°36.51-36.91'S, 168°14.45-15.47'E

Creek Ai is located on the north-west coast of Efate, 15 km north of Port Vila. It originates up to 8.7 km inland on a limestone plateau and emerges at the sea near Manga'asi village.

Province: Shefa.

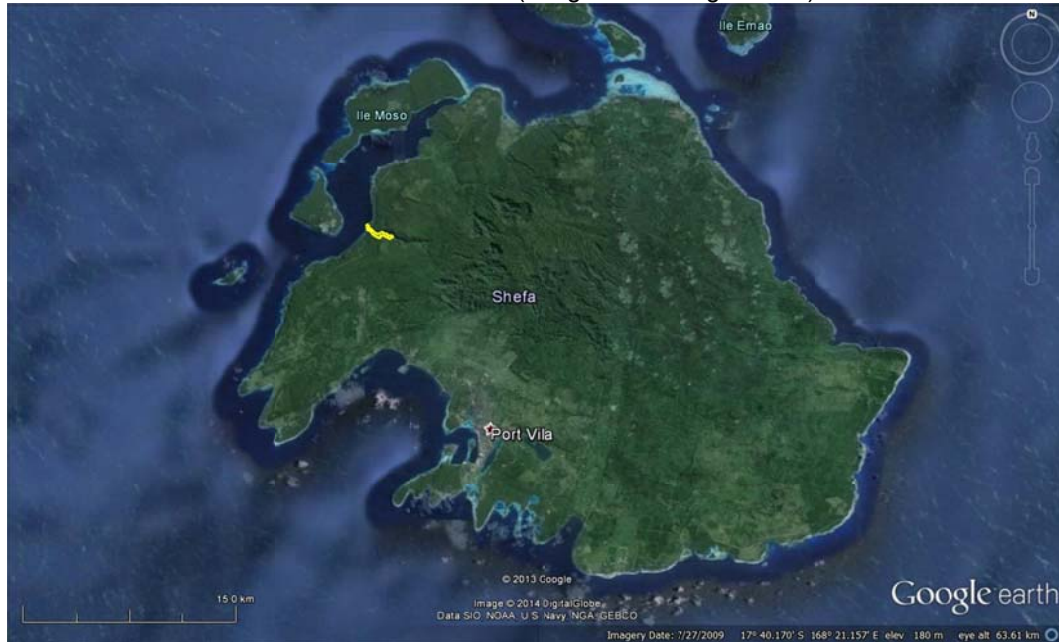
Local man with throw net, Creek Ai (Photo: R. Jaensch)



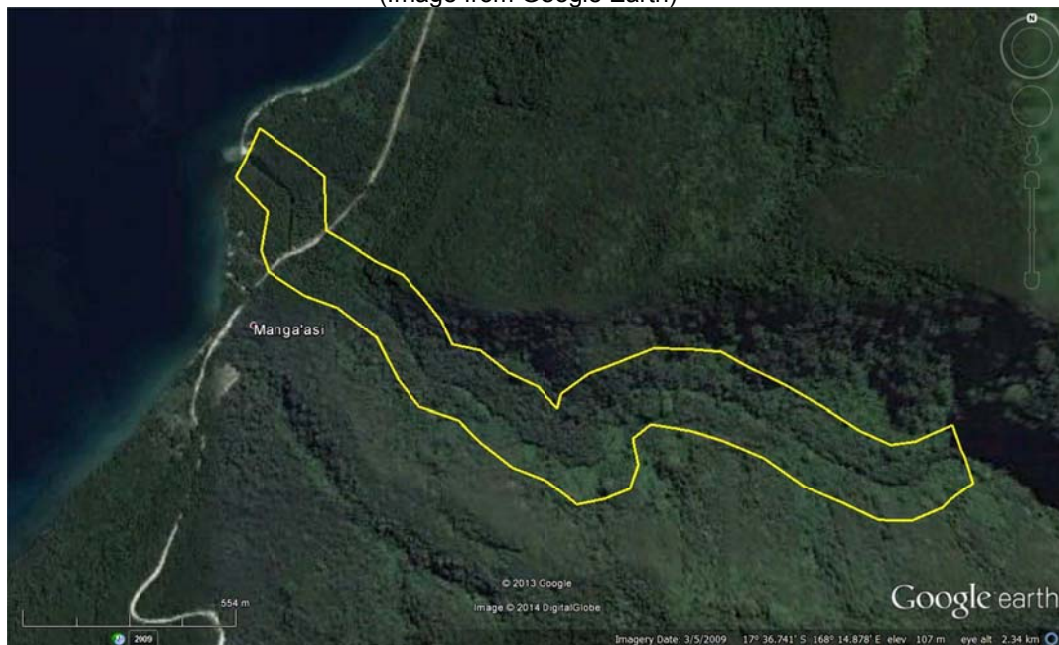
D. Site maps:

The site boundary shown in this account serves to define the scope of information in the site account and has no legal status. It is provisional and subject to further discussion.

Location of Creek Ai (Image from Google Earth)



Creek Ai: suggested site 'boundary' (for discussion)
(Image from Google Earth)



Creek Ai: suggested site 'boundary' (for discussion)
(Image from Google Earth)



E. Ramsar Wetland Types:

M: permanent stream.

F. Geomorphic setting:

Elevation: from sea-level to several metres above sea-level.

Creek Ai originates in a limestone plateau and passes through steep-sided valleys before emerging on the coast. It has no floodplain.

G. Biogeographic region: Vanuatu Freshwater Ecoregion (Abell *et al.* 2008).

H. Climate:

The climate is humid tropical with little seasonal variation in rainfall, although November to April are slightly wetter than the other months. At Bauerfield Airport near Port Vila (12 km to the south-east), from 2009 to 2012 the average annual rainfall was 2,353 mm and mean annual temperature was about 25°C with monthly variation of only one or two degrees. (Older sources (1993 Directory) state the average annual rainfall in this area as 2,270 mm.) Land and sea areas of Vanuatu experience 2-3 cyclones per year, mostly during January to March; some cyclones are very destructive.

I. Soil:

The soil is derived from limestone geology. The stream bed includes areas of sand and rubble substrate.

J. Water regime:

The stream is permanent. During periods of heavy rainfall, water level in Creek Ai may rise about 2 m at the crossing of the coastal road, 300 m upstream of the coast.

K. Water chemistry:

The water is fresh and clear as it comes from a totally forested catchment.

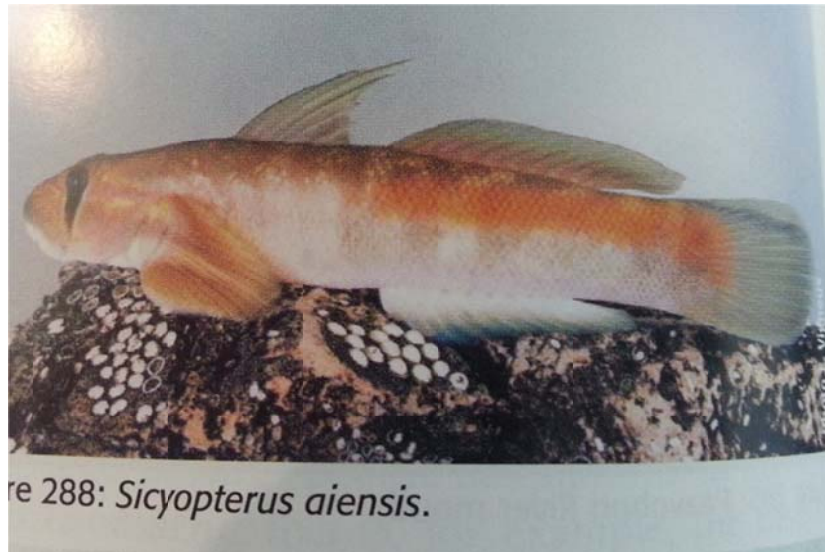
L. Biota:

The stream is too small and fast flowing to have developed communities of wetland-dependent plants but remnants of native dry-land forest occur along the creek's lower reaches.

Freshwater fishes and invertebrates of Creek Ai were surveyed by the French Museum and DEPC staff in 2002, 2003 and 2005 (Keith *et al.* 2007). So far, 16 freshwater crustaceans from six genera (including 6 species of *Macrobrachium* and 4 spp. of *Caridina*) and 15 species of freshwater fish – mostly gobies – from 12 genera (e.g. the eel *Anguilla marmorata*, two species of *Kuhlia*) have been recorded from the creek. The creek is the type locality for the goby *Sicyopterus aiensis* (Keith *et al.* 2004) which was named after the locality and has subsequently been found on at least six of Vanuatu's islands (Keith *et al.* 2007).

Eastern Reef Egrets *Egretta sacra* occasionally venture up the creek to feed on fish and crustaceans.

The Vanuatu endemic fish, *Sicyopterus aiensis* (Photo: from Bouchet *et al.* 2011)



M. Land use:

Especially near the road crossing, the creek is used by people from local villages – including from the nearby island – for collection of fresh water (there is no supply on that island) and for personal washing. Due to its accessibility it is also a popular site for recreational swimming. Some small-scale subsistence fishing occurs.

Upland catchment has little or no land use but the margins of the lower reaches have some gardens.

N. Pressures and trends:

Some gardens are on the banks of the creek and thereby contribute to sedimentation during higher flows. As land around the lower reaches of the creek is increasingly sold to non-local/foreign owners, it is being developed for even less compatible developments.

O. Land tenure and administrative authority:

Land tenure: Mostly under customary ownership, with some recent sales to immigrant owners.

Administrative authority: The site is under the jurisdiction of the Department of Lands. Ownership questions are addressed by the Land Tribunal assisted by the island court.

P. Ramsar listed? No, Vanuatu is not yet a Contracting Party to the Convention.

Q. Ramsar Criteria met:

Criterion 1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

Criterion 3. Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

R. Justification for Ramsar Criteria met:

Criterion 1: The site is a good representative example of a wetland type found in the Vanuatu Freshwater Ecoregion: permanent stream (Type M) and its catchment is largely undisturbed.

Criterion 3: One species of freshwater fish *Sicyopterus aiensis* occurring at the site is endemic to Vanuatu and thus the bioregion; therefore, the site meets criterion 3 by contributing significantly to the biodiversity of the ecoregion. The site has additional biodiversity significance because it is the type locality of this species.

S. Conservation and management status of the wetland:

The upper catchment of Creek Ai is within an area protected from development in order to sustain water supply in this part of Efate. No specific protection measures have been enacted at lower reaches of the site.

T. Ecosystem services:

Water supply: a reliable source of fresh water for local people.

Food supply: small quantities of fish and crustaceans are harvested from the creek by local people.

Recreation: a popular site with local people and travellers for swimming.

U. Current recreation and tourism: See item T: ecosystem services.

V. Existing scientific research:

A series of surveys of freshwater species has been conducted by the French Museum (Keith *et al.* 2007).

W. Management plans and monitoring programs: None at present.

X. Current communication and public education programs: None at present.

Y. References cited:

Abell, R., Thieme M., Revenga C. *et al.* 2008. Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *BioScience* 58, 403–414.

Bouchet, P., Le Guyader, H. and Pascal, O. (eds.) 2011. The Natural History of Santo. National Museum of Natural History of Paris. 569 pp.

Keith, P., Marquet, G. and Watson, R.E. 2004. *Sicyopterus aiensis*, a new species of freshwater goby from Vanuatu (Teleostei: Gobioidaei). *Cybium* 28: 111-118.

Keith, P., Lord, C., Marquet, G., Gerbeaux, P. and Kalfatak, D. 2007. List of freshwater species recorded in the rivers of Vanuatu. Unpublished table of records.

Z. Compilers:

Original compilers: Donna Kalfatak and Roger Jaensch, May 2014.

Appendix 1. List of freshwater fishes and invertebrates recorded from Ai Creek, Efate, Vanuatu (Keith *et al.* 2007)

CRUSTACEANS

Caridina brevicarpalis
Caridina longirostris
Caridina weberi
Caridina serratirostris
Macrobrachium australe
Macrobrachium latidactylus
Macrobrachium gracilirostre
Macrobrachium lar
Macrobrachium bariense
Macrobrachium placidulum
Palaemon concinnus
Palaemon debilis
Atyopsis spinipes
Atyoida pilipes
Varuna litterata
Utica gracilipes

FISH

Anguilla marmorata;
Stiphodon rutilaureus
Stenogobius sp.
Kuhlia munda
Kuhlia rupestris
Eleotris fusca
Microphis retzii
Microphis meto
Glossogobius celebius
Redigobius bikolanus
Sicyopterus lagocephalus
Sicyopterus aiensis.
Ophieleotris aporos
Hypseleotris guentheri
Schismatogobius sp.

4 Candidate new sites

During the process of conducting the 2014 update, a number of candidate new sites were identified through literature searches and consultations. Time and resources did not allow preparation of full site accounts nor review or consultation on drafts for these sites. However, to guide future updates these sites are listed below, with brief notes on their importance.

Homo Bay River (Pentecost)

Coordinates: 15° 57'S, 168° 12'E

Wetland types: permanent river.

Importance: one endemic freshwater fish.

Threats: invasive plants.

Conservation measures: a conservation area covers lower reaches and may be extended upriver into headwater catchment.

Comments: site is included in the Forestry and Protected Area Management Project.

Talise River (Maewo)

Coordinates: to be determined.

Wetland types: permanent river.

Importance: four species of endemic freshwater fish.

Threats: flow has been modified by a hydroelectricity project.

Conservation measures: no information.

Comments: data are available from an EIA for the hydro development.

North Ambae streams (Ambae)

Coordinates: 15° 21'S, 167° 47'E

Wetland types: seasonal streams.

Importance: one species of endemic freshwater fish.

Threats: no information.

Conservation measures: no information.

Comments: the streams are immediately north of the Ambae Caldera Lakes.

Millenium Cave (Santo)

Coordinates: to be determined.

Wetland types: subterranean karst wetland (cave, stream).

Importance: a spectacular example of this wetland type.

Threats: no information.

Conservation measures: no information.

Comments: the site is a popular ecotourism and recreation feature.

Eratap Mangroves (Efate)

Coordinates: 17° 47'S, 168° 21'E

Wetland types: mangrove forest; shallow tidal lagoon.

Importance: fish nursery; source of fish, timber and firewood; protection of coast.

Threats: ecotourism developments (clearing of mangrove, increased turbidity).

Conservation measures: no information.

Comments: two resorts have been established in the site; the site was included in the MESCAL project on mangroves; economic value of products assessed.

Rakotom River (Erromanga)

Coordinates: to be determined.

Wetland types: permanent river; estuary.

Importance: one species of endemic freshwater fish.

Threats: no information.

Conservation measures: no information.

Comments: the only important site identified so far in southern Vanuatu.

Other sites for which less information has been obtained, but which may prove to meet criteria for importance, are:

- Belmoul Inlet and swamp wetlands complex (Santo)
- Lusunwe and Sarakata Rivers (Santo)
- Aseluka Lagoon system (Malo)
- Nguna-Pele Marine and Land Protected Area Network (Efate)
- Black sand turtle-nesting beach near Male (Efate)
- A seagrass area (Aneityum).