WorleyParsons®
resources & energy

EcoNomics™

GOVERNMENT OF TIMOR-LESTE, THROUGH THE SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

ATTACHMENT 1

Tasi Mane - Suai Supply Base EIA

Terrestrial Flora and Fauna Technical Report

DRAFT

301012-01504-EN-REP-0001

23 March 2012

Level 7, QV1 Building
250 St Georges Terrace
Perth WA 6000 Australia
Tel: +61 8 9278 8111
Fax: +61 8 9278 8110
www.worleyparsons.com
WorleyParsons Services Pty Ltd
ABN 61 001 279 812

Disclaimer

PROJECT 301012-01504 - TASI MANE - SUAI SUPPLY BASE EIA

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	M Love	S Hudson	A Faulkner	23 Mar 12	N/A	
0	Issued for client review				23 Mar 12		

CONTENTS

Appendices

EXECUTIVE SUMMARY

In December 2011, WorleyParsons was commissioned by the Secretaria de Estado dos Recursos Naturais, on behalf of the Government of Timor-Leste, to undertake a flora and vertebrate fauna assessment for the Tasi Mane Project, specifically the Suai supply base. This was part of a wider commission to prepare an environmental impact assessment to describe the likely environmental and social impacts associated with the proposed development.

The Suai supply base will be located on the south coast on the island nation of Timor-Leste. Timor-Leste is part of the Lesser Sunda Archipelago, an assemblage of islands comprised of a northern, volcanogenic arc (the Inner Banda Arc, with main islands Bali, Lombok, Sumbawa, Flores, and Wetar) and a southern, orogenic arc (the Outer Banda Arc, with main islands Sumba, Roti, and Timor). The site is approximately 90 km south west of the capital city of Dili.

The flora assessment and the vertebrate fauna assessment for the project occurred from 9 to 13 December 2011 and from 6 to 8 February 2012.

The objectives of the flora assessment were to:

- Validate the accuracy of desktop reviews;
- Describe broad vegetation units and agricultural areas;
- Identify remnant areas of primary and secondary forest, coastal forest and mangroves;
- Identify species of potential conservation significance (International Union for Conservation of Nature (IUCN) Red List);
- Identify species of economic importance (teak, rosewood, sandalwood, food crops); and
- Determine any significant impacts to species or vegetation communities of conservation significance.

The objectives of the vertebrate fauna assessment were to:

- Validate the accuracy of desktop reviews;
- Ground-truth the extent and condition of fauna habitat types present;
- Identify species of potential conservation significance (IUCN Red List);
- Further delineate and characterise the species and fauna habitat types present and potentially present at each site;
- Provide additional information for any subsequent clearing requirements; and
- Determine any significant impacts to species of conservation significance.

The Tasi Mane Project - Suai Supply Base investigation is discussed further in this report. The geographical area covered by this project is termed the Suai development area, and it comprises five components: the Suai supply base, industrial estate, Nova Suai, Suai Airport upgrade, and two crocodile reserves (We Dare and We Matan Bua Oan).

Flora and vegetation results for the Suai development area are preliminary at this stage and limited to specimens identified from the first survey conducted in December 2011. Dominant and common species were the main focus of the flora and vegetation survey due to time constraints. Most flora recorded in the Suai development area have a widespread distribution in the tropics. Three of these species are listed on the IUCN's Global Invasive Species Database (GISD) of the 100 worst invasive species, Siam weed *(Chromolaena odorata*), cogon grass (*Imperata cylindrica*) and coffee bush (*Leucaena leucocephala*).

Thirty-six plant species are listed as being of 'Least Concern' on the IUCN Red List for Timor-Leste, and none of these were recorded during the field survey. No further flora species were listed by the IUCN Red List specifically for Timor-Leste; however, sandalwood (*Santalum album*) and rosewood (*Pterocarpus indicus*), both 'Vulnerable' species listed for south-east Asia, were recorded in the Suai development area.

Several species of economic or local importance, primarily timber or food crops, were recorded in the Suai development area. Two of these species, rosewood (*Pterocarpus indicus)* and sandalwood (*Santalum album)* are also of conservation concern. Small plantations or estates of coconuts, bananas, and occasionally mango were present in the Suai development area. The tenure of trees within estates may be external to local villages. Occasional fruit and spice trees were encountered and appear to be individually owned and marked accordingly.

Natural vegetation within the Suai development area exists primarily as narrow bands of open coastal forest with small areas of mangrove and riparian vegetation. The coastal plain has largely been cleared in association with swidden (or 'slash and burn') agriculture, sandalwood harvesting, plantation estates and timber plantations. Remnant vegetation exists as highly fragmented and secondary communities.

Mangroves, which are considered to be of conservation significance, were recorded in the proposed areas for the crocodile reserves and supply base. Mangroves are an important coastal habitat for marine organisms and also function to stabilise soils, thereby reducing the amount of soil erosion that would otherwise occur.

Within the Suai development, area 68 species of vertebrate fauna were recorded, consisting of two species of amphibians, seven species of reptiles, 48 species of birds and 11 species of mammals. Due to a lack of baseline knowledge and regional context, it is difficult to gauge the adequacy of survey effort and therefore the extent of expected faunal assemblages for the area.

Species listed as Critically Endangered, Endangered, Vulnerable and Near Threatened under the IUCN Red List constitute species as having conservation significance. Lack of baseline data of Timor-Leste's fauna means that conservation significant species which have not been recorded may still be

present. Five species of conservation significance were recorded in the study area: the yellow-crested cockatoo (*Cacatua sulphurea*), canut's horseshoe bat (*Rhinolophus canuti timoriensis*), beach thick-knee (*Esacus magnirostris*), slaty cuckoo dove (*Turacoena modesta*) and Timor bush-chat (*Saxicola gutturalis*). The yellow-crested cockatoo (listed as Critically Endangered on the IUCN Red List) was recorded on five occasions within the Suai development area, making the habitat within the Suai development area potentially sensitive to environmental impacts proposed by the project.

Limitations existed for both the flora and vegetation, and fauna surveys, given the limited assessment period. Further survey effort to achieve optimum results should be undertaken throughout the year and for longer periods of time, enabling the identification of a broader range and seasonality of species to be identified.

Environmental impacts associated with flora and vegetation include but are not limited to; the loss of IUCN listed flora species, loss of commercial timber species, loss of mangrove habitats, spread of weeds and the destabilization of soils.

Fauna environmental impacts include the potential depletion/degradation of the habitat associated with supporting five conservation significant species found in the Suai development area, one of which is Critically Endangered.

1. INTRODUCTION

In December 2011, WorleyParsons was commissioned by the Secretaria de Estado dos Recursos Naturais (SERN), on behalf of the Government of Timor-Leste (GoTL) to undertake a flora and vegetation, and vertebrate fauna assessment of the Tasi Mane Project – Suai Supply Base (the project). This study involves only one of thje three components of the Tasi Mane project - the development of the Suai supply base component. This was part of a wider commission to prepare an environmental impact assessment (EIA) to describe the likely environmental and social impacts associated with the proposed development.

The project comprises the following components:

- Supply base area;
- Industrial estate;
- A new town, Nova Suai;
- Upgrade to the existing Suai Airport; and
- Two crocodile reserves.

1.1 Location

The Suai development area will be located on the south coast of the island nation of Timor-Leste. Timor-Leste is part of the Lesser Sunda Archipelago, an assemblage of islands comprised of a northern, volcanogenic arc (the Inner Banda Arc, with main islands Bali, Lombok, Sumbawa, Flores, and Wetar) and a southern, orogenic arc (the Outer Banda Arc, with main islands Sumba, Roti, and Timor). The Suai development area is approximately 138 km south west of Dili (the capital city of Timor-Leste).

1.2 Project Brief/Scope

The proposed project development is likely result in the clearance of some terrestrial flora and vegetation, and have further adverse impacts on the species that currently relies on the vegetation. WorleyParsons' ecological team surveyed and described terrestrial flora and vertebrate fauna species at each site in accordance with the terms of reference, in order to provide sufficient information to address both biodiversity conservation and ecological function values, and meet the GoTL objectives for the protection of the environment.

The Tasi Mane Project - Suai Supply Base investigation is discussed further in this report. The geographical area covered by this project is termed the Suai development area, and comprises five components: the Suai supply base, industrial estate, a new town (Nova Suai), upgrade to the existing Suai Airport, and the extablishment of two crocodile reserves.

A broad focus approach was taken to flora and vegetation surveys in order to obtain information on species and areas of conservation and economic importance. Given time constraints and limited knowledge of the flora and vegetation in the Suai development area, the survey focused on potential matters of environmental and economic importance to the people of Timor-Leste and GoTL.

A greater emphasis was placed on the flora survey rather than the vegetation survey due to time constraints. This allowed for the collection of preliminary baseline information in the absence of a baseline survey. Adequate baseline flora data is a prerequisite to completing meaningful vegetation survey work. This also provided more time to focus on the assessment of threatened species and economically important species. Broad objectives for the assessment included:

- Review existing knowledge on the flora, vegetation and fauna of Timor-Leste through a desktop study;
- Conduct a database search to identify species of potential conservation significance on the IUCN Red List;
- Describe, analyse and report on the project's terrestrial flora and vertebrate fauna species present;
- Describe the conservation significant species present in and within the vicinity of the project; and
- Provide baseline ecological knowledge for the project.

1.3 Regulatory Context

The Democratic Republic of Timor-Leste (RDTL) became party to the United Nations Convention on Biological Diversity (UNCBD) in 2007. A thematic assessment report of Timor-Leste was prepared for the UNCBD by Alves (2007). Under this Convention, countries are obliged to develop a National Biodiversity Strategy and Action Plan (NBSAP) which involves identifying actions and measures for conservation of biodiversity. Timor-Leste is yet to develop regulations and policy documents specifically addressing biodiversity conservation.

There are several laws and regulations from previous administrations (United Nations Transitional Administration in East Timor (UNTAET) and Indonesian) that address environmental protection and biodiversity conservation in Timor-Leste:

- Law No. 5, 1990 on Conservation of Biological Resources and their Ecosystems;
- Law No. 5, 1994 Concerning Biodiversity;
- Government Regulation No. 28, 1985 on Forest Protection;
- Government Regulation No. 51, 1993 on Environmental Impact Analysis;
- UNTAET Regulation No. 2000/17; and

- UNTAET Regulation No. 2000/19.

UNTAET Regulation No. 2000/19 on protected places (30 June 2000) was in place for the purpose of protecting designated areas, endangered species, wetlands, mangrove areas, historic, cultural and artistic sites, conservation of biodiversity and protection of the biological resources of Timor-Leste. Fifteen natural areas were protected under this regulation and have been designated as Protected Natural Areas (PNAs). The majority comprise primary forest areas, coral reefs, mangroves, wetland habitat and mountain summits above 2,000 m.

Of particular relevance to this survey is:

- Section 5 - Wetlands and Mangroves, which states that wetlands and mangrove areas shall be protected. Cutting, damaging or removing of a mangrove shall be prohibited; and
- Section 3 - Endangered Species – which states that endangered species and their habitats shall be protected throughout the terrestrial territory of Timor-Leste.

Section 3 states that the following species of animal shall constitute endangered species within Timor-Leste:

- Sea turtles;
- Marine mammals, including bottlenose dolphins, whales and dugongs;
- Wallabies;
- Crocodiles;
- All animal and plant species listed in Appendix I or Appendix II of the Convention on the International Trade in Endangered Species; and
- Any other plant or animal species designated as endangered by the Transitional Administrator.

The State Secretariat for the Environment (SEMA), under the Ministry of Economy and Development, and the Ministry of Agriculture, Forestry and Fisheries (MAFF) are the two government agencies with primary responsibilities for the environment. SEMA deals with the environmental issues in the sectors, and MAF deals with resource management, including; forests, fisheries, and biodiversity conservation. The laws and regulations from previous administrations listed above are not necessarily recognized.

The Convention on International Trade in Endangered Species (CITES) is an international agreement that aims to ensure that international trade in fauna and flora does not threaten their survival. The Convention controls international trade in fauna but does not necessarily reflect conservation status in a particular country. Appendix I lists species that are considered the most endangered among CITES-listed animals and plants, while Appendix II lists species that are not necessarily currently threatened with extinction but that may become so unless trade is closely controlled. Consequently, CITES can be used to provide some indication of the relative global conservation status of species listed under CITES but not assessed on the IUCN Red List (e.g., pythons, monitor lizards, birds of prey).

2. EXISTING ENVIRONMENT

2.1 Climate

Little climate information is available for the south-coast of Timor-Leste. Trainor *et al*. (2008) identified Timor-Leste as having a highly seasonal, dry tropical climate which is geographically variable depending on the elevation and aspect of the location. The south coast is known to receive the highest rainfall, falling in the wet season which occurs mainly between November and April and extending sometimes to June **(**Trainor 2008). The annual precipitation for Timor-Leste is approximately 1,500 to 4,000mm of rain per year (Trainor *et al*. 2008). Coastal towns are typically hot during the day (31°C to 33°C) and warm at night (20°C to 25°C); however, the dry season is cooler (18°C to 20°C at night compared to 25°C to 28°C by day) and less humid (Trainor 2008).

2.2 Biogeography

The island of Timor-Leste is part of the Malay Archipelago, representing the largest and easternmost of the Lesser Sunda Islands (World Bank 2009). The island is non-volcanic, part of the Outer Banda Arc, derived from the basement of rocks of the Australian continental margin and is characteristically limestone with karst formations.

Timor-Leste is located in the Central Melesia (Wallacea) region and its flora is considered to be transitional between the main rainforest blocks of the Sunda (Peninsula Malaysia, Sumatra, Borneo, West Java) and Sahul (New Guinea) shelves (van Welszen *et al.* 2005).

Few publications document the flora and vegetation of Timor-Leste; however, some information can be gained from studies undertaken in the bordering country of Nusa Tenggara (West Timor) and surrounding islands. A review of literature by Monk *et al.* (1997) concludes that Nusa Tenggara has a mixture of Indo-Malay and Australian elements.

A total of 407 endemic species and five genera of plants are known from Nusa Tengarra and Maluku, of which only eight species are shared between each location (Monk *et al.* 1997). Nusa Tengarra and the Maluku groups of islands have differing geological origins, ranging from young, active volcanic islands, to limestone with karst formations. The plant genera endemic to Timor are *Sautiera* and *Sinthraoblastes*. Timor was identified as having the highest number of endemic species recorded in Indonesia, at approximately 10.3% (Monk *et al.* 1997).

Both Indo-west Malaysian (rainforest plants) and eastern genera species (mix of rainforest and seasonal) are moderately represented in Nusa Tenggara. Wallace's Line has no significance for plants between Bali and Lombok Islands and both western and eastern floral elements are present. Wallace's Line was not the most significant biogeographic boundary for plant species in the study (Rhee *et al.* 2004).

The following broad vegetation types have been described within Nusa Tenggara:

- Lowland Evergreen Rainforests are common, generally on the drier slopes;
- Semi-Evergreen Rainforest is structurally complex vegetation which is transitional between Lowland Evergreen Rainforest and Monsoon Forest;
- Montane Forest – little seasonal Montane Forest survives in Nusa Tenggara;
- Seasonal Montane Forest occurs above Monsoon Forest, and would have originally covered mountainous areas in Nusa Tenggara;
- Heath Forests are rare with small patches in Timor-Leste;
- Forests on ultra-basic rocks occur on Timor island;
- Forests on limestone rocks in Nusa Tenggara occur in both ever wet and seasonal areas; and
- Mangroves – small areas.

Existing forest cover in Timor-Leste occurs in scattered areas along the south coast with smaller remnants elsewhere. The former closed forest areas of Timor-Leste currently consist of a mosaic of secondary forest and grassland, possibly with primary forest fragments. In 1991, approximately one quarter of the forested area was primary forest and three quarters was secondary forest (Oxfam 2003).

The rate of deforestation in Timor-Leste from 1972 to 1999 has been estimated at 1.1% per year, which is four times as high as the global average of 0.3%. The direct results have been severe soil erosion, reduced forest productivity and loss of biodiversity (Alves 2007).

Alves (2007) identified that there are six major ecosystem types recognized within Timor-Leste and the status of biological diversity was assessed for each (Table 1).

Table 1 Ecosystem Types

Ecosystem Type	Description	Efforts to Manage Biological Diversity
Marine and Coastal Zone	Includes specialised coastal vegetation like mangroves, shallow seas adjacent to land, coral reefs and sea grass beds	Mangroves and coral reefs are protected by (UNTAET) Regulation No. 2000/19
Arid Lowland Areas	n/a	n/a
Moist Lowland Areas	Include those areas roughly between the altitudes of 0 and 600 m, where the temperatures are above 24°C, there is a heavier rainfall and the dry season lasts three months. The original vegetation was mainly moist deciduous forest, semi-evergreen forests or rain forests. Present vegetation includes cultivated lands, plantations, secondary vegetation and some badlands. Includes the coastal plain and steep hillsides	BirdLife International has identified nine Important Bird Areas in closed forest canopy vegetation Identification of two endangered tree species, conservation and restoration activities including provision of seedlings (government initiated reforestation)
Mountainous Areas	Areas characterised by steep terrain, of altitudes 600 m and above, originally semi-evergreen forest, moist deciduous forest or non-deciduous forest	Specific sites are protected by (UNTAET) Regulation No. 2000/19
Highland Plains	n/a	n/a
Wetlands	n/a	n/a

2.3 Flora and Vegetation

2.3.1 Previous Surveys

Recent published flora and vegetation knowledge has been confined to the far east of Timor-Leste. Since Timor-Leste independence, several flora and vegetation surveys have been undertaken in the

proposed Jaco-Tutuala-Lore National Park (Cowie 2006, 2007). The proposed park contains the largest remaining area of natural closed forest vegetation on the island of Timor-Leste. Several flora and vegetation surveys have also been completed for proposed infrastructure projects such as the Iralalaro Hydropower Project (Cowie 2007). The flora of Timor-Leste was estimated at 2,500 species and 22 new plant species were recorded during preliminary findings by Cowie (2006).

Cowie (2006) provides an account of the previous botanical exploration of Timor-Leste and states that there are limited recent flora checklists for Timor-Leste. Flora collections have been intermittent and were often conducted for specific purposes such as ethnobotanical study or taxonomic studies relating to specific groups. A recent checklist of Timor-Leste orchids comprised 66 species, including 32 new species records for the island, and four newly described species (Silveira *et al.* 2008). At least 10 species are considered endemic to Timor-Leste. This list is likely to increase as further plant material is identified and further botanical research is undertaken.

Primary forests are closed communities including ever-wet, semi-evergreen and moist deciduous forests. These feature an abundance and dominance of tree species with relatively large fleshy fruits (bird attractive fruits). These trees may be dependent on larger fruit pigeons and flying foxes for dispersal of seed.

The large fruited trees are absent from the secondary dry deciduous forest and thorn forest typical in most parts of Timor-Leste.

2.4 Fauna

2.4.1 Previous Surveys

Current documented vertebrate fauna knowledge of Timor-Leste is limited, especially for the south coast. The few biological surveys that have been undertaken within the past ten years include Rapid Biodiversity Surveys in Jaco Island and Lake Iralalaru areas, which were conducted by conservation organisations such as BirdLife International in conjunction with NDCF.

Historically, the vertebrate fauna of Timor-Leste has been poorly documented; however, some studies have been conducted on herpetofauna, birds and mammals. Kaiser *et al.* (2011) conducted field surveys throughout Timor-Leste resulting in the identification of seven species of amphibians and 30 species of reptiles. Among the amphibians the most frequently encountered were toads, rice paddy frogs and rhacophorid treefrogs (Kaiser *et al*. 2011). Common skinks included the four fingered skinks (*Carlia* spp.), wedge skinks (*Sphenomorphus* spp.) and night skinks (*Eremiascincus* spp.). Of the snakes recorded, pitvipers such as *Cryptelytrops insularis* amounted to 25% of all the snakes found.

Trainor *et al*. (2008) noted that 262 bird species are known for Timor-Leste, and of these, 169 are considered resident, 76 regular migrants and 17 vagrants. Up to 1980, 24 ornithological surveys or reports are listed for Timor Island (White and Bruce 1986). Recent studies by Richard Noske (Noske 1994, 1996, 1997, Noske and Saleh 1996) have added many new birds to the expected species list.

Extensive tropical forests in Lautem district have been the prime target of recent fieldwork Trainor *et al*. (2008).

The mammal faunas are dominated by Asian families and species where at least 52 mammalian species potentially occur, with about one-third introduced Trainor *et al*. (2008). Remarkably, only four native terrestrial mammals have been recorded including the Timor Shrew (*Crocidura tenuis*), Sunda shrew (*Crocidura maxi*), timor rat (*Rattus timoriensis*) and ricefield rat (*Rattus argentiventer*) Trainor *et al*. (2008). Timor once had a native rat fauna including giant rats, but these may have become extinct after the introduction of mammals associated with human settlement during the last 1,000 to 7,000 years (Glover 1986).

There have been relatively few bat surveys on the island of Timor, and the fauna is not yet completely described. The earliest and still the most comprehensive summary of the bats of Timor is that of Goodwin (1979), who conducted field surveys, an extensive examination of museum collections and a review of the literature to derive a list of taxa with their current taxonomy. Based on Goodwin's field surveys and taxonomic examinations, there are 22 species known from Timor, 11 of which he added (Goodwin 1979).

3. METHOD

3.1 Survey Areas

An investigation of flora and vegetation communities, and fauna was completed at Suai supply base development area, including the proposed Suai supply base, industrial estate, Nova Suai, Suai Airport updgrade, and two crocodile reserves (We Dare and We Matan Bua Oan).

3.2 Timing of Surveys

A five day field survey was made from 9 to 13 December, 2011, and a second three day field survey from 6 to 8 February, 2012.

3.3 Flora and Vegetation

3.3.1 Desktop Review – IUCN

Before fieldwork was undertaken, data from a detailed desktop review of historical information and past surveys undertaken near the study area was compiled into a list of flora, vegetation and fauna species present.

The IUCN Red List of Threatened Species was used for this desktop review, identifying the conservation status of some species in Timor-Leste that have been assessed by IUCN.

The IUCN Red List is recognised globally as being the most comprehensive tool for evaluating the conservation status of plant and animal species, not only allocating a category (out of nine) for relative risk of extinction but also their distribution. Conservation can then be targeted towards those species at higher risk of extinction. A full description and list of IUCN categories is available in **Appendix 1**.

The flora and vegetation assessment comprised of a desktop review to collate historical data and/or knowledge, previous opportunistic flora collections and delineation and characterisation of the known range of vegetation communities present in the study area. The flora and vegetation desktop assessment included:

- Review of all available and current information; and
- IUCN Red List search;

3.3.2 Vegetation Survey

A broad assessment of plant communities and their distribution, floristic composition and structure was undertaken. Vegetation communities were sampled opportunistically within each study area at

observation points. Information regarding dominant species present and the physical characteristics at each site was recorded. It was not possible to complete a quadrat sampling design in the time available for surveys.

Vegetation descriptions used for the Suai development area were adapted from those developed by Cowie (2006, 2007) in the Lautem district on the east coast of Timor-Leste, approximately 100 to 200 km from the study area. Descriptions were based on vegetation structure and dominant species composition.

3.3.3 Flora Survey

The overall objectives of the flora and vegetation assessment within the Suai development area include:

- Identify species of potential conservation significance (IUCN Red List);
- Identify commercial timber and food crops (teak, coconuts, bananas, sandalwood);
- Collect and photograph dominant species;
- Describe broad vegetation units – remnant areas of primary and secondary forest, coastal, mangroves, agricultural, riparian; and
- Determine any significant impacts to species or vegetation communities of conservation significance.

Within the Suai development area more emphasis was given to the flora survey than the vegetation survey. This approach was adopted by Cowie (2006, 2007) for the east coast of Timor-Leste and allows for the collection of preliminary baseline information for the project in the absence of a baseline survey. Adequate baseline flora data is a prerequisite to completing meaningful vegetation survey work. This also provided more time to focus on the assessment of threatened species and economically important species.

The flora survey aimed to record the diversity of flora species in the Suai development area, with a focus on the common and dominant species and on species of conservation and economic importance. There was no emphasis placed on quantitative sampling or recording structural attributes. Where known, the threatened status or weed status was recorded, as well as local names in Tetum.

Specimens were collected from various plant life forms including trees, shrubs, herbaceous species, vines, grasses and sedges, ferns, and epiphytes (non-ferns). Photographs were taken where possible of live specimens in the field or of fresh pressed specimens.

All collected plant specimens were pressed for several days in field presses and then preserved for the short term, using a technique described by Forman and Bridson (1989) to suit the wet tropical conditions experienced at the time of survey. This technique involved pressing specimens between folds of newspaper which were then tied in bundles with string and placed in heavy duty plastic bags

to which sufficient 70% ethanol was added to wet newspaper. The top of the bag was folded over and sealed with adhesive tape, and then placed in a second bag to reduce drying. On return to Australia the plant specimens were submitted for Gamma irradiation to meet Australian Quarantine Inspection Services (AQIS) regulations. This process took approximately four weeks for the first collection of plants (December 23, 2011 to January 23, 2012). On completion of treatment plant specimens were submitted to the Northern Territory herbarium where they were returned to normal plant presses and dried at 50^{o}C.

Flora identifications were completed by Ian Cowie of the Northern Territory (NT) Herbarium who has considerable expertise with the flora of east Timor-Leste and Northern Australia. The NT Herbarium houses a reference collection of Timor-Leste flora collected by Cowie (2006, 2007)[1].

3.4 Fauna

3.4.1 Desktop Review

The terrestrial vertebrate fauna assessment also comprised a desktop review to collate historical knowledge on fauna species and fauna habitat present. A comprehensive inventory of relevant fauna was compiled, using as many sources as possible. The fauna desktop assessment included the following:

- Review of all available and current information; and
- IUCN Red List search.

Additional locally relevant information was sourced from relevant reference texts and important key stakeholders.

The purpose of the desktop review was to gather background information on the study area and the fauna that it may support. This involved a search of the following sources:

- Birdlife International database search;
- IUCN Red List expected species search tool; and
- Previous vertebrate fauna surveys (e.g. previous biological surveys / research).

Collectively, these sources were used to compile a list of species that have been previously recorded in the region and specifically within the vicinity of the study area. This list will invariably include some species that do not occur in the study area, because some fauna have a limited or patchy distribution, high level of habitat specificity, are locally extinct or were erroneously identified in previous surveys. Some records were excluded from this list, such as extinct species.

[1] A number of the flora collected also occurs in Northern Australia.

3.4.2 Field Survey

The primary objectives of the terrestrial fauna assessment were to:

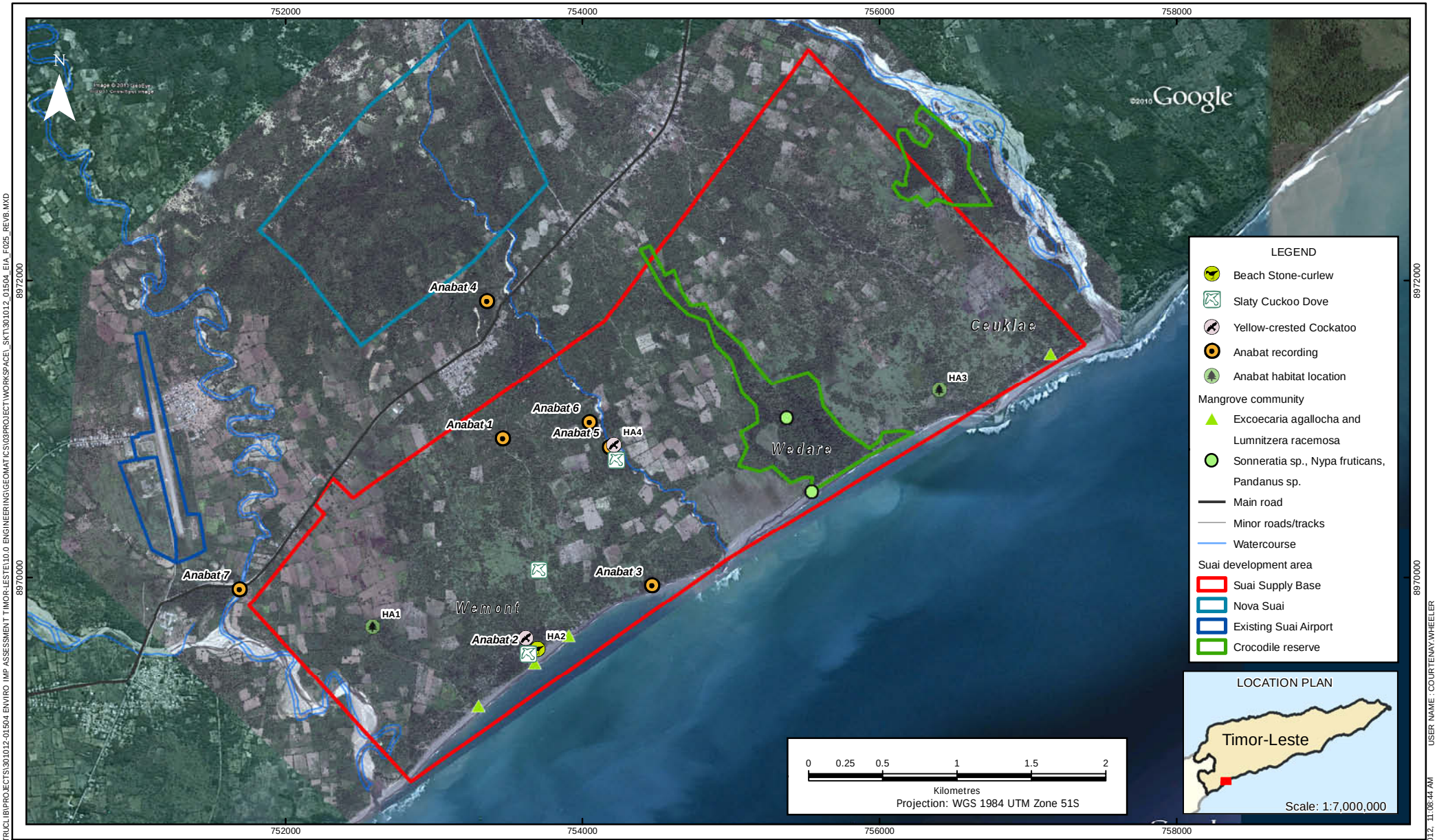
- Validate the accuracy of desktop reviews;
- Ground-truth the extent and condition of fauna habitat types present;
- Identify species of potential conservation significance (IUCN Red List);
- Further delineate and characterise the species and fauna habitat types present and potentially present at each site;
- Provide additional information for any subsequent clearing requirements; and
- Determine any significant impacts to species of conservation significance.

The fauna field methodology comprised the following:

- Selection of field sites from aerial photography;
- A description of fauna habitat at each site;
- Map the extents of each fauna habitat type;
- Conduct Anabat microbat recordings;
- Opportunistic observations of vertebrate fauna species present; and
- Assessment of the site's potential to house species of conservation significance.

Broad fauna habitats were identified based on vegetation associations and known landforms. These fauna habitats were then assessed for their potential to support fauna, in particular species of conservation significance. Habitats were assessed on the basis of their complexity, the presence of microhabitats (including significant trees with hollows, loose bark, fallen hollow logs and leaf litter) and other habitat features likely to provide foraging opportunities and/or shelter for fauna, such as water bodies and rocky outcrops (Figure F025).

Acoustic ultrahigh frequency equipment was used to record the presence of microbats. Acoustic Anabat recording equipment was placed in the study area to achieve a broad coverage but also designed to target potential maternal and breeding roosts. The analysis of ultrasonic echolocation calls of bat species with bat recording or other acoustic equipment is a very convenient and cost-effective method to determine the presence of bat species at a particular site. Often many more species can be identified at a greater number of sites using passive acoustic recording equipment than by trapping alone such as harp traps and mist nets (Figure F025).



LOCATION: \\PERWORFILL1\INFSTRUCL\B\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\301012_01504_EIA_F025_REVB.MXD

USER NAME: COURTENAY.WHEELER

PLOT DATE & TIME: 23 MAR 2012, 11:08:44 AM

NOTES:

This map consists of:
1. Imagery Suai: SRTM (2011)
2. Imagery: Google Earth (2010)
3. Rivers: GIGTimorLeste (2010)
4. Roads: DivaGIS (2010)

DRAFT

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
B	23/03/2012	FOR CLIENT REVIEW	MW	RG	CW	-	CW	

A4 SHEET | SCALE 1:7,000,000

PROJECT No: 301012-001504

WorleyParsons resources & energy

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

TASI MANE PROJECT
ENVIRONMENTAL IMPACT ASSESSMENT

Figure F025
Suai study area biodiversity key sites

3.4.3 Nomenclature

Naming conventions for amphibians and reptiles are based on the paper by Kaiser *et al.* (2011). For bird species, BirdLife International (2012) is used, with the following exceptions: the distinctive *capistratus* race of rainbow lorikeet *Trichoglossus haematodus* is recognised as a full species, as is the marigold lorikeet (*T. capistratus*) and the distinctive Timor race of pheasant coucal is recognised as a full species, Timor coucal (*Centropus mui*). The nomenclature for mammals follows the adopted taxonomy contained in the IUCN Red List. Local Tetum names were included where known.

3.5 Limitations

3.5.1 Flora and Vegetation

A broad approach was taken to assess flora and vegetation within the Suai development area to accommodate the limited time frame available for field survey. Flora and vegetation were assessed together to maximise available time at each site. An emphasis was placed on vegetation structure and dominant species composition.

Mapping of vegetation types was not undertaken during these surveys. Extensive ground-truthing, detailed inventories from plots/quadrats and high resolution aerial photography is required for vegetation mapping. It has previously been documented that the classification and field recognition of closed canopy forest formations (rainforest and monsoon) is problematic (Cowie 2006).

An exhaustive species inventory of each site could not be prepared in the limited survey period, and as such effort was focused on recording dominant species and plants of interest. Less emphasis was placed on ferns, herbs and other non-dominant flora. Lichens, bryophytes (mosses, liverworts), epiphytes and parasitic plants occurring high up in the tree canopy were not included in the survey.

Flora surveys are ideally undertaken at the best time of year for detecting the most plant species. In areas with highly seasonal rainfall distribution this is at the end of the wet season. Field work at other times of the year is also needed to detect the full range of species. The wet season is not the optimal sampling period for many plant species, and is likely to have limited the number of species recorded at the site.

3.5.2 Fauna

The significant lack of fauna baseline data for Timor-Leste makes the assessment of project impacts on population, distribution and ecological occurrences of fauna problematic. Fauna surveys are ideally undertaken throughout the year, across seasons, to be able to identify a full range of species. Conducting a study in the wet season may have impacted on the completeness of results. The length of field survey may also impact results, with eight days being insufficient to extensively survey the project area and accurately identify all species that potentially occur.

4. RESULTS

4.1 Flora and Vegetation

4.1.1 Vegetation Communities

General Overview

A Global Forest Resources Assessment was completed for Timor-Leste in 2010 by the Forestry Department of the Food and Agriculture Organization (FAO) of the United Nations (FRA 2010). This report states that no consistent and agreed land and vegetation classification system had been developed for the country, and therefore a set of classifications and definitions were created (Table 4).

Cowie (2006) noted that there is no structural/floristic classification derived from vegetation data collected in any region of Timor-Leste. Plant communities recognized by Cowie (2006) were regarded as preliminary and were based on field observations and limited quadrat data from few locations without classification or ordination of quadrat data. Importantly, Cowie (2006) notes that many plant communities intergrade floristically and structurally and the boundaries and distinctions between these are arbitrary and difficult to determine in the field.

Table 4 Vegetation classifications and definitions developed for Timor-Leste (FRA 2010)

National Class	Definition		Size of Area (ha)
Lowland Forest <1000 m asl	Forest defined as trees and shrubs > 30% tree canopy cover Occurs below 1000 m asl	Moist lowland forest - dense	261,694
		Moist lowland forest - sparse	174,992
		Dry lowland forest - mainly one species	135,720
		Dry lowland forest - mixed composition	189,080
Highland		Moist mixed forest	65,103

National Class	Definition		Size of Area (ha)
Forest 1000-2000 m asl		Single species forest	2,356
Montane Forest > 2000 m asl			2,611
Wetland Forest	Wetland forests are identified with drainage and slope. Normally flat poorly drained wetland areas or basin type features will contain wetland vegetation and/or related land uses.	Swamp forest	269
		Palm forest	NA
Coastal Forest	Includes three subclasses (i) Mangrove forest; (ii) Dune forests – mixed species; (iii) Coastal forest – single species	Mangrove forest	19,709
		Dune forests – mixed species	NA
		Coastal forest – single species	NA
Man-made Forest		Teak Other commercial plantings, woodlots	918

SUAI DEVELOPMENT AREA

The south coast of Timor-Leste features a broad coastal plain with hills that extend to the coastline at intervals. Rivers are numerous and mainly without water, and there are large drainage areas between rivers. Soil erosion is high, especially within drainage basins.

The Suai Supply base study area lies between two major rivers on a broad coastal plain and is intersected by several predominantly dry rivers and numerous drainage channels. Low lying areas between the rivers and drainage channels are frequently inundated and muddy during the wet season, a period from October to February as indicated by local sources. There are also several coastal lagoon areas at inlets, two of which are within the proposed crocodile reserve areas (We Dare and We Matan Bua Oan). The We Dare area is located near the center of the proposed Suai supply base development area, extending inland from the coastline and covers approximately 45 ha. The We Matan Bua Oan area is located inside the north-east boundary of the Suai development area (adjacent to the Rio Raiketan) and covers approximately 10 ha. Nova Suai and the upgrade works to Suai Airport will be located within 3 km from the coastline and also lie on the broad coastal plain.

Natural vegetation within the Suai development area exists primarily as narrow bands of open coastal forest with small areas of mangrove and riparian vegetation. The coastal plain has largely been cleared in association with swidden agriculture, sandalwood harvesting, plantation estates and timber plantations. Remnant vegetation exists as highly fragmented and secondary communities.

The majority of vegetation within the Suai development area has been cleared for villages and associated agriculture along with small teak and coconut plantations. Remnant vegetation exists in strips along drainage channels and isolated patches that are no larger than 20 ha. Aerial imagery indicates that less than 20% of the study area is covered by remnant secondary vegetation. Most of the understory within remnant vegetation and agricultural land is dominated by invasive weeds, particularly Siam weed *(Chromolaena odorata)* and cogon grass (*Imperata cylindrica*). Grasses are extensively grazed by domestic animals such as cattle, water buffalo, pigs and goats.

There is no remnant vegetation within the Suai Airport study area, and the land is highly disturbed and covered with invasive shrubby weeds including Siam weed, crown flower (*Calotropis gigantea*) and Bellyache bush (*Jatropha gossypifolia*) and thickets of prickly *Acacia* (*Vachellia nilotica*) trees (Plate TERP001 – Airport). This area is used for cattle grazing.

Vegetation in the Suai development area can be described as mixed coastal vegetation, with small communities of riparian and mangrove vegetation.

Source:

Plate TERP001 Airport

Source:

Plate TERP002 Coastal Vegetation

COASTAL VEGETATION

Three main types of coastal vegetation are commonly recognised in the Melasian regions; *Pes-caprae* formation, Barringtonia formation and vegetation of rocky shores (Whistler 1987). The work by Monk *et al*. (1997) regards coastal vegetation as open forest and doesn't define coastal forest. Cowie (2006) interprets coastal vegetation on the east coast of Timor-Leste as strand vegetation and the associated non-closed forest formations, excluding mangroves.

Barringtonia formation occurs on sandy soils and is a common beach forest/mangrove along south Timor coastline; however, no *Barringtonia* vegetation was observed in the Suai development area. No rocky shore vegetation occurred at any of the study areas.

Pes-caprae formation occurs along sandy foreshores where sand is actively deposited or eroded, and is typical near lagoons and in areas of low nutrients and high salt (Monk *et al*. 1997). Pes-caprae is described as an open community of low sand-binding herbs, trailing vines, grasses and sedges including *Ipomoea pes-caprae* and *Spinifex longifolius* or *S. littoreus.* Within the area of the Suai development area, the *Pes-caprae* formation is highly degraded and largely disturbed by cattle grazing and water erosion. The characteristic *Ipomoea pes-caprae* and *Spinifex littoreus* were present on the beach within the crocodile reserve area. The weed *Calotropis gigantea* was prevalent.

Coastal vegetation within the Suai supply base is structurally diverse and comprises a mosaic of *Imperata cylindrica* grassland, strand vegetation, shrubland and open forest dominated by *Borassus flabellifer* and *Corypha utan* palms and *Schleichera oleosa*. Other common tree species within the open forest were *Casuarina* sp. affin. *junghuhniana, Albizia saman, Ficus variegata, Alstonia scholaris, Nauclea orientalis, Peltophorum pterocarpum, Albizia lebbeckoides, Terminalia catappa,* and *Diospyros montana.* Common shrub species include *Tabernaemontana pandacaqui, Ziziphus timoriensis, Ziziphus mauritiana* and *Gmelina elliptica. Fimbristylis cymosa* sedges and *Christella arida* ferns occur in low lying drainage areas.

Also present within the mixed coastal forest were thickets of invasive tree species such as coffee bush (*Leucaena leucocephala*) and prickly *Acacia* (*Vachellia nilotica)* and introduced fruit and timber trees including candlenut (*Aleurites moluccana*), tamarind (*Tamarindus indicus*), teak (*Tectona grandis*), *Stercula foetida,* mango (*Mangifera indica*), breadfruit (*Artocarpus altilis*) and jackfruit (*Artocarpus heterophyllus*). There are also food plants including Timor Cherry (*Muntingia calabura*). The majority of tree species appear to be deciduous in the dry season, apart from palms.

Sandy beaches are bordered with narrow strips of strand vegetation and common species include *Borassus flabellifer, Corypha utan*, *Pandanus tectorius*, *Hibiscus tiliaceous* and *Thespesia populnea*. In some places, dense *Borassus flabellifer* palms fringe the coast (Plate TERP002 – Coastal Vegetation). Scattered *Borassus flabellifer, Pandanus* spp. and *Casuarina* sp. affin. *junghuhniana* trees commonly occur on very limited areas of sandy substrates along the south coast.

Source:

Plate TERP003 Nova Suai

Source:

Plate TERP004 Riparian Vegetation

The vegetation at Nova Suai is predominantly open coastal forest with very little understory and a heavy infestation of Siam Weed and Bellyache bush (Plate TERP003 - Nova Suai). Dominant species include *Barossus flabellifer*, *Alstonia scholaris* (ai-roti), *Schleichera oleosa* (ai-dak), *Senna timorensis* (ai-cachote) and Tamarind to 20 m in height over a shrub understory dominated by *Tabernaemontana pandacaqui*. The vegetation is deciduous with the majority of the canopy losing leaves at the completion of the wet season. Soils are muddy during the wet season and prone to flooding.

RIPARIAN VEGETATION

Several large dry river beds intersect the Suai supply base study area. The majority of river banks are eroded by turbulent water flow and cattle trampling creating a loss of vegetation. Riparian vegetation included Bamboo (*Bambusa blumeana*), occasional *Pterocarpus indicus*, *Albizia lebbeckoides* and infestations of Siam Weed (Plate TERP004 - Riparian). Often gardens and paths were located adjacent to river banks. Riparian vegetation is predominantly deciduous during the dry season.

MANGROVES

In the Suai supply base area several mangrove communities were present on the beach and surrounding coastal lagoons at river outlets.

Excoecaria agallocha (ai-tano) was the dominant mangrove species occurring in stands on beach sand and in muddy lagoons with freshwater input adjacent to the beach. *Excoecaria agallocha* is a multi-stemmed tree or shrub growing to 15m in height and is characterised by exposed cable roots and leaves which turn red and orange before falling in the dry season. *Lumnitzera racemosa* (ai-biku) was the second dominant mangrove species, and also occurred on both beach sand and muddy lagoons. *Lumnitzera racemosa* is a multi-stemmed evergreen tree or shrub growing to 15m in height.

A large *Excoecaria agallocha* and *Lumnitzera racemosa* mangrove forest community was recorded on a large inlet/lagoon with freshwater input in an area known locally as 'Wemout'. This area was considered to be an important crocodile habitat by local people. Epiphytes including *Drynaria quercifolia* (basket fern), *Pyrrosia longifolia* (fern) and *Dischidia major* (rattle skulls) were present on large trees. This mangrove community merged into coastal forest further inland. Other tree species included *Cathormion umbellatum* and *Peltophorum pterocarpum.*

A small area of *Excoecaria agallocha* trees occurred on the exposed coastline adjacent to the coastal forest. This area is subject to land and river runoff, and is unprotected from high tides and storm surges. These trees appeared to be declining and those close to the high tide mark have died, possibly due to salt water toxicity. A number of trees had been felled for timber.

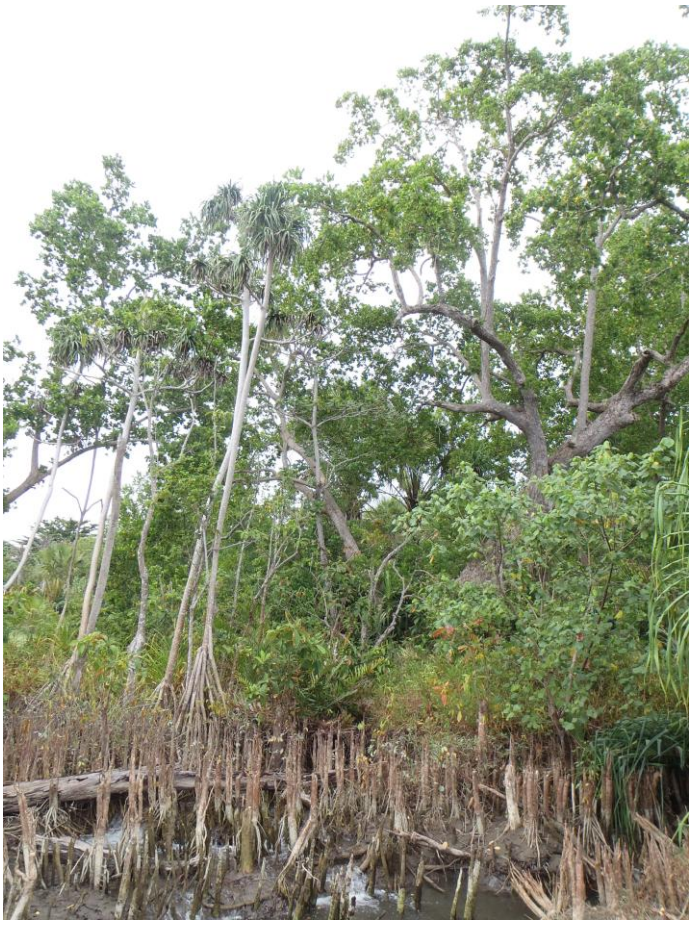
Rhizophora stylosa propagules (hypocotyl) were found on the beach, and this species may occur within the area.

The crocodile reserve site is located within the boundary of the Suai supply base site in an area known locally as 'We Dare'. The vegetation within this area is relatively undisturbed deciduous coastal forest and mangrove community. The We Dare area includes a spring fed creek which drains into an area of mangroves on a lagoon adjacent to the beach. Mangrove vegetation includes *Excoecaria agallocha, Sonneratia caseolaris, Pandanus* sp., *Nypa fruticosa* (Mangrove Palm) and *Hibiscus tiliaceus* (Plate TERP005 - Mangroves.

Sonneratia caseolaris (Red-flowered Apple Mangrove) is a large evergreen tree growing to 20 m in height with cone-shaped pneumatophores up to 1.5 m tall. *Nypa fruticans* (Mangrove Palm) is a trunkless palm that grows to 10 m in height and occurs in river dominated estuaries. The vegetation communities recorded in the Suai development area are presented below in Table 5.

Table 5 Vegetation types recorded in the Suai development areas

Vegetation Formation (Monk *et al*. 1997)	Vegetation Formation (Cowie 2006)	Presence in project areas	Biological Features	Inferred Distribution	Current Threats to Vegetation
Coastal Forest	Coastal and strand vegetation	Suai supply base, Nova Suai		Coastal plain	Intensive grazing by cattle, conversion for agriculture, weed invasion
Tidal Forest	Mangroves	Suai supply base, crocodile reserves	Refers to the habitat rather than a single entity. includes trees, shrubs, palm or ground fern	Small scattered areas, coastal lagoons	Fire wood harvesting
		Suai supply base, Nova Suai, crocodile reserves	Riparian	Large rivers	Potentially conversion for rice, cattle grazing, weeds



Source:

Plate TERP005 Mangroves

Source:

Plate TERP006 Corn Garden

4.1.2 Agriculture

The traditional slash and burn (swidden) system of agriculture is used in Timor-Leste. Forest is cleared for cultivation, cropped for several years and then followed by fallow periods to allow for natural regeneration. Boundary markers are used around plots of land to indicate land ownership.

Cultivated soils appear to be nutrient-poor with little remaining topsoil. Run-off of topsoil into rivers and the ocean is high. The soil is generally shallow and susceptible to landslides and flooding (Oxfam 2003). The vulnerability to erosion is enhanced by highly uneven and erratic rainfall. Large river systems flow onto the coastal plain.

The majority of the area within the Suai development area comprised agricultural land used for subsistence farming. Few marketable cash crops were encountered. Gardens appeared to be in fallow over the wet season. The primary crops grown are corn/ maize, cassava, peanuts, long beans, papaya, watermelon and bananas (Plate TERP006 – Corn Garden). Gardens in the study areas supported weeds and secondary species. A large area established for rice cultivation within the Suai supply base site is no longer used. Small plantations or estates of coconuts, bananas, and occasionally mango were present in the Suai development area. Grazing by water buffalo, cattle, goats and pigs is widespread in the Suai development area.

A large area of teak plantation and several large agricultural gardens occur in the Nova Suai study area (Plate TERP007 – Teak Estate). Other timber trees recorded within the study area include *Senna timorensis* (ai-cachote), *Pterocarpus indicus* (ai-na), *Gemelina arborea* (Malaysian teak), *Senna siamea* [ai-johar] and ai-lantoro. Large gardens were predominantly planted with corn crops with minor crops of papaya, basil, cassava and coconut.

4.1.3 Vegetation of Conservation Interest

In the Suai supply base area several mangrove communities were present on the beach and surrounding coastal lagoons at river outlets (locations shown in Figure F025).

Mangroves are of particular conservation interest in the Suai development area for their economic and conservation benefits; however they are also cut for timber. Mangroves stabilize soils, primarily in coastal and estuarine communities and reduce coastal and soil erosion, and also provide important marine and fauna habitat. Loss of mangrove habitat affects the conservation status of Timor-Leste and also the economic gain by reducing land available for agriculture and forestry.

The mangroves are listed under the UNTAET Regulation No. 2000/19, section 5 ‘Wetlands and Mangroves’, prohibiting any destruction of this vegetation type. Exploitation still occurs, however.

Source:

Plate TERP007 Typical Teak Plantation

4.1.4 Flora

These results focus on the dominant flora species, conservation significant flora, economically important flora species and weed species.

At the time this report was prepared only the specimens collected from the December 2011 had been identified, and specimens collected on the February 2012 trip were expected to arrive in Darwin at the completion of quarantine treatment in late March 2012[2]. Local Tetum names were recorded where possible, and this list of names is considered indicative only as there were several inconsistences. In some cases the usage of the same name varied between local guides and regions, and several species or plant forms were grouped together under one name.

At the time of reporting 131 species were identified from collected material (December field trip), 52 species were identified in the field or from photographs and 42 specimens were awaiting identification (February field trip). A species list for the Suai development area is presented in **Appendix 3**.

Two species listed on the IUCN Red List as Vulnerable were recorded; rosewood (*Pterocarpus indicus)* and sandalwood (*Santalum album*). A large number of species recorded in the Suai development area have a widespread distribution in the tropics. Several of these are invasive weed species and discussed in detail below, and several are considered to be naturalized species.

Some large fruited species that are bird and bat attracting were recorded; including *Cerbera manghas*, *Ficus variegata* and other *Ficus* spp.

4.1.5 Species of Conservation Interest

The IUCN Red List of Threatened Species does not list any Critically Endangered, Endangered or Vulnerable plant species specifically for the region of Timor-Leste (IUCN 2011). However, there are previous records of three Vulnerable species from the east coast of Timor-Leste; *Intsia bijuga*, *Pterocarpus indicus* and *Santalum album* (Cowie 2006, 2007). Two of these were recorded in the Suai development area during the field surveys, *Pterocarpus indicus* and *Santalum album.* There are 36 plant species on the IUCN Red List that are listed as being of Least Concern for Timor-Leste, and these are considered to have a low risk of extinction (**Appendix 2**). None of these were recorded in the Suai development area during the field surveys.

Within the broad region of Indonesia the following numbers of plant species are listed on the IUCN Red List: 207 Vulnerable, 86 Near Threatened, 78 Endangered and 115 Critically Endangered. It is likely that as more surveys are undertaken within Timor-Leste that more plant species will be listed specifically for the country.

[2] It is expected that drying and initial identification of these will take 3 to 4 weeks

Santalum album (sandalwood, Tetum ai-cameli*)* was present in very low numbers in Nova Suai as young trees only and not at the harvestable stage. Sandalwood is a highly sought after timber which has been overexploited for several centuries. By the beginning of the 1900s Sandalwood was brought close to extinction by Chinese and European traders (Sandlund *et al*. 2001). Further overexploitation occurred during Indonesian occupation during 1975 to 1999.

Pterocarpus indicus (rosewood, Tetum ai-na) was present within the Nova Suai site on the banks of a dry river bed. It is a tall timber species, reaching 25 to 35 m, is a briefly deciduous tree and can be useful for soil stabilization and adding nitrogen to soil. It is a highly sought after timber and listed as an IUCN Red List vulnerable species. Described as a widespread tree found in lowland primary and some secondary forest, native subpopulations have declined because of overexploitation of the timber and increasing general habitat loss. Cultivated subpopulations are widely distributed throughout the tropics.

Intsia bijuga (Moluccan ironwood) is a reasonably common tree of primary semi-evergreen rainforest, moist deciduous forest, and coastal forest.

Cowie (2006) also lists a further four species recorded on the east coast that may be considered threatened in Timor-Leste; *Antiaris toxicaria, Neoalsomitra podagrica, Carallia brachiate* and *Cycas rumphii.* The forest communities in which these species occur are under threat; deciduous forest, thorn forest and coastal forest. None of these species were recorded in the Suai development area.

Sheoak trees (*Casuarina* sp. aff. *junghuhniana)* occurring within the Suai development area in low numbers are thought to be an important habitat for the yellow-crested cockatoo. Previously these trees have been recorded occurring abundantly along the sandy beaches of south Timor (Monk *et al*. 1997) and able to grow on poor sandy soils.

A large patch of *Albizia saman* trees (ai-matan dukur) were recorded within Suai supply base area in place known locally as ‘To’os ai-lok laran’.

4.1.6 Species of Economic Importance

Within the Suai development area the species listed in Table 2 are considered to have economic or local importance either as timber or food crops. Two of these species, rosewood (*Pterocarpus indicus)* and *s*andalwood (*Santalum album),* have been discussed in the previous section.

Small plantations or estates of coconuts, bananas, and occasionally mangos were present in the Suai development area. The tenureship of trees within estates may be external to local villages. Occasional breadfruit, jackfruit, cashew or cinnamon trees were encountered, and appear to be individually owned and marked accordingly.

The Suai supply base is located near some State Forest Plantations in the Covalima district and some seedlings may have been made available and planted within the Suai development area in previous government forestry initiatives. The following species were planted in nearby areas; *Tectona grandis* (teak), *Gmelina arborea*, *Senna siamea* (johar), *Albizzia chinensis* (sengon), *Pterocarpus* sp.

(kayu merah), *Swietenia* sp. (mahogany), *Santalum album* (sandalwood), *Aleurites moluccana* (kemiri) and *Anacardium occidentale* (Cashew).

Table 2 Species of economic interest and/or local importance recorded in the Suai development area

Common Name	Scientific Name	Tetum Name	Use/Importance
Coconut	*Cocus nucifera*	nú	Food
Cashew	*Anacardium occidentale*	caijus	Food
Banana	*Musa spp.*	hudi	Food
Breadfruit	*Artocarpus altilis*	kulu modo	Food
Mango	*Mangifera spp.*	has	Food
Candlenut	*Aleurites moluccana*	kemiri or cami	Food
Cinnamon	*Cinnamomum sp.*	ai-canela	Spice
Teak	*Tectonia grandis*	ai-teka	Timber
Gmelina	*Gmelina arborea*	gmelina, ai-teka Malaysia	Timber
Cassod tree	*Senna siamea*	ai-johar	Timber
Sandalwood	*Santalum album*	ai-cameli	Timber
Rosewood, Narra	*Pterocarpus indicus*	ai-na	Timber
Mangrove trumpet tree	*Dolichandrone spathacea*	ai-sirian	Timber

4.1.7 Weeds / Invasive Species

Weeds are a major component of secondary vegetation in the Suai development area, and many are likely to have spread through intensive grazing. The major weed species recorded are listed in Table 3. Siam weed *(Chromolaena odorata*), cogon grass (*Imperata cylindrica*) and coffee bush (*Leucaena leucocephala*) are listed on the IUCN's Global Invasive Species Database (GISD) of the 100 worst invasive species.

Table 3 Major weed species identified in the Suai development area

Weed Species	Common Name	Tetum Name	Location
Chromolaena odorata	Siam weed	ai-funanmutik	all
Imperata cylindrica	Cogon grass	pae	all
Leucaena leucocephala	Coffee bush	ai-café	all
Lantana camara	Lantana	ai-funan meak	Suai supply base
Vachellia nilotica	prickly *Acacia*	bakuro malae, ai-tarak	Suai supply base, Suai Airstrip
Chrysopogon aciculatus	Golden false beardgrass	du'ut	all
Jatropha gossypifolia	Bellyache bush	miro	all
Calotropis gigantea	Crown flower	fuka	all
Zizyphus mauritiana	Jujube, Chinese Apple	Ai-lok	all

Siam weed is a perennial shrub in the *Asteraceae* family which forms dense tangled thickets up to 2m tall. It has an extremely fast growth rate and prolific seed production (CRC Weed Management 2003). Siam weed was the most widespread weed throughout the Suai development area. Originally native to Central and South America, it is highly invasive and is considered to be one of the world's worst tropical weeds. It is estimated that Siam weed covers more land than any other plant species in Timor-Leste (Cowie 2007), and affects about one-fifth of all cropland (World Bank 2009). Siam weed invades secondary vegetation and agricultural land and its spread may be facilitated by fire.

Cogon grass is considered to be one of the ten worst weeds in the world. This species is of concern as it displaces native plant and animal species. It has an extensive rhizome system and adapts to poor soils.

Coffee bush is a fast growing tree that was widely introduced as a fodder plant and has become an aggressive invader of agricultural and disturbed areas, often coastal and riverine habitats, in many tropical locations (GISD). It can form dense thickets and may threaten endemic species of conservation concern in some areas (Smith 1995). It was originally native to Central America.

Bellyache bush was widespread throughout all development areas and a second weed species of the same genus, *Jatropha curcas,* was recorded infrequently in the Suai development area. *Jatropha* spp. form erect perennial shrubs with thick stems and have small red flowers clustered on stalks, oblong

fruit capsules and toxic seeds. Shrubs form dense thickets which out-compete other species (Smith 1995).

Calotropis gigantea is a shrub growing to 4m in the *Asclepiadaceae* family, which has clusters of waxy white or mauve coloured flowers. It is a common weed of roadsides, disturbed areas, sandy beaches, water courses and river flats and thrives on poor soils. It is particularly widespread in coastal vegetation.

Prickly *Acacia* (*Vachellia nilotica)* is a fast growing species that forms thickets and may displace native species (Smith 1995).

Chrysopogon aciculatus is a rhizomatous perennial grass growing to 0.4m in height. This grass was widespread.

Lantana camara is a sprawling thicket-forming shrub growing to 5m in height. This plant is considered a major invasive weed in many habitats, although within the Suai development area Lantana is not widespread.

Zizyphus mauritiana is a spiny evergreen shrub growing to 15m in height, and is commonly found in tropical regions.

Several introduced flora species are now considered naturalized as they are widespread and not considered invasive weeds. *Passiflora foetida,* part of the *Passifloraceae* family, is a woody climber with cream-white-blue flowers and occurs in coastal areas and rivers. Tamarind (*Tamarindus indicus*) is a common tree species in secondary forest.

4.2 Fauna

4.2.1 Fauna Habitat

Currently the knowledge on the habitat requirements of Timor-Leste vertebrate fauna is lacking and most studies conducted have largely been focused on bird species. The level of knowledge on ground-dwelling species such as reptiles and mammals is minimal and therefore conducting an assessment for such species requirements is difficult. There is no baseline data to compare against and develop an understanding of regional representation. This therefore makes deducing possible impacts from development to population occurrences, distribution and ecological diversity problematic. Therefore, for this project a broad assessment approach was adopted, utilising the best possible information available.

An important information source was the Global Forest Resources Assessment for Timor-Leste in 2010 by the Forestry Department of the Food and Agriculture Organisation (FAO) of the United Nations (FRA 2010). Six vegetation classifications were recognised and can be used as analogues for vertebrate fauna habitats. As previously stated that no consistent and agreed land and vegetation classification system had previously been developed for the country, and therefore a set of classifications and definitions were created (Table 4).

Other significant vertebrate fauna work included Trainor *et al*. (2007). Although largely confined to avian species diversity and distribution, this study provided a detailed account of habitat types. Their classification included tall evergreen forest (tree height up to 40 m), semi-deciduous and tropical dry forest types (tree height up to 20 m), a patchy tropical Montane forest (elevations > 1,000 m), beach forest and coastal scrub, savanna woodland, open eucalyptus forest, shaded coffee plantations (> 600 m), swamps and swamp forests, rice paddies, and village land.

A compilation of previously identified vertebrate fauna habitats, plus those described for the project during the field survey, was developed for the current assessment. This process also took into consideration the study areas' location on the south coast of Timor-Leste and was correspondingly revised. Table 6 describes the four categories of vertebrate fauna habitats that were present within the project's study areas and immediate vicinity.

Seven vertebrate fauna habitat assessments were conducted across the project study areas (**Appendix 4**).

Table 6 Vertebrate fauna habitat types developed for the Tasi Mane Timor-Leste project, relevant for Suai development area.

Fauna Habitat Type	Vegetation	Study Area
Deciduous Woodland / Forest	Woodland defined as trees and shrubs < 30% tree canopy cover	Suai
Coastal	Includes three subclasses (i) Mangrove forest; (ii) Dune forests – mixed species; (iii) Coastal dunes and reef platforms	Suai
Riparian	Includes drainage lines (major and minor), drainage basins, creek lines and water catchments; includes associated vegetated banks.	Suai
Swidden Agriculture	Includes 'man made' plantations and associated fringing vegetation and habitat	Suai

4.2.2 Fauna Assemblages

General

Fauna assemblages were collated from the desktop review. Many of the species identified from the desktop assessment are unlikely to occur in the study areas on a regular basis since the desktop addressed a large area encompassing a wide range of habitats (**Appendix 5**).

Within the Suai development area 68 species of vertebrate fauna were recorded, and this includes two species of amphibians, seven species of reptiles, 48 species of birds and 11 species of mammals (Table 7).

Table 7: Number of Species recorded for the Suai development area

Assemblage	Suai Development Area
Amphibians	2
Reptiles	7
Birds	48
Mammals	11
Total	**68**

Previous study results can be found in **Appendix 5.**

Amphibians

The two amphibians identified within the Suai development area were the Common Indian Toad (*Duttaphrynus melanostictus*) and the Indian Bullfrog (*Fejervarya* sp.).

Reptiles

Reptiles identified in the Suai development area comprised seven species from five families including: tokay (*Gekko gecko*), Asian house gecko (*Hemidactylus frenatus*), East Indian brown mabuya (*Eutropis* cf. *multifasciata*), common wolf snake (*Lycodon capucinus*), and the saltwater crocodile (*Crocodylus porosus*).

Birds

A large number of birds were identified within the Suai development area, consisting of 20 families and 48 species. The most common species included the spotted dove (*Streptopelia chinensis*), the barred dove (*Geopelia maugei*) and the streak-breasted honeyeater (*Meliphaga reticulata*). The two most common families were the *Columbidae* (pigeons and doves) and the *Meliphagidae* (honeyeaters).

MAMMALS

Mammal species recorded in the Suai development area consisted of seven families and 11 different species, and included the domestic dog / dingo (*Canis familiaris*), domestic pig (*Sus scrofa*), bali cattle (*Bos javanicus*), domestic cattle (*Bos taurus*) and the domestic goat (*Capra hircus*).

BATS

Within the Suai development area four species of known bats were recorded, including the Canut's horseshoe bat (*Rhinolophus canuti)* which is listed as Vulnerable on the IUCN Red List, and the little long-fingered bat (*Miniopterus australis),* which is listed as being of Least Concern. A full report on survey results for bats is included in **Appendix 6.**

4.2.3 Conservation Significant Fauna

Species listed as Critically Endangered, Endangered, Vulnerable and Near Threatened on the IUCN Red List comprise species of conservation significance (Table 8). The lack of baseline data regarding the fauna of Timor-Leste suggests that conservation significant species which have not been recorded could potentially be present. The full extent of results including all categorised species is described in **Appendix 7.**

In addition, Section three of the UNTAET Regulation No. 2000/19, states that 'All animals and plant species listed in Appendix I or Appendix II of the Convention on the International Trade in Endangered Species' (CITES)''shall mean a species of animal or plant at risk of extinction within East Timor'.

The desktop review identified 34 species of conservation significance potentially occur or have been previously recorded for Timor-Leste.

Five species of conservation significance were recorded in the study area: the yellow-crested cockatoo (*Cacatua sulphurea*), Canut's horseshoe bat (*Rhinolophus canuti timoriensis*), Beach thick-knee (*Esacus magnirostris*), Slaty Cuckoo Dove (*Turacoena modesta*) and Timor Bush-chat (*Saxicola gutturalis*).

Table 8 shows that two of the fauna species identified from desktop and field studies, one 'Possible', the Christmas Island Frigatebird, and one 'Recorded', yellow-crested cockatoo are also listed on CITES Appendices I or II and thus considered Endangered under Regulation 2000/19.

Table 8: Conservation significant species and their likelihood of occurring in the Suai development area

Species	Conservation Significance				Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced	
Mauremys reevesii Reeves' turtle	EN			x	Unlikely
Fregata andrewsi Christmas Island frigatebird	CR		App I		Possible
Esacus magnirostris Beach thick-knee	NT				Recorded
Charadrius peronii Malaysian plover	NT				Possible
Charadrius javanicus Javan plover	NT				Possible
Numenius madagascariensis Far eastern curlew	VU				Likely
Numenius arquata Eurasian curlew	VU				Likely
Limosa limosa Black-tailed godwit	NT				Likely
Calidris tenuirostris Great knot	VU				Likely

Species	Conservation Significance				Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced	
Limnodromus semipalmatus Asian dowitcher	NT				Likely
Turacoena modesta Slaty cuckoo-dove	NT				Recorded
Gallicolumba hoedtii Wetar ground-dove	EN				Possible
Treron psittaceus Timor green-pigeon	EN				Likely
Ducula rosacea Pink-headed imperial-pigeon	NT				Likely
Ducula cineracea Timor imperial-pigeon	EN				Unlikely
Cacatua sulphurea yellow-crested cockatoo	CR		App I		Recorded
Psitteuteles iris Iris lorikeet	NT				Likely
Aprosmictus jonquillaceus Olive-shouldered parrot	NT				Likely
Todiramphus australasia Cinnamon-banded kingfisher	NT				Likely

Species	Conservation Significance				Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced	
Bradypterus timoriensis Timor bush-warbler	NT				Unlikely
Heleia muelleri Timor white-eye	NT	x			Possible
Ficedula timorensis Black-banded flycatcher	NT	x			Possible
Saxicola gutturalis Timor bushchat	NT				Recorded
Zoothera dohertyi Chestnut-backed thrush	NT				Unlikely
Zoothera peronii Orange-banded thrush	NT				Likely
Lonchura fuscata Timor sparrow	NT				Possible
Acerodon mackloti Sunda fruit bat	VU				Possible
Nyctimene keasti Keast's tube nosed fruit bat	VU				Unlikely
Pteropus temminckii Temminick's flying-fox	VU		App II		Unlikely

Species	Conservation Significance				Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced	
Pteropus vampyrus Large flying-fox	NT		App II		Possible
Rhinolophus canuti timoriensis Canut's horseshoe bat	VU				Recorded

The conservation significant IUCN Red Listed species recorded during this survey, including their locations, are detailed in Table 9.

Table 9: The conservation significant fauna recorded during survey work in the Suai development area

Common Name	Conservation Status	Location
Beach thick-knee	NT	Suai
Slaty cuckoo-dove	NT	Suai
yellow-crested cockatoo	CR	Suai
Timor bushchat	NT	Suai
Canut's horseshoe bat	VU	Suai

The yellow-crested cockatoo, listed as Critically Endangered on the IUCN Red List, was sighted in the Suai development area. Up to 11 individuals were recorded on five occasions within the Suai development area only. Generally this species was recorded foraging and roosting in Sheoak (*Casuarina* sp. affin. *junghuhniana*) as well as individuals seen flying overhead. It is categorized as Critically Endangered mainly due to unsustainable trapping for the caged bird trade in the late 20th century (BirdLife International 2012). Its home is usually between sea level – 1,000 m in tropical dry forest or woodland plantations and it was found widely in Wallacea until intensive trading commenced in the late 1970s (Trainor *et al*. 2008). Fewer than 5,000 birds are thought to still remain in the wild, with approximately 500 in Timor-Leste (Trainor *et al*. 2008). It has been found to sometimes depend on closed canopy primary forest; however, it has also been identified in areas of cleared land which highlights it's apparent capability of being flexible with habitat choice. The yellow-crested cockatoo's nesting habits rely on tree cavities with specific requirements, and they tend to use cracks or fissures in a trunk or branch, or a pre-existing nest-hole made by other species, usually in dead, snagged or rotting trees (BirdLife International 2012). The distribution and abundance of suitable nesting cavities may be an additional limiting factor on the distribution of the yellow-crested cockatoo.

Bats identified as species of conservation interest include two cave roosting horseshoe bats; the Timorese horseshoe bat (*Rhinolophus montanus*) and the Canut's horseshoe bat (*R. canuti timoriensis*). The Timorese horseshoe bat is listed as Data Deficient and the Canut's Horseshoe-bat is listed as Vulnerable on the IUCN Red List. In addition to these species, the possibility of some of the undescribed taxa discovered on recent surveys by Pavey and Milne (2004) and Armstrong (2007), namely *Pipistrellus* spp., may occur in the Suai development area.

The recording of the Timorese horseshoe bat is significant as it has only been recorded on two previous occasions; the site of the first collection near Lequi Mia, south of Ermera (7 to 8 individuals), and calls from the Ira Chaupiti watercourse on the southern side of the Paitchau Range. The Canut's horseshoe bat (*R. canuti*) was commonly encountered in the acoustic and trapping surveys of Pavey

and Milne (2004) and Armstrong (2007), but there is no information on how widespread this species is outside of the most forested areas in the east of Timor-Leste.

Conservation significant fauna, listed in **Appendix 7** includes species distribution and ecology, their regional context and their likelihood of occurring in the Timor-Leste study areas.

4.2.4 Endemic Fauna

Timor-Leste lies in a biogeographic region known as Wallacea, which is predominately colonised with plants and animals from Asia and Australia. Due to the island's long isolation, endemism has reached exceptional levels (Trainor *et al*. 2008), with Timor having the highest rates of endemism recorded in Indonesia, at 10.3 % (Rhee *et al.* 2004). Endemism occurs especially for frogs (about 50% Timor-endemic), skinks (25%) and geckos (25%). Remarkably, only four native terrestrial mammals have been recorded including the Timor shrew (*Crocidura tenuis*), Sunda shrew (*Crocidura maxi*), Timor rat (*Rattus timoriensis*) and ricefield rat (*Rattus argentiventer*) Trainor *et al*. (2008).

5. DISCUSSION

5.1 Summary

A flora and vertebrate fauna assessment for the Tasi Mane Project - Suai Supply Base was undertaken in December 2011 and February 2012. A total of 183 species of flora were recorded in the preliminary assessment. Sixty-eight species of vertebrate fauna were recorded, consisting of two species of amphibians, seven species of reptiles, 48 species of birds and 11 species of mammals.

Species listed as Critically Endangered, Endangered, Vulnerable and Near Threatened under the IUCN Red List constitute species as having conservation significance. A lack of baseline data of Timor-Leste's flora and fauna indicates that not all occurrences of conservation significant species have been assessed by the IUCN. There is a possibility that further species within the Suai development area may be considered to have conservation significance.

Two Vulnerable listed flora species have been recorded in the Suai development area to date, *Pterocarpus indicus* and *Santalum album,* which are both valuable timber species. Five fauna species of conservation significance were recorded in the study area: the yellow-crested cockatoo (*Cacatua sulphurea*), Canut's horseshoe bat (*Rhinolophus canuti timoriensis*), Beach thick-knee (*Esacus magnirostris*), Slaty cuckoo dove (*Turacoena modesta*) and Timor bush-chat (*Saxicola gutturalis*). The yellow-crested cockatoo is Critically Endangered on the IUCN Red List and was recorded on five occasions within the Suai development area, making Suai potentially sensitive to environmental impacts proposed by the project.

Mangrove communities in the Suai development area represent some of the only remnant vegetation in good condition and are considered to have conservation significance. The largest communities recorded were the *Excoecaria agallocha* and *Lumnitzera racemosa* mangrove community on the lagoon at 'Wemout', and the *Excoecaria agallocha*, *Sonneratia caseolaris*, *Pandanus* sp., *Nypa fruticosa* (Mangrove Palm) community on the lagoon at 'We Dare'.

5.1.1 Environmental Impacts / Issues

FLORA AND FAUNA

In the absence of detailed design information on the project, the following section is written based on the conservative assumoption that there is to be 100% clearance of all vegetation and agricultural land within the Suai development area, with the exclusion of two areas of existing crocodile habitat that are proposed for reserves. The We Dare area is located near the center of the proposed Suai supply base development area, extending inland from the coastline and covers approximately 45 ha. The We Matan Bua Oan area is located inside the north-east boundary of the Suai development area (adjacent to the Rio Raiketan) and covers approximately 10 ha.

The construction and operation of the Suai development area will have adverse effects on the terrestrial environment. The potential environmental and economic impacts upon the area and its people, include, but are not limited to;

- Loss of individuals of IUCN listed species; *Santalum album* (sandalwood) *Pterocarpus indicus* (rosewood), both valuable timber trees;
- Loss of floristic biodiversity that has not been documented;
- Secondary weed invasion after clearing, particularly Siam weed and Cogon grass;
- Loss of forest and tree cover;
- Loss of important mangrove habitat;
- Loss of agricultural land and subsistence gardens;
- Loss of food crops and estates e.g. coconuts, bananas;
- Loss of timber for fuel source;
- Loss of cash crops e.g. teak, rosewood and sandalwood; and
- Loss of fauna habitat, specifically important habitat for species of conservation significance.

The removal of vegetation cover is likely to result in the destabilization of soils and an increased rate of erosion and sedimentation.

5.1.2 Avoidance, Management and Mitigation Measures

Flora and Fauna

Management issues exist for the protection of remnant flora and vegetation within crocodile reserves. These include:

- The conversion of coastal forest for swidden agriculture;
- Harvesting of timber for firewood and building materials;
- Grazing of coastal vegetation; and
- Weed invasion of disturbed understory.

The loss of vegetation within the Suai development is a likely and unavoidable consequence of the construction process. The potential impact of these alterations has been reduced by avoiding sensitive and high conservation value habitats when selecting the development location.

Construction and operational activities will unavoidably result in the clearance of all remnant vegetation excluding the proposed crocodile reserves. Limiting the size of clearance areas will reduce the intensity and extent of impact on remnant vegetation.

Policies and procedures will be developed for construction works to reduce unnecessary vegetation clearance. These procedures will be incorporated into an environmental management system for the Suai supply base. A reporting and response system will be developed to ensure that vegetation clearing activities are controlled and monitored.

The impact of remnant vegetation clearance may be reduced by avoiding impacts to the high conservation value remnant vegetation within the two crocodile reserve boundaries.

Removal of the vegetation within the Suai development area will result in the loss of soil structure and associated soil erosion. This effect is likely to be greatest around rivers with the loss of riparian vegetation. It is recommended that riparian vegetation be preserved and rehabilitated to reduce erosion and maintain current flow patterns of rivers.

To reduce soil erosion, those areas not in use within the Suai supply base area can be rehabilitated and revegetated.

MANGROVES

Construction will unavoidably remove some areas of mangrove habitat and the faunal communities they contain. Further impacts on mangroves will be limited through the control of vegetation clearance.

The location of any wastewater or desalination outlet is critical for the minimisation of impacts from the discharge on mangrove habitat. This should be located away from remnant mangrove vegetation within the two crocodile reserve areas.

INVASIVE PLANT SPECIES

The removal of the canopy layer in coastal forest is likely to result in the spread of invasive weeds, in particular Siam weed, Cogon grass and Coffee bush. Weed hygiene practices should be adopted to reduce spread of weed seeds, and weed control measures to reduce the colonization of weed species within the development area.

Protocols will be developed into an invasive weed management plan and incorporated as part of the environmental management system for the Suai supply base.

5.1.3 Monitoring and Reporting

FLORA AND FAUNA

The monitoring and reporting measures for flora and fauna during construction and operations include:

- A multiple season baseline flora, vegetation and fauna assessment of the remnant vegetation within the proposed crocodile reserves is recommended;

- Surveys undertaken at different seasons during the year to record different fauna species assemblages and to capture fruiting and flowering patterns;
- A monitoring program for the proposed crocodile reserves may be designed and implemented at the completion of a baseline assessment, including independent expert advice on the potential sites ability to house displaced individuals; and
- A mangrove health monitoring program should be established within the remnant mangrove communities to document the health of mangrove species during the construction and operation phase of the project.

5.1.4 Recommendations

FLORA

To complete a multiple season baseline flora and vegetation assessment of the proposed Suai development area, including:

- Quadrats to define floristic composition and structural form of each vegetation community, particularly in mangrove and moist forest vegetation;
- A checklist of flora species including annual herbs, ferns, epiphytes, mosses, bryophytes, parasitic plants, to record floristic diversity; and
- Vegetation mapping at a scale of 1:10,000.

Limitations existed for both the flora and vegetation and fauna surveys, with the emphasis being placed on length of study and seasonality. Further survey effort should be undertaken throughout the year and for longer periods of time, enabling the identification of a broader range of species to be identified.

FAUNA

The high level approach used for this survey due to the lack of baseline data means that more intensive work needs to be completed. Multiple surveys in each season would be required, plus extending the duration of the trips to ensure a more thorough survey. This is to ensure that potentially critically endangered species which could be present in the area but not yet sighted can be recorded. Further work will provide more established results, providing a more exhaustive environmental assessment and improved knowledge on potential environmental and economic impacts.

Sightings of the Critically Endangered yellow-crested cockatoo highlight the need for further work to identify specific habitat requirements, the abundance and distribution of nesting sites and their tolerance to varying disturbance levels.

6. REFERENCES

Alves, G. (2007). *Thematic Assessment Report, the United Nations Convention on Biological Diversity (UNCBD). National Capacity Self Assessment (NCSA) Project, Timor Leste*. Thematic Working Group (TWG) Consultant Report to UNCBD, January 2007.

Bates, P., Francis, C., Gumal, M., Bumrungsri, S., Walston, J., Heaney, L. and Mildenstein, T. (2008). Pteropus vampyrus. In: IUCN 2011*. IUCN Red List of Threatened Species. Version 2011.2*. <www.iucnredlist.org>. Downloaded on 19 January 2012.

BirdLife International (2012) *IUCN Red List for birds*. Downloaded from http://www.birdlife.org on 19/01/2012.

Chasen, F.N. (1933). *Notes on the fauna of Christmas Island, Indian Ocean*. *Bull. Raffles Mus*. 8: 51-87.

Convention on International Trade in Endangered Species of Wild Fauna and Flora, (March 2012) Appendices I, II and III.

Cowie, I. (2007). *Survey of Flora and Vegetation of the Proposed Iralalaro Hydropower Project, Timor Leste*. Report to EPANZ Services by the Northern Territory Herbarium June 2007.

Cowie, I. (2006). *A survey of flora and vegetation of the proposed Jaco-Tutuala-Lore National Park, Timor-Leste (East Timor)*. Report to Birdlife International by the Northern Territory Herbarium.

CRC Weed Management, (2003). *Weed Management Guide, Siam weed or Chromolaena (*Chromolaena odorata*)*. Commonwealth Department of the Environment and Heritage.

Dickinson, E.C., Rasmussen, P.C., Round, P.D. and Rozendaal, F. G. (2001). *Systematic notes on Asian Birds*. *A review of the russet bush-warbler* Bradypterus seebohmi (Ogilvie-Grant, 1895) Zool. Vert. 331: 11-64.

Fong J.J and Chen T.H. (2010) *DNA evidence for the hybridization of wild turtles in Taiwan: possible genetic pollution from trade animals*. Conservation Genetics 11: 2061-2066.

Food and Agriculture Organization of the United Nations (FRA), (2010). *Global Forest Resources Assessment 2010*, Country Report Timor Leste.

Forman, L. and Bridson, D. (1989) *The Herbarium handbook.* Kew: Royal Botanic Gardens and HMSO.

Garnett, S. T. and Crowley, G. M. (2000). *The Action Plan for Australian Birds 2*000. Environment Australia, Canberra.

Gibson-Hill, C.A. (1947). *Notes on the birds of Christmas Island*. *Bull. Raffles Mus*. 18: 87-165.

Global Invasive Species Database (http://www.issg.org/database) [accessed on 29 February 2012].

Glover I. (1986). *Archaeology in Eastern Timor, 1966-1967*. TerraAustralis II. Canberra: ANU.

Gore, M.J.E. (1968). *A Check-list of the birds of Sabah, Borneo*. Ibis 110: 165-196.

Hayman, P., J. Marchant and T. Prater. (1986). *Shorebirds – an Identification Guide to the Waders of the World*. Houghton Mifflin Company, USA.

Higgins P. and Davies S. (eds) (1996). *Handbook of Australian, New Zealand and Antarctic Birds Volume 3: Snipe to Pigeons*. Oxford University Press, Melbourne.

Kaiser, H., Venancio Lopes Carvalho, Jester Ceballos, Paul Freed, Scott Heacox, Barbara Lester, Stephen J. Richards, Colin R. Trainor, Caitlin Sanchez, Mark O'Shea (2011). *The herpetofauna of Timor-Leste: a first report*.

del Hoyo, J., Elliott, A. and Sargatal, J. (eds). (1996). *Handbook of the birds of the world. Vol. 3. Barcelona: Lynx Edicions*. 821 pp.

Huffman, B. (1999). 'Celebes Pig: Sulawesi Warty Pig *Sus celebensis*' (On-line). Ultimate Ungulate Page. Accessed May 28, 2004 at http://www.ultimateungulate.com/Artiodactyla/Sus_celebensis.html.

IUCN. (2011). *2011 IUCN Red List of Threatened Species*. Version 2011.2. http://www.iucnredlist.org [accessed on 30 January 2012].

Johnsgard, P. A. (1981). *The plovers, sandpipers, and snipes of the world*. Univ. Nebraska Press, Lincoln. 493pp.

Lambert, F. R, Trainor, C. R., and Xavier, A. F. (2006). Observations of Wetar Ground-dove Gallicolumba hoedtii from Timor-Leste (East Timor). Forktail.22: 165-170.

Macdonald, A. (1993). *Pig, Peccaries and Hippos*. IUCN, 5.7: 155-160.

Marchant, S. and P.J. Higgins. (1990). *Handbook of Australian, New Zealand and Antarctic Birds. Vol. 1*, Oxford University Press, Melbourne.

Mauro I. (2003). *New and significant ornithological records from Asia's newest country: Timor Leste*. Unpublished report to BirdLife International.

Monk, K.A., de Fretes, Y. and Reksodiharjo-Lilley, G. (1997). *The Ecology of Nusa Tenggara and Maluku*. Periplus, Hong Kong.

Noske, R. (1994) *Shining Bronze Cuckoo and Channel-billed Cuckoo: first records for Timor*. Kukila 7: 68–69.

Noske, R. A. (1996) *At the crossroads of two avifaunas—Timor*. Oriental Bird Club Bull. 21: 34–38.

Noske, R. A. (1997) *The ecology of Timor birds*. Pp 353–362 in K. A. Monk, Y. de Fretes and G. Lilley, eds. The ecology of Nusa Tenggara and Maluku. Singapore: Periplus Editions.

Noske, R. A. and Saleh, N. (1996). *The conservation status of forest birds in West Timor*. Pp.65–74 in D. Kitchener and A. Suyanto, eds. Proceedings of the first International Conference on Eastern Indonesian–Australian Vertebrate Fauna. Manado, Indonesia. Jakarta: Indonesian Institute of Sciences (LIPI) and Western Australian Museum.

Oxfam, (2003). *The Customary Use of Natural Resources in Timor Leste*.

Parker, S. (1990). *Sus Celebensis*. Pp. 20,21,33-47 in Grzimek's Encyclopedia of Mammals, Vol. 5. New York:

Silveira, P., Schuiteman, A., Jan Vermeulen, JAAP., Sousa, J.A. Silva, H., Paiva, J., and De Vogel, E. (2008). *The orchids of Timor: checklist and conservation status*. Botanical Journal of the Linnean Society, 157, 197-215.

Smith, N. M. (1995). *Weeds of Natural Ecosystems. A Field Guide to Environmental Weeds of the Northern Territory, Australia*. Environment Centre NT.

Snow, D.W. and Perrins, C.M. (1998) *The birds of the western Palearctic, Concise ediditon*. Oxford University Press.

Trainor, C.R., and Soares, T. (2004) *Birds of Atauro Island, Timor Leste (East Timor)*. Forktail 20: 41-48

Trainor, C. R., Santana, F., Xavier, A., do Santos, L. Xavier, F., and dos Santos, J. (2004). *Status of globally threatened birds and internationally significant sites in Timor-Leste (East Timor) based on rapid participatory biodiversity assessments*. Report to BirdLife International – Asia Programme.

Trainor, C. R. Santana, F., Rudyanto, Almeida, A. F., Pinto, P. and de Oliveira, G. F. (2007a) *Important Bird Areas in Timor-Leste: key sites for conservation*. Cambridge, UK: BirdLife International.

Trainor, C.R., Coates, B. and Bishop, K. D. (2007b) *Birds of Timor-Leste*, BirdLife International and Dove Publications.

Trainor.C, Santana. F, Pinto. P, Xavier, Safford. R, and Grimmett. R. (2008). *Birds, birding and conservation in Timor-Leste*. BirdingASIA 9: 16–45.

Walker, S. J., Cahill, A, J. and Marsden S. J. (2006). *Recovery within a population of the Critically Endangered citron-crested cockatoo* Cacatua sulphurea *citrinocristata in Indonesia after 10 years of international trade control.* Oryx, 40 , pp 161-167 doi:10.1017/S0030605306000366

White C.M.N. and Bruce M.D. (1986). *The birds of Wallacea (Sulawesi, the Moluccas and Lesser Sunda Islands Indonesia): an annotated check-list*. London: British Ornithologists' Union (Check-list No. 7).

World Bank (2009). *Timor-Leste: Country Environmental Analysis July 2009*. Sustainable Development Department East Asia and Pacific Region, World Bank.

van Welson, P.C., Ferry Slik, J.W., and Alahuhta, J. 2005. Plant distribution patterns and plant tectonics in Melesia. *Biol. Skr.* 55: 199-217.

Appendix 1 – IUCN Red List

The IUCN Red List of Threatened Species™ is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species (IUCN 2012). It provides taxonomic, conservation status and distribution information on plants and animals that have been globally evaluated using the IUCN Red List Categories and Criteria (IUCN 2012). The IUCN red List describes nine categories that which a species of flora and fauna can be assessed as. Table 1 details the nine categories in which species can be determined as. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable). The IUCN Red List also includes information on plants and animals that are categorized as Extinct or Extinct in the Wild; on taxa that cannot be evaluated because of insufficient information (i.e., are Data Deficient); and on plants and animals that are either close to meeting the threatened thresholds or that would be threatened were it not for an ongoing taxon-specific conservation programme (i.e., are Near Threatened) (IUCN 2012).

Table 1 The detailed criteria and categories of the IUCN Red List

Criteria		Description
EX	Extinct	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
EW	Extinct in the Wild	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
CR	Critically Endangered	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.
EN	Endangered	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.
VU	Vulnerable	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable, and it is therefore considered to be facing a high

Criteria		Description
		risk of extinction in the wild.
NT	Near Threatened	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
LC	Least Concern	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
DD	Data Deficient	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.
NE	Not Evaluated	A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

Source: http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria

Appendix 2 – IUCN Listed Flora

Table 1 Flora Species on IUCN Red List in Timor-Leste

Family	Species	Status
Acanthaceae	*Acanthus ilicifolius* (Holy Mangrove)	Least Concern
Burmanniaceae	*Burmannia disticha*	Least Concern
Ceratophyllaceae	*Ceratophyllum muricatum*	Least Concern
Cyperaceae	*Carex baccans* (Crimson Seeded Sedge)	Least Concern
Cyperaceae	*Cyperus compactus*	Least Concern
Cyperaceae	*Diplacrum caricinum*	Least Concern
Cyperaceae	*Echinochloa picta*	Least Concern
Cyperaceae	*Eleocharis geniculata* (Canada Spikesedge)	Least Concern
Cyperaceae	*Eleocharis retroflexa*	Least Concern
Cyperaceae	*Fimbristylis argentea*	Least Concern
Cyperaceae	*Fimbristylis bisumbellata* (Fimbristylis à Deux Ombelles)	Least Concern
Cyperaceae	*Fimbristylis consanguinea*	Least Concern
Cyperaceae	*Fimbristylis dipsacea* (Harper's Fimbristylis)	Least Concern

Family	Species	Status
Cyperaceae	*Fimbristylis nutans*	Least Concern
Cyperaceae	*Fimbristylis ovata*	Least Concern
Cyperaceae	*Fuirena pubescens* (Fuirène Pubescent)	Least Concern
Cyperaceae	*Lipocarpha gracilis*	Least Concern
Cyperaceae	*Pycreus macrostachyos*	Least Concern
Cyperaceae	*Pycreus sanguinolentus*	Least Concern
Cyperaceae	*Schoenoplectiella lateriflora*	Least Concern
Cyperaceae	*Scleria mikawana*	Least Concern
Cyperaceae	*Scleria terrestris*	Least Concern
Fabaceae	*Parochetus communis* (Blue Oxalis)	Least Concern
Halagoraceae	*Myriophyllum tuberculatum*	Least Concern
Leguminosae	*Sesbania javanica*	Least Concern
Lemnaceae	*Lemna minor* (Common Duckweed)	Least Concern
Lygodiaceae	*Lygodium microphyllum*	Least Concern

Family	Species	Status
Poaceae	*Brachiaria eruciformis*	Least Concern
Poaceae	*Eriochloa procera* (Spring Grass)	Least Concern
Poaceae	*Leptochloa fusca*	Least Concern
Poaceae	*Leptochloa obtusiflora*	Least Concern
Poaceae	*Leptochloa panicea* (Mucronate Sprangletop)	Least Concern
Podocarpaceae	*Podocarpus rubens*	Lower Risk/least concern
Podocarpaceae	*Sundacarpus amarus*	Lower Risk/least concern
Podostemaceae	*Cladopus nymanii*	Least Concern
Scrophulariaceae	*Lindernia antipoda*	Least Concern

Appendix 3 – Flora Species List

Table 1 Vascular flora species recorded in the Tasi Mane project area

Life Form Key: Tree (T), Shrub (S), Vine (V), Herb (H)

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
ACANTHACEAE	*Acanthus ilicifolius*		Holly leaf mangrove	S		
ACANTHACEAE	*Avicennia marina*	ate-dara		T		
ACANTHACEAE	*Lepidagathis eucephala*			H		
ACANTHACEAE	*Ruellia tuberosa*		Petunia	H		
AMARANTHACEAE	*Aerva sanguinolenta*			H		
AMARYLLIDACEAE	*Crinum* affin *stuhlmannii*			H		
ANACARDIACEAE	*Anacardium occidentale*	caijus	cashew	T		
ANACARDIACEAE	*Mangifera indica*	has	mango	T		
ANACARDIACEAE	*Mangifera timorensis*	has fuik	wild mango	T		
ANNONACEAE	*Annona squamosa*	ayata		T		
ANNONACEAE	*Uvaria rufa*	hudi-clar		V		
APOCYNACEAE	*Alstonia scholaris*	ai-roti		T		
APOCYNACEAE	*Alstonia spectabilis*	ate-rutik	native frangipani	T		
APOCYNACEAE	*Amphineurion marginatum*			V		
APOCYNACEAE	*Asclepias curassavica*			H		
APOCYNACEAE	*Cascabela thevetia*	ai-askabit		S		
APOCYNACEAE	*Cerbera manghas*	ai-odi	native frangipani	T		
APOCYNACEAE	*Dischidia major*	tatalik		V		
APOCYNACEAE	*Tabernaemontana pandacaqui*	ai-kahoruk		S		
APOCYNACEAE	*Wrightia* sp.	ai-lele fuik		V		
ARACEAE	*Amorphophallus paeonifolius*	maek		H		
ARECACEAE	*Borassus flabellifer*	tali	palm	T		
ARECACEAE	*Cocus nucifera*	nú	coconut	T		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
ARECACEAE	*Corypha utan*	tuatali metan	Kennedy palm	T		
ARECACEAE	*Nypa fruiticans*	ai-tasi	mangrove palm	T		
ARECACEAE	*Salacca edulis*	ai-rota		T		
ASCLEPIDIACEAE	*Calotropis gigantea*	fuka	Crown flower	S	*	
ASPARAGACEAE	*Asparagus racemosus*	hatikibi		V		
ASPARAGACEAE	*Pleomele flexuosa*			S		
ASTERACEAE	*Chromolaena odorata*	ai-funanmutik	Siam weed	S	*	
ASTERACEAE	*Pluchea indica*			S		
ASTERACEAE	*Tridax procumbens*			H		
BIGNONIACEAE	*Dolichandrone spathacea*	ai-sirian		T		
BORAGINACEAE	*Cordia dichotoma*	ai-nunak		T		
BORAGINACEAE	*Cordia subcordata*	ate-biamete		S		
BORAGINACEAE	*Tournefortia sarmentosa*	vine		S		
CACTACEAE	*Opuntia ficus-indica*		cactus	S		
CARICACEAE	*Carica papaya*	aidila	papaya	S		
CASUARINACEAE	*Casuarina* sp. affin. *junghuhniana*	ai-kakeu	she-oak	T		
CELASTRACEAE	*Maytenus marginata*	ai-luruka		T		
CLEOMACEAE	*Cleome viscosa*			H		
CLUSIACEAE	*Calophyllum inophyllum*	ai-toh		T		
COMBRETACEAE	*Lumnitzera racemosa*	ai-biku	mangrove	T		Timor, Alor
COMBRETACEAE	*Terminalia catappa*	ai-lesse		T		
CONVOLVULACEAE	*Ipomoea aquatica*	kanko (Kangkung)		H		
CONVOLVULACEAE	*Ipomoea batatas*	fehuk midar	sweet potato	H		
CONVOLVULACEAE	*Ipomoea pes-caprae*			V		
CONVOLVULACEAE	*Ipomoea sp.*			V		
CONVOLVULACEAE	*Ipomoea triloba*	tatalik		V		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
CONVOLVULACEAE	*Merremia emarginata*	tatalik		V		
CUCURBITACEAE	*Citrullus lanatus*	pateka	watermelon	V		
CUCURBITACEAE	*Cucumis sativus*	pipinu	cucumber	V		
CUCURBITACEAE	*Cucumis sp.*	melansia	melon	V		
CUCURBITACEAE	*Cucurbita sp.*	lakeru	pumpkin	V		
CYPERACEAE	*Cyperus javanicus*	du'ut	sedge	H		
CYPERACEAE	*Fimbristylis cymosa*	du'ut	sedge	H		
CYPERACEAE	*Fimbristylis ferruginea*	du'ut		H		
CYPERACEAE	*Schoenus falcatus*			H		
EBENACEAE	*Diospyros littorea*	ai-metan		T		
EBENACEAE	*Diospyros montana*	ai-metan		T		Philippines, Celebes, E Java, LSI (Lombok, Sumba, Flores, Timor)
EUPHORBIACEAE	*Aleurites moluccana*	cami	candlenut	T		India to Pacific Is; t/o Malesia; (pres Timor), cult
EUPHORBIACEAE	*Euphorbia tithymaloides*	ai-tatalik tasi		H		
EUPHORBIACEAE	*Excoecaria agallocha*	ai-tano	mangrove	T		
EUPHORBIACEAE	*Jatropha curcas*	banut-mutin		S	*	
EUPHORBIACEAE	*Jatropha gossypiifolia*	miro		S	*	introduced Timor
EUPHORBIACEAE	*Mallotus philippensis*	ai-sablama		T		
EUPHORBIACEAE	*Manihot esculenta*	aiferina	cassava	H		
FABACEAE	*Abrus prectatorius*	olonanawa		V		
FABACEAE	*Albizia lebbeckoides*	ai-samtuku, ai-martuku		T		China to NG; LSI (Bali, Kisar, Sumba, Sumbawa, Komodo, Flores, Timor)
FABACEAE	*Albizia saman*	ai-matan dukur	sleeping tree	T		Native to S Am; intro in LSI; scarcely naturalised Timor
FABACEAE	*Arachis hypogaea*	forai	peanut	H		
FABACEAE	*Bauhinia cunninghamii*			S		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
FABACEAE	*Cathormion umbellatum*	ai-lulun		T		
FABACEAE	*Centrosema molle*	tatalik		V		
FABACEAE	*Delonix regia*		poinciana	T		
FABACEAE	*Desmanthus virgatus*			S		
FABACEAE	*Dichrostachys cinerea*	ai-adelae		T		
FABACEAE	*Leucaena leucocephala*	ai-café	coffee tree	T	*	Pantropical; t/o Malesia (intro) Timor
FABACEAE	*Peltophorum pterocarpum*	ai-máme, bak-mur		T		Sri Lanka to N Aust; t/o Malesia, pres Timor
FABACEAE	*Pterocarpus indicus*	ai-na		T		
FABACEAE	*Senna timorensis*	ai-cachote		S		
FABACEAE	*Tamarindus indica*	sukaer	tamarind	T	*	
FABACEAE	*Teramnus labialis*			V		
FABACEAE	*Uraria lagopodioides*	Ervilha	pea	H		all LSI
FABACEAE	*Vachellia nilotica*	ai-bakuro malae, ai-tarak		T	*	
FABACEAE	*Vigna unguiculata* subsp. *sesquipedalis*	fore	beans	H		
FLAGELLARIACEAE	*Flagellaria indica*	tatalik tirilolo		V		
GOODENIACEAE	*Scaevola taccada*	ai- tasi	scaevola	S		
LAMIACEAE	*Callicarpa candicans*	sapateri	vine	S		
LAMIACEAE	*Gmelina arborea*	ai-teka	teak	T		
LAMIACEAE	*Gmelina elliptica*	ai-lok fuk		V		
LAMIACEAE	*Ocimum tenuiflorum*			H		
LAMIACEAE	*Premna serratifolia*	tatalik, ai-tasi	vine	S		
LAMIACEAE	*Vitex pinnata*	ai-tahan tolu		T		
LAMIACEAE	*Vitex trifolia*	ai-tasi		S		
LAURACEAE	*Cinnamomum* sp.	ai-canela	cinnamon tree	T		
LAURACEAE	*Litsea glutinosa*			T		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
LECYTHIDACEAE	*Barringtonia racemosa*	ai-baknas	mangrove	T		
LILIACEAE	*Gloriosa superba*	tatalik	vine	V		
LOGANIACEAE	*Strychnos lucida*	bakmur lotuk		T		IndoAustralia, E Java, LSI (Bali, Flores, Sumbawa, Timor, Wetar, Babar)
LOMARIOPSIDACEAE	*Nephrolepis sp.*		fern	F		
LYGODIACEAE	*Lygodium circinnatum*	ai-tatalik lutu	fern	F		
LYTHRACEAE	*Sonneratia alba*	ate-kesu	red mangrove	T		
LYTHRACEAE	*Sonneratia caseolaris*	ai-tano	mangrove	T		
MALPIGHIACEAE	*Hiptage benghalensis*	tatalik		V		India to Taiwan to LSI (Bali, Alor, Timor) vine, mericarp1, 3-winged
MALPIGHIACEAE	*Ryssopterys timoriensis*	tatalik		V		
MALVACEAE	*Ceiba petandra*	cabas katal - Timor	wild cotton	T		
MALVACEAE	*Gossypium arboreum*		wild cotton	S		
MALVACEAE	*Grewia sp.*			T		
MALVACEAE	*Helicteres isora*			S		
MALVACEAE	*Heritiera littoralis*	ai-kebo	mangrove	T		
MALVACEAE	*Hibiscus tiliaceus*	ai-fau, ai-araleu, ai-katar		T		
MALVACEAE	*Sida.* sp.			H		
MALVACEAE	*Stercula foetida*	ai-bano		S		
MELIACEAE	*Aphanamixis polystachya*			T		
MELIACEAE	*Melia azedarach*	ai-betukate		T		
MELIACEAE	*Xylocarpus moluccensis*	ate-sabrika	mangrove	T		India to N Aust.; t/o Malesia, pres Timor
MORACEAE	*Artocarpus altilis*	kulu modo	breadfruit	T		
MORACEAE	*Artocarpus heterophyllus*	kulu jaka	jackfruit	T		
MORACEAE	*Broussonetia papyrifera*	ai-bau		T		India to NG; LSI(Fl,Ti,Al,We)
MORACEAE	*Fatoua pilosa*			H		Philippines, Celebes, Java, all

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
						LSI, Moluccas, Melanesia
MORACEAE	*Ficus ?benjamina* or *microcarpa*		fig	T		
MORACEAE	*Ficus hispida*	ai-kapkou		T		
MORACEAE	*Ficus sp.*	ai-hale	fig	T		
MORACEAE	*Ficus variegata*	ai-kun	fig	T		
MORACEAE	*Ficus virens, drupacea* or *superba*	hale	fig	T		
MORACEAE	*Streblus taxoides*			S		India to LSI (Fl,Ti)
MUNTINGIACEAE	*Muntingia calabura*	cerejes	Timor cherry	T		
MUSCACEAE	*Musa* sp.	hudi	banana	T		
MYRTACEAE	*Psidium guajava*	goyava	guava	T		
NYCTAGINACEAE	*Boerhavia errecta*	marlale		H		
ORCHIDACEAE	*Tropidia curculigoides*	trilolo		H		
OXALIDACEAE	*Averrhoa bilimbi*	belimbe		S		
PANDANACEAE	*Pandanus* sp.	ai-hedan	pandanus	T		
PANDANACEAE	*Pandanus tectorius*		pandanus	T		
PASSIFLORACEAE	*Passiflora foetida*	marquisas	wild passionfruit	V		
PHYLLANTHACEAE	*Bridelia ovata*	ate-siki		T		LSI (Ba, Sw, Su, Fl, Ti, Al)
PHYLLANTHACEAE	*Bridelia tomentosa*	ate-kai lakudiri		T		
PHYLLANTHACEAE	*Flueggea virosa*			S		Af to N Aust; LSI (Fl, Sw, Ti)
PHYLLANTHACEAE	*Glochidion xerocarpum*	metikai-kobi		T		
POACEAE	*Bambusa blumeana*	au	bamboo	H		D.Franklin (pers.comm.); Apparently native, possibly naturalised from historical introductions
POACEAE	*Chloris truncata*		grass	H		
POACEAE	*Chrysopogon aciculatus*	du'ut	grass	H	*	
POACEAE	*Cyrtococcum trigonum*		grass	H		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
POACEAE	*Imperata cylindrica*	pae	grass	H	*	
POACEAE	*Saccharum spontaneum*	du'ut	grass	H	*	
POACEAE	*Spinifex littoreus*		beach spinifex	H		
POACEAE	*Zea mays*	batar	corn	S		
POLYPODIACEAE	*Drynaria quercifolia*	kluku	basket fern	F		
POLYPODIACEAE	*Platycerium* sp.	pakis (indonesian)	staghorn	F		
POLYPODIACEAE	*Pyrrosia longifolia*		fern	F		
PRIMULACEAE	*Maesa* sp. affin. *integrifolia*	ai-lenuk, ai-tasi		S		
PTERIDACEAE	*Adiantum caudatum*		fern	F		
PTERIDACEAE	*Doryopteris concolor*		fern	F		
PTERIDACEAE	*Pteris ensiformis*		fern	F		
RHAMNACEAE	*Ziziphus mauritiana*	ai-lok		T	*	
RHAMNACEAE	*Ziziphus timoriensis*	ai-metan bo'ot, lerhula ki'ik		T		
RHIZOPHORACEAE	*Rhizophora stylosa*		mangrove	T		
RUBIACEAE	*Hedyotis biflora*			H		
RUBIACEAE	*Morinda citrifolia*	mengkudu or ai-lenuk		T		
RUBIACEAE	*Nauclea orientalis*	ai-kafira, sawa		T		
RUTACEAE	*Aegle marmelos*	aidila fatuk	wild papaya	T		
RUTACEAE	*Fimbristylis ferruginea*			H		
RUTACEAE	*Harrisonia brownii*	ate-gaba		S		
RUTACEAE	*Luvunga monophylla*			V		
SANTALACEAE	*Exocarpos latifolius*	ai-cacasa, tatalik metan		T		
SANTALACEAE	*Santalum album*	ai-cameli	sandalwood	T		Australia (N Territory), S NG, S Celebes, LSI (Timor, Flores);
SAPINDACEAE	*Allophylus cobbe*			S		Pantropical; all Malesia (pres Timor)

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
SAPINDACEAE	*Elattostachys verrucosa*	ai-baknas		T		Java to Philip & Moluccas, LSI (Bali, Lombok, Sumba, Sumbawa, Flores, Timor, Wetar)
SAPINDACEAE	*Elattostachys verrucosa*	ate-asaulalai		T		Java to Philip & Moluccas, LSI (Bali, Lombok, Sumba, Sumbawa, Flores, Timor, Wetar)
SAPINDACEAE	*Lepisanthes rubiginosa*			S		N India to NW Aust (WA); common Malesia (Timor)
SAPINDACEAE	*Schleichera oleosa*	ai-dak		T		Sri Lanka to China & Moluccas; LSI (Bali Sumba, Sumbawa, Flores, Timor, Alor)
SCROPHULARIACEAE	*Myoporum montanum*	ai-kahoruk ki'ik		S		
SMILACACEAE	*Smilax zeylanica*	tatalik siapa	vine	V		
SOLANACEAE	*Capsicum annuum*	ai-manas		H		
STERCULIACEAE	*Helicteres isora*	oel		T		
THELYPTERIDACEAE	*Christella arida*	pakis (Indonesian)	fern	F		
VERBENACEAE	*Lantana camara*	ai-funan meak	lantana	V	*	
VERBENACEAE	*Stachytarpheta cayennensis*			H	*	
VERBENACEAE	*Tectona grandis*	ai-teka	teak	T		
VIOLACEAE	*Hybanthus enneaspermus*	fore tali		H		Philippines, E Java, all LSI, Moluccas, NG. Once in N Borneo
VITACEAE	*Ampelocissus arachnoideus*			V		
VITACEAE	*Cayratia trifolia*	tatalik		V		
VITACEAE	*Leea aequata*	ai-manek		H		Nepal to Moluccas; LSI (Sumba, Timor, Wetar)

Appendix 4 – Fauna Habitat Assessments

WorleyParsons
resources & energy

EcoNomics

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	10 December 2011	ML
Site Number – HA1 [Suai]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 51L Easting 752588 Northing 8969667		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Albizia saman* [ai-matandukur], *Casuarina* sp. affin. *junghuhniana* [ai-kakeu], Gebang Palm *Chorypha utan* [tuatali metan]	10-40%	15-20 m
Mid-story	Pandanus spp. [ai-hedan], Palmyra Palm *Borassus* spp. [tali], *Acacia* spp. [ai-tarak]	>20%	~4 m
Under-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], deciduous herbs and grasses	>20%	< 0.5 m

Litter cover	Logs (%) <1%		Twigs (%) <5%		Leaves (%) 10-20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown sand /mud complex					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Lack of complex understory species / stratum reduced micro-niche potential; area subject to repeatable fire events and swidden agriculture and logging.					

WorleyParsons
resources & energy

EcoNomics

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	10 December 2011	ML
Site Number – HA2 [Suai]			
Habitat	Coastal		
UTM Coordinates	Zone 51L Easting 753697 Northing 8969520		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Excoecaria agallocha*	10-15%	8-15 m
Mid-story	nil	nil	nil
Under-story	nil	nil	nil

Litter cover	Logs (%) <1%		Twigs (%) <5%		Leaves (%) 10-20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Grey – black sand /mud complex					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	High tide inundation					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Lack of complex understory species / stratum typical of mangrove sites which are frequently inundated in high tide events. Very little leaf litter and under-story.					

WorleyParsons
resources & energy

EcoNomics

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	11 December 2011	ML
Site Number – HA3 [Suai]			
Habitat	Riparian		
UTM Coordinates	Zone 51L Easting 756401 Northing 8971261		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Albizia saman* [ai-matandukur], *Schleichera oleosa* [ai-dak]	10-20%	8-10 m
Mid-story	[ai-fau], Bamboo, *Peltophorum pterocarpus* [ai-mame], [ai-na]	>20%	1-6 m
Under-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], deciduous herbs and grasses	>20%	< 0.5 m

Litter cover	Logs (%) <1%		Twigs (%) <5%		Leaves (%) 10-20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown sand /mud complex					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	Small creek line with running water and stagnate pools					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Lack of complex understory species / stratum reduced micro-niche potential; area subject to repeatable fire events and swidden agriculture.					

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	12 December 2011	ML
Site Number – HA4 [Suai]			
Habitat	Riparian		
UTM Coordinates	Zone 51L Easting 754211 Northing 8970894		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Albizia saman* [ai-matandukur], *Schleichera oleosa* [ai-dak], *Casuarina* sp. affin. *junghuhniana* [ai-kakeu], Gebang Palm *Chorypha utan* [tuatali metan]	10-20%	8-10 m
Mid-story	[ai-fau], Bamboo, *Peltophorum pterocarpus* [ai-mame], [ai-na]	>20%	1-6 m
Under-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], deciduous herbs and grasses	>20%	< 0.5 m

Litter cover	Logs (%) 5%		Twigs (%) 10%		Leaves (%) >10%	
Boulders	nil		Surface Rocks		Riverine, cobbles and pebbles	
Soils	Grey Sand					
Tree Hollows	Large	Present	Medium	Present	Small	Present
Water Bodies	Dry creek bed					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	0.1 m	Width (m)	0.1 m	Depth (m)	
Notes	Dry river bed approximately 10 m wide, heavily eroded banks (2-4 m tall). Burrowing potential for ground dwelling reptiles and mammals. Burrows / nests in heavily eroded banks (Rainbow Bee-eater nests). Large trees fringing the drainage line edge /creek bed with strong hollow potential.					

WorleyParsons
resources & energy

EcoNomics

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	7 February 2012	ML
Site Number – HA12 [Suai]			
Habitat	Deciduous Woodland / Forest (Swidden Agriculture)		
UTM Coordinates	Zone 51L Easting 753133 Northing 8973261		

Stratum	Species	Cover (%)	Height (m)
Over-story	Gebang Palm *Chorypha utan* [tuatali metan], Palmyra Palm *Borassus* spp. [tali], [sawa], *Ziziphus mauritiana* [ai-lok], [ai-martuku], *Ficus variegata* [ai-kun], Ficus spp. [hali], [ai-catimu], *Casuarina* sp. affin. *junghuhniana* [ai-kakeu]	<20%	10-15 m
Mid-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], Bellyache Bush *Jatropha gossypifolia* [miro]	>50%	1-3 m
Under-story	nil	nil	nil

Litter cover	Logs (%) <1%		Twigs (%) <10%		Leaves (%) >10%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Grey-Brown sand/mud complex					
Tree Hollows	Large	nil	Medium	nil	Small	present
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Lack of under-story diversity and abundance dominated by weed species restricts the level of micro-niche diversity. Plantation species present include Teak [ai-teka] and Sandalwood [ai-morin]					

WorleyParsons
resources & energy

EcoNomics

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	8 February 2012	ML
Site Number – HA13 [Suai]			
Habitat	Coastal		
UTM Coordinates	Zone 51L Easting 757223 Northing 8971496		

Stratum	Species	Cover (%)	Height (m)
Over-story	Gebang Palm *Chorypha utan* [tuatali metan], Palmyra Palm *Borassus* spp. [tali], *Casuarina* sp. affin. *junghuhniana* [ai-kakeu], Mangrove species [ai-biku, ai-tanu, ai-tano], [ai-martuku], *Ficus variegata* [ai-kun], [ai-catimu]	<20%	20-30 m
Mid-story	Pandanus spp. [ai-hedan]	<10%	1-4 m
Under-story	nil	nil	nil

Litter cover	Logs (%) <5%		Twigs (%) <10%		Leaves (%) >30%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Soils	Brown sand					
Tree Hollows	Large	Present	Medium	Present	Small	Present
Water Bodies	Coastal Estuary (30 m wide)					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Complex over-story structure and diversity, little to no mid and under-story structure and species; good potential habitat for the Saltwater Crocodile. Extensive leaf litter micro-niches and good burrowing potential for estuarine species.					

WorleyParsons
resources & energy

EcoNomics

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	8 February 2012	ML
Site Number – HA14 [Suai]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 51L Easting 755382 Northing 8971067		

Stratum	Species	Cover (%)	Height (m)
Over-story	Palmyra Palm *Borassus* spp. [tali], ai-dak], [sawa], *Ziziphus mauritiana* [ai-lok], [ai-martuku], *Ficus variegata* [ai-kun], Ficus spp. [hali], [ai-catimu]	<35%	<25 m
Mid-story	*Acacia* spp. [ai-tarak], Pandanus spp. [ai-hedan], Bellyache Bush *Jatropha gossypifolia* [miro]	<15%	1-5 ml
Under-story	Herbaceous and deciduous grasses and herbs, Siam Weed *Chromolaena odorata* [ai-funanmutik],	>50%	<1 m

Litter cover	Logs (%) <5%		Twigs (%) <8%		Leaves (%) >20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown sand					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Large amounts of leaf litter (Logs, Twigs & Leaves) providing an array of micro-niches. Large trees providing nesting and roosting potential for avian and airborne mammalian species. Good burrowing potential for ground dwelling reptile and mammals					

Appendix 5 – Timor-Leste Vertebrate Fauna list

Scientific Name	Common Name	Conservation Codes				A	B	C
		IUCN	CITES	Endemic	Introduced			
Phalangeridae								
Phalanger orientalis	Northern Common Cuscus	LC	App II		x	x	x	
Soricidae								
Crocidura fuliginosa	Southeast Asian Shrew	LC			x	x	x	
Crocidura maxi	Javanese Shrew	LC				x	x	
Crocidua monticola	Sunda Shrew	LC		x		x	x	
Crocidura tenuis	Thin Shrew	DD				x	x	
Suncus murinus mulleri	House / Musk shrew	LC			x	x	x	
Crocidura sp.	Shrew						x	
Pteropodidae								
Acerodon mackloti	Sunda Fruit Bat	VU						
Cynopterus titthaecheilus	Indonesian Short-nosed Fruit Bat	LC						
Dobsonia moluccensis	Moluccan Naked-backed Fruit Bat	LC						
Dobsonia peronii peronii	Western Naked-backed Fruit Bat	LC						
Eonycteris spelaea	Lesser Dawn Bat	LC						
Macroglossus minimus	Dagger-toothed Long-nosed Fruit Bat	LC						
Nyctimene keasti	Keast's Tube-nosed Fruit Bat	VU						
Pteropus griseus	Gray Flying-fox	DD	App II					
Pteropus lombocensis	Lombok Flying-fox	DD	App II					
Pteropus temminckii	Temminck's Flying-fox	VU	App II					
Pteropus vampyrus	Large Flying-fox	NT	App I			x		
Rousettus amplexicaudatus	Geoffroy's Rousette	LC						
Emballonuridae								
Saccolaimus saccolaimus	Bare-rumped Sheath-tailed Bat	LC						
Taphozous achates	Indonesian Tomb Bat	LC						
Taphozous melanopogon	Black-bearded Tomb Bat	LC						
Rhinolophidae								
Rhinolophus canuti timoriensis	Canut's Horseshoe Bat	VU		x				x
Rhinolophus celebensis parvus	Sulawesi Horseshoe Bat	LC		x				x
Rhinolophus montanus	Timorese Horseshoe Bat	DD		x				
Rhinolophus aff. *philippinensis maros*	Unidentified Large-eared Horseshoe Bat			x				
Hipposideridae								
Hipposideros bicolor hilli	Bicoloured Leaf-nosed Bat	LC		x				
Hipposideros diadema diadema	Diadem Leaf-nosed Bat	LC						x
Hipposideros sumbae aff. *rotiensis*	Sumban Leaf-nosed Bat	LC		?				
Vespertilionidae								
Harpiocephalus aff. *harpia*	Unidentified Hairy-winged Bat			?				
Kerivoula sp.	Unidentified Woolly Bat			?				
Miniopterus australis	Little Long-fingered Bat	LC						x
Miniopterus magnater	Western Long-fingered Bat	LC						
Miniopterus oceanensis	Australasian Bent-winged Bat	LC						
Miniopterus pusillus	Small Long-fingered Bat	LC		x				
Murina aff. *florium*	Unidentified Tube-nosed Bat			?				
Myotis adversus adversus	Large-footed Myotis	LC						
Nyctophilus sp.	Unidentified Long-eared Bat			?				
Pipistrellus sp.	Unidentified Pipistrelle			?				

Scotophilus collinus	Sody's Yellow House Bat	LC						
Scotorepens sanborni	Northern Broad-nosed Bat	LC						
Tylonycteris robustula	Greater Bamboo Bat	LC						
Cercopithecidae								
Macaca fascicularis	Long-tailed Macaque	LC				x	x	x
Muridae								
Mus castaneus	Asian House Mouse				x		x	
Mus domesticus homourus	European House Mouse	LC			x	x	x	
Rattus timorensis	Timor Rat	DD		x			x	
Rattus argentiventer	Ricefield Rat	LC		x		x	x	
Rattus exulans	Polynesian Rat	LC			x	x	x	
Rattus rattus	Ship Rat	LC			x	x	x	
Rattus norvegicus	Brown Rat	LC			x	x	x	
Rattus tanezumi	Oriental House Rat	LC			x	x	x	
Canidae								
Canis familiaris	Domestic Dog / Dingo				x		x	x
Viverridae								
Paradoxurus hermaphroditus	Common Palm Civet	LC			x	x	x	
Felidae								
Felis catus	Domestic Cat				x		x	
Suidae								
Sus celebensis	Sulawesi Wild Boar / Warty Pig	NT			x	x	x	
Sus scrofa	Domestic Pig	LC			x	x	x	x
Cervidae								
Cervus timorensis	Timor / Rusa Deer	VU			x	x	x	
Bovidae								
Bos javanicus	Banteng (Bali cattle)	EN			x	x	x	x
Bos taurus	Domestic Cattle / Ongole				x		x	x
Bubalis bubalis	Water Buffalo				x		x	x
Capra hircus	Domestic Goat				x		x	x
Ovis aries	Domestic Sheep				x		x	
Equidae								
Equus ferus caballus	Horse				x			
Equus africanus asinus	Donkey				x			

Key: A = Listed under IUCN Red List; B = Recorded in previous survey; C = Recorded in current assessment

(CR, EN, VU, NT, LC, DD) denotes Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern and Data Deficient under the IUCN Red List; (x) denotes recorded during the survey or database search

Appendix 6 – Bat Calls Identification for Timor-Leste

Bat call identification

from the south coast of Timor-Leste

DRAFT 20120306

Type:	Bat Call Analysis
Prepared for:	WorleyParsons Services Pty Ltd
Date:	$$ March 2012
Job No.:	SZ240
Prepared by:	Dr Kyle Armstrong and Ms Yuki Konishi Specialised Zoological ABN 92 265 437 422 + 61 (0) 404 423 264 kyle.armstrong@graduate.uwa.edu.au kyle.n.armstrong@gmail.com

Disclaimer page

Contents Page

SZ240 Document revision history

Date	Type
16 February 2012	First incomplete draft submitted to WorleyParsons
6 March 2012	Full draft submitted to WorleyParsons
pending	Final version submitted to WorleyParsons

1.0 INTRODUCTION

Bat species were identified on the basis of echolocation call recordings made with electronic bat detectors, as part of the flora and fauna survey for the Timor-Leste South Coast Environmental Impact Assessment, prepared by WorleyParsons Services Pty Ltd for the proposed Tasi-Mane petrochemical project. Further context details of the project can be found in the main flora and fauna report. This report by Specialised Zoological includes details related to the chiropteran mammals only, with some reiteration included in the main report. Specialised Zoological contributed electronic bat detectors, undertook analysis of echolocation recordings, provided background information (some of it the subject of private unpublished research in progress) and interpretation of the results. Apart from taxonomic comments on the Pteropodidae, the majority of this report concerns echolocating species in the remaining five chiropteran families present on Timor. For a summary of findings, please refer to section *5.0 Conclusions*.

2.0 BAT BIODIVERSITY IN TIMOR

Timor is part of the non-volcanic southern archipelago of the Lesser Sunda islands (also known as Nusa Tenggara), which forms part of the Indo-Australian tectonic plate. It can be further classified into the Moluccan Division, and the western part of the Wallacea ecoregion that contains biota of mixed Asian and Australasian origin, but with the predominance of the former. This Moluccan Division is characterised by "very impoverished faunas" according to Corbet and Hill (1992:6), being characteristic of islands east of Lombok with low endemism, and was considered to be very poorly known even as recently as this publication.

There have been relatively few bat surveys on the island of Timor, and the fauna is not yet completely described. The earliest and still the most comprehensive published summary of the bats of Timor is that of Goodwin (1979), who conducted field surveys, an extensive examination of museum collections and a review of the literature to derive a list of taxa with their current taxonomy. Based on Goodwin's field surveys and taxonomic examinations, there were 22 species known from Timor, 11 of which he added from identifications of previously described taxa or descriptions of new ones.

More recently, systematic bat surveys were conducted as part of an environmental impact assessment for a hydropower scheme involving power generation infrastructure in the vicinity of the Ira Lalaro polje and the Paitchau Range. The first survey in March 2004 near the village of Malahara recorded 16 species, of which up to four taxa were new records for the island and possibly species new to science (Pavey and Milne 2004). A second survey in October 2006 north and south of the Paitchau Range recorded 15 species, at least one of which was a new record for the island and also possibly new to science (Armstrong 2007). Voucher specimens, reference echolocation calls and tissue biopsies were collected on both surveys, and follow up taxonomic work involving comparisons with other museum specimens, micro-CT scanning of skulls, analysis of reference calls and DNA sequencing of tissue biopsies has been conducted as part of a manuscript in preparation (Armstrong et al., ms in prep.). Much of the unpublished information used for identifications in the present report is derived from this resource.

These unpublished reports have provided updates to Goodwin's (1979) species list for the island of Timor, in conjunction with another brief informal survey conducted by Helgen (2004). Based on the capture of a species of long-eared bat *Nyctophilus* sp. and the examination of museum skins, most notably of one resembling *Dobsonia moluccensis*, Helgen (2004) compiled from various sources a list of 27 (with a minimum of 25) bat species thought to be on Timor.

Armstrong (2007) provided a further update based on his own survey, museum records (most notably based on the many collections made by Kitchener et al. from the Western Australian Museum), that of Pavey and Milne (2004), and based on the taxonomic treatments of Simmons (2005), which brought the total for the island of Timor to 31 species. Of those, 28 were confirmed from within the boundaries of the nation of Timor-Leste. The work conducted for the manuscript in preparation (Armstrong et al. ms in prep.) has revised the list produced by Armstrong (2007), and is reproduced here in Table 1. Excluding doubtful records or species that may now be extinct on the island (*Dobsonia moluccensis, Nyctimene keasti, Pteropus temminckii*), there are 32 species currently likely to be extant on Timor, of which 29 are known from Timor-Leste, and of which six are currently the subject of active taxonomic studies and are potentially species or subspecies new to science. Of the 32 extant species of bat on Timor, one is endemic, an additional three have recognised endemic subspecies, and there are seven taxa that might be endemic at either species or subspecies level, pending further taxonomic investigation (Table 1). The endemics are in the families Hipposideridae, Rhinolophidae and Vespertilionidae.

Many of the bat species on Timor have an IUCN conservation status listing of Least Concern (20 species). However this means that just over a third of bats are, or could be, of conservation significance. If the three doubtful species records are excluded, two species are listed as Vulnerable, and one species is listed as Near Threatened. For the remainder, there is insufficient information on their distribution to allocate them to a category: four species are listed as Data Deficient; there are a further five taxa first recorded by Helgen (2004), Pavey and Milne (2004) and Armstrong (2007) on Timor that are not currently listed because of their uncertain taxonomic status, or because they are new and have yet to be described and evaluated; and there is one species thought previously to be widespread and listed as Least Concern, but which might actually be an undescribed endemic taxon based on recent genetic work (*Pipistrellus* aff. *tenuis*; Armstrong et al. ms in prep.). Given that there are only three other extant, non-introduced and non-commensal species of mammal on Timor (*Crocidura maxi* [widespread in Indonesia], *Crocidura tenuis* [endemic to Timor] and *Rattus timoriensis* [endemic to Timor]; Kitchener et al. 1991; Ruedi 1995; Aplin and Helgen 2010), bats represent around 90% of the known, non-commensal, native and extant Timorese mammal assemblage, and this is a significant proportion that needs consideration in the context of development proposals.

3.0 METHODS

3.1 Acoustic Recordings

The ultrasonic echolocation calls of bats, which are produced for spatial orientation and prey detection in flight, are useful for taxonomic identification because each species produces a unique and distinguishable (in many cases) signal type. Analysis of the recordings made using electronic 'bat detectors' can reveal echolocating bat diversity at sampling sites with minimal effort as part of a comprehensive to surveying bats. On the present survey, acoustic recordings were made with AnaBat SD1 and SD2 bat detectors (Titley Scientific, Brisbane), which were chosen for their ease of use and deployment, and the efficiency of data storage[1]. Data was available from two field survey periods: 10 – 19 December 2011 and 7 – 13 February 2012, and equipment was deployed by staff of WorleyParsons.

Bat detectors were waterproofed in plastic boxes, and microphones (both HiMic/green and ST1) on an extension lead were placed in a funnel made from a plastic drink bottle to reduce the chance of water exposure. The use of funnels reduces slightly the zone of signal detection, but was unavoidable as sites received rain frequently. The detectors were employed as passive stationary data recorders, being set in position prior to dusk and collected after dawn, and placed off the ground (1 m or more) with the microphone capsule tied to trees. The equipment was placed in a variety of habitats to maximise the potential to encounter all species present. A GPS position was recorded at each recording site and associated with the serial number of the recording unit and deployment date.

Echolocation signals were divided by a factor of 8 by AnaBat detectors, and stored automatically on a Compact Flash card, with each sequence of calls receiving a time and date stamp. The recording effort is summarised for each sampling locality in Table 2. The total recording effort was seven full night AnaBat recording sessions in December 2011 and six sessions in February 2012. Further deployments of AnaBat detectors were made, but recordings were not recovered because of issues with equipment.

3.2 Analysis of Acoustic Recordings

AnaBat recordings were downloaded using CFC Read 4.3s software. The output consisted of two sets of data: 1. the individual sequence files produced during interpretation by CFC Read software, which are organised into folders representing a single night's recording; and 2. the continuous representation of the AnaBat recordings in ZCA and MAP files, which show all of the signals detected by the AnaBat microphone but which have not been parsed into individual sequence files according to default interpretation parameters. The signals in both parsed sequence files and the ZCA and MAP files were examined in AnalookW 3.8s software.

Bat echolocation calls recorded with 'passively' deployed bat detectors at stationary sites over a full night are referred to here as 'anonymous' because there is no *a priori* knowledge of the number and identity of contributing bats. The first step in any analysis of acoustic recordings

[1] SM2BAT detectors (Wildlife Acoustics, Massachusetts) were available for December 2011 but could not be deployed.

of bats is attributing these anonymously recorded call types to a single species. This is usually done with the help of a reference library of good quality calls recorded from confidently identified bats. Given that trapping for bats was beyond the scope of the present survey, we took two approaches to making identifications from the recordings. Firstly, we used reference call information collected from Timorese bats by Armstrong (2007; summarised in Armstrong et al. ms in prep.). Identification of the anonymously recorded calls was made by inspection of parsed ZCA format files and matching the observed pulses with information from reference calls (pulse shape and measurement variables). Three call variables were measured on good quality search phase pulses in representative call sequences: pulse duration (milliseconds), maximum frequency (kHz) and characteristic frequency (the point at the end of the flattest portion of a pulse before any terminal secondary frequency sweep; kHz). A fourth variable was measured on Constant Frequency calls: the frequency with the greatest number of cycles (the flattest part of the call, designated as Fpz in AnalookW software). Summaries of pulse variables (Table 3) and representative sequence traces (Figure 1) are presented in support of the analysis and identifications, as recommended by the Australasian Bat Society (ABS 2006).

Call types that could not be identified based on the limited reference call material available were allocated a descriptive name according to a new nomenclatural scheme (Armstrong and Aplin ms in prep.) that defines the pulse in terms of its characteristic frequency and shape (Table 4). The scheme was modified from de Oliveira (1998a,b) and Corben and O'Farrell (1999), and has been used previously for surveys in Papua New Guinea (Armstrong and Aplin 2011; other unpublished confidential reports by K.P. Aplin and K.N. Armstrong) where the echolocation calls of many bat species have yet to be recorded and described. Fourteen call types, each representing a single species, could be recognised based on both the call type classification scheme and the reference calls. Notes on each call type and a justification for the identifications are provided, and where call types could not be attributed to a single species, candidates were noted for later verification (Table 5).

3.3 Interpreting echolocation calls – limitations and considerations

Several caveats and considerations are noted with regard to the identification of bat species based on recordings of their echolocation calls, of relevance to this survey:

- Two or more bat species may produce calls that are so similar that they cannot be distinguished reliably using the available methods or reference recordings (examples from Australia in McKenzie and Muir 2000; Milne 2002).

- A single bat species may produce more than one call type (e.g. search phase calls, approach phase calls, clutter calls) that might suggest the presence of more than one species. With sufficient experience of related species, it is generally possible for a bat echolocation specialist to take this into account, and to base identifications on the typically more diagnostic search phase calls. The development of an adequate call reference library will diminish this limitation.

- While the most recent bat surveys in Timor (Helgen 2004; Pavey and Milne 2004; Armstrong 2007) have together discovered up to six species new to Timor (some

possibly new to science), the majority of the unidentified call types will likely belong to described or these previously encountered species for which there are no verified echolocation reference calls, rather than additional new forms. As further reference calls become available, it will be possible to identify retrospectively many of the unallocated calls. Moreover, it should be noted that taxonomically unallocated call types are still useful for comparing trends in bat richness, relative abundance and community composition across sites and habitats. By using the call type as the unit of presentation and analysis, retrospective identifications can be applied through all analyses, site and habitat summaries; and knowledge of bat community structure and ecological function based on the echolocation call structure will allow predictions of changes within the bat assemblage in response to habitat modification.

- In the process of making identifications, the practice of identifying call types on the basis of general correlations between physical characteristics (e.g. forearm length, body weight) and echolocation call frequency (e.g. based on Jones 1996; Robinson 1996; Bogdanowicz *et al.* 1999; Zhang *et al.* 2000; Feng *et al.* 2000) (see Richards 2005, 2008 as an example) was avoided. Although this inferential method has merit in some circumstances, a more cautious, evidentiary approach that minimises the chance of calls being misidentified was preferred in the present survey.

- Absolute abundance of each species or call type at a site cannot be estimated from bat detector recordings because it is not possible to distinguish between relatively few bats passing the detector but contributing many calls, and a larger number of individuals passing the detector with each contributing relatively few calls. If sufficient site replication (multiple nightly sessions) in each locality is available, a measure of relative abundance of each call type can be derived. This value represents the proportional occurrence of each species / call type across replicate recording sessions, and gives a rough indication of 'commonness'.

- Finally, it should be noted that in all acoustic surveys (regardless of bat detector brand and model) the detectability of each species is determined to some extent by characteristics of their echolocation calls. In particular, species that produce ultra-high frequency (> 100 kHz) calls or those that produce calls with low amplitude (e.g. long-eared bats *Nyctophilus* spp.) will have relatively short detection distances, which will lead to their being under-represented or even missed altogether in an acoustic survey. The detectability of different call types is also influenced by atmospheric conditions, most notably relative humidity and temperature that act together to attenuate ultrasound, the effects of which are dramatic at higher frequencies (e.g. Armstrong and Kerry 2011). Thus, acoustic detection represents only one component of a comprehensive survey approach for bats, and targeted effort is required for species with lower acoustic detectability.

4.0 RESULTS AND DISCUSSION

A total of 13 informative AnaBat sessions were made on the two field surveys. All represent a full night of passive stationary recording at one of the survey localities. A total of 14 different call types was distinguished, and six call types could be allocated to species level through comparison with available reference calls (Tables 2 and 6). The remaining eight call types could not be assigned to either species or genus level, though possibilities are given in Table 5.

The replication of passive recording sites in the Suai locality allowed for the calculation of a species accumulation curve and the relative abundance of each species in that locality. Similar patterns could not be derived for the other sites because only one or two nights were available for each. The accumulation curve was calculated on the basis of the number of recording sites rather than survey nights to make it easier to display the pattern taken over two separate survey periods that were separated by around one month (Figure 2). Where several recordings (=sites) were made on the same night, those with cumulatively additional species were plotted first. Relative abundance of each species / call type is calculated as the proportion of nightly recordings that contain signals of that taxon (Table 6).

The accumulation curve reached eight species / call types after four bat detector nights in December 2011, and the addition of a further six survey nights in February 2012 added five species. While the curve appears to be approaching an asymptote, the plot also suggests that further taxa might still be added with additional survey nights because the asymptote is based on survey sites rather than nights. Obviously effort to detect non-echolocating fruit bats will likely add more chiropteran species, but further survey work will also help determine firstly whether there are additional echolocating bat species present and secondly what the unidentified call types may be attributed to if they can be captured.

At Suai, there were seven of 13 species with relatively high abundance (values of 0.8 and above). These included two species that forage widely in the open spaces above treetops (*21 sh.cFM, 25 cFM*; attributable to species of *Saccolaimus* and *Taphozous*, see Table 5); four species that forage in gaps and open spaces around stands of vegetation (*37 st.cFM, 41 st.cFM, 54 st.cFM, 63 st.cFM Miniopterus australis*) and one species that forages within and among stands of vegetation (*72 lCF Rhinolophus canuti timoriensis*). Most of these species roost in trees, suggesting that this resource is well supported in the locality, and also that caves are nearby for at least one of the species (*72 lCF Rhinolophus canuti timoriensis*). The other species present at lower abundance all roost in caves (*28 lCF Rhinolophus* aff. *philippinensis, 47 st.cFM, 55 sCF Hipposideros diadema, 86 lCF Rhinilophus celebensis parvus*), the latter has reduced detection potential because of its relatively high frequency. Thus, the values of relative abundance at Suai also reflect the more minor but important contribution of nearby cave habitats.

Species of conservation significance include two cave roosting species of horseshoe bat (Canut's horseshoe bat *Rhinolophus canuti timoriensis;* Timorese horseshoe bat *Rhinolophus montanus*). The recording of *R. montanus* is significant since it has only been recorded on two previous occasions: the site of first collection near Lequi Mia, south of Ermera (7-8 individuals; by Goodwin 1979), and calls from the Ira Chaupiti watercourse on the southern side of the Paitchau Range (Armstrong 2007). Canut's horseshoe bat *R. canuti* was

commonly encountered in the acoustic and trapping surveys of Pavey and Milne (2004) and Armstrong (2007), but there is no information on how widespread this species is outside of the most forested areas in the east of Timor-Leste. It roosts in caves during the day, and will be dependent on them for persistence in a local area. Both this and other species of horseshoe bat are likely to be sensitive to human disturbance of colonies in caves.

The presence of *Rhinolophus* species plus the Diadem leaf-nosed bat *Hipposideros diadema* also suggests that other cave roosting bat species are present at Suai. While no calls of the other two *Hipposideros* were recorded, the survey effort to date is possibly insufficient to rule out their presence, and their apparent absence may also be partly a function of their ultra-high frequency calls (over 100 kHz in both cases) that cannot be detected at the same distance as the lower frequency calls of other species. There is also likely to be one or more species of bent-winged bat *Miniopterus* sp. present and some of the unallocated call types are almost certainly attributable to this genus. Bent-winged bats tend to have large home ranges and are known to migrate in other countries (e.g. Dwyer 1969; Cardinal and Christidis 2000; Rodrigues et al. 2010), so the roost site of any *Miniopterus* identified in the project area could be a reasonable distance away. Conversely, the presence of *Hipposideros* or *Rhinolophus* would suggest that caves are relatively close by, given their flight morphology that is typical of agile fliers that do not travel large distances nightly (e.g. Norberg and Rayner 1987; Kingston et al. 2003).

There was a general paucity of species that forage within stands of vegetation, with the exception of the species of horseshoe bat *Rhinolophus* spp. encountered. Calls of relatively short duration and large bandwidth (calls types *bFM*, *st.sFM.d*) suitable for foraging in this structural habitat (e.g. Denzinger et al. 2004) and that could be attributable to taxonomically unresolved species of *Harpiocephalus, Kerivoula, Murina* and *Nyctophilus* were not detected, possibly because the habitats surveyed were not suitable for these species, but it could also reflect the relatively low survey effort or call detectability. Such call types are typically emitted at relatively low amplitude, and are thus less detectable (have a shorter detection range) than other call types, requiring greater effort to encounter them.

The low frequency calls (< 30 kHz) attributed to species of sheath-tailed bats *Saccolaimus saccolaimus* and tomb bats *Taphozous achates* and *T. melanopogon* were difficult to distinguish because of the variability in call structure and characteristic frequency. It is likely that all three species were present, though better quality anonymous recordings and reference calls would help with identification in the future. While there were only three candidate species for the three unallocated low frequency call types, the characteristic frequency of *T. achates* is not known, and *S. saccolaimus* produces calls with a characteristic frequency ranging by 5 kHz or more across its range throughout South East Asia and Australasia (Milne et al. 2009; Corben 2010), overlapping with one of the two *Taphozous* species in this case. All three species were commonly recorded foraging in the open spaces above the sites, though roost sites might be some distance away given their good capacity for relatively long distance flight.

The calls of many vespertilionids and miniopterids are often difficult to distinguish because of their similar structure (*st.cFM*), undocumented characteristic frequencies and geographic variation preventing direct comparison with the same species on other islands. It is possible that several species attributable to *Miniopterus, Pipistrellus, Scotophilus* and *Scotorepens*

were present based on the observation of the six *st.cFM* call types. Further good quality recordings and capture effort will likely help with the attribution of species names to some of the call types documented in the survey. While all species to which this general call type are attributable are not listed in a Threatened conservation category, several of them (*Miniopterus* spp.) form large colonies in caves and may be vulnerable to disturbance if this habitat is removed or modified, or if an increase in human presence because of the project activities leads to increased cave visitation and thus colony disturbance.

5.0 CONCLUSIONS

1. At least 14 echolocating bat species are present at the survey sites (6 -13 species depending on the site and taking into account survey effort), representing six species that were able to be identified, and eight species that need some additional follow up capture work to confirm their identity. The latter can be identified retrospectively at each site based on the call classification system used.

2. One of the detected species is listed in a Threatened category: Canut's horseshoe bat *Rhinolophus canuti timoriensis* (Vulnerable B1ab(iii)), which is also represented as an endemic taxon (at subspecies level) on Timor. It had high relative abundance at Suai, suggesting the presence of nearby caves containing colonies of reasonable size, and was also present at Betano and Viqueque.

3. Four species that are not currently listed by the IUCN for lack of information were either confirmed as being present—*Rhinolophus montanus* (DD)—or considered likely to be present pending further confirmation by fieldwork and attribution of echolocation call types—*Taphozous achates* (DD); *Rhinolophus* aff. *philippinensis* (NE); *Pipistrellus* sp. aff. *tenuis* (NE). While these species are not currently listed, they may represent endemics, have limited distribution on the island and be subject to threatening processes that have not yet been identified formally.

4. The number of endemic species or subspecies confirmed from the project area was three—*Rhinolophus canuti timoriensis, Rhinolophus montanus, Rhinolophus celebensis parvus*; while a further two might be present if their identification from echolocation calls and taxonomy can be confirmed—*Rhinolophus* aff. *philippinensis*; *Pipistrellus* sp. aff. *tenuis.* The list of other endemics that might also be present pending further survey (and taxonomic) effort includes: cave roosting species *Hipposideros bicolor hilli* and *Hipposideros sumbae rotiensis*; and forest roosting species *Harpiocephalus* aff. *harpia, Kerivoula* sp., *Murina* aff. *florium,* and *Nyctophilus* sp.

5. The diversity of echolocating bat species in the project was relatively high and indicative of reasonably intact habitats, though species that prefer primary undisturbed forest or thicker stands of vegetation were absent. To some degree this might be a function of their detectability (because of their low amplitude calls), but further survey effort would provide better evidence of their apparent absence.

6. At least six species of cave roosting bat were recorded and identified to species (species of *Rhinolophus; Hipposideros* diadema, *Miniopterus australis*), with several others likely (other *Miniopterus* spp.; *Taphozous* spp.). Thus, at least half of the 14 echolocating bat species recorded on the survey use caves for daytime roosting. Careful management of cave habitat will be an important consideration in the proposed project because of the presence of endemics, Threatened species, taxonomically unresolved forms with undefined conservation status, large aggregations (bat colonies) with high vulnerability to a single event of human disturbance, and the long term importance of such structures for animal populations in a landscape that may have limited replication (i.e. alternative habitat) elsewhere.

6.0 REFERENCES

ABS 2006. Recommendations of the Australasian Bat Society Inc for reporting standards for insectivorous bat surveys using bat detectors. *The Australasian Bat Society Newsletter* 27: 6–9.

Andersen, K. 1912. *Catalogue of the Chiroptera in the collection of the British Museum. Vol. 1: Megachiroptera*. British Museum (Natural History), 854 pp.

Aplin, K.P. and Helgen, K.M. 2010. Quaternary murid rodents of Timor Part I: new material of *Coryphomys buehleri* Schaub, 1937, and description of a second species of the genus. *Bulletin of the American Museum of Natural History* 341, 80 pp.

Appleton, B.R., McKenzie, J.A. and Christidis, L. 2004. Molecular systematics and biogeography of the bent-wing bat complex *Miniopterus schreibersii* (Kuhl, 1817) (Chiroptera: Vespertilionidae). *Molecular Phylogenetics and Evolution* 31: 431–439.

Armstrong, K.N. 2007. *Survey for bats on the proposed Ira Lalaro hydropower scheme, Timor-Leste. Field survey and impact assessment.* Unpublished report by Molhar Pty Ltd for EPANZ Services Pty Ltd (New Zealand) and the Norwegian Water Resources and Energy Directorate, 19 June 2007.

Armstrong, K.N. and Aplin, K.P. 2011. Bats of the Muller Range, Papua New Guinea. Chapter 19, pp. 222–234 In: Rapid Biological Assessments of the Nakanai Mountains and the upper Strickland Basin: surveying the biodiversity of Papua New Guinea's sublime karst environments. *RAP Bulletin of Biological Assessment* 60. Conservation International, Arlington USA.

Armstrong, K.N. and Kerry, L. 2011. Modelling the prey detection performance of *Rhinonicteris aurantia* (Chiroptera: Hipposideridae) in different atmospheric conditions discounts the notional role of relative humidity in adaptive evolution. *Journal of Theoretical Biology* 278: 44–54.

Bogdanowicz, W., Fenton, M.B. and Daleszczyk, K. 1999. The relationships between echolocation calls, morphology and diet in insectivorous bats. *Journal of Zoology* 247: 381–393.

Bonaccorso, F.J. 1998. *Bats of Papua New Guinea*. Conservation International Tropical Field Guide Series. Conservation International, Washington, D.C.

Cardinal, B.R. and Christidis, L. 2000. Mitochondrial DNA and morphology reveal three geographically distinct lineages of the large bentwing bat (*Miniopterus schreibersii*) in Australia. *Australian Journal of Zoology* 48: 1–19.

Churchill, S.K. 2008. *Australian bats.* 2nd ed. Allen and Unwin, Crows Nest, NSW.

Corben, C. and O'Farrell, M. J. 1999. AnaBat system user's guide. *AnaBat system manual*, 2nd ed., published by the authors.

Corben C. 2010. Acoustic identification of *Saccolaimus*. Oral presentation at the 14th Australasian Bat Society conference, Darwin, Northern Territory, 12 – 14 July 2010.

Corbet G.B. and Hill J.E. 1992. *The mammals of the Indomalayan region: a systematic review.* Oxford University Press: Oxford.

Csorba G. 2002. Remarks on some types of the genus *Rhinolophus* (Mammalia, Chiroptera). *Annales Historico-Naturales Musei Nationalis Hungarici* 94: 217–226.

Csorba, P., Ujhelyi, P. and Thomas, N. 2003. *Horseshoe bats of the world (Chiroptera: Rhinolophidae)*. Alana Books: Bishop's Castle.

de Oliveira, M.C. 1998a. Towards standardized descriptions of the echolocation calls of microchiropteran bats: pulse design terminology for seventeen species from Queensland. *Australian Zoologist* 30: 405–411.

de Oliveira, M.C. 1998b. *AnaBat system practical guide*. Department of Natural Resources, Queensland.

Denzinger, A., Kalko, E.K.V. and Jones, G. 2004. Ecological and evolutionary aspects of echolocation in bats. pp. 311–326 In: *Echolocation in bats and dolphins*. (eds. J.A. Thomas, C.F. Moss and M. Vater), University of Chicago Press, Chicago.

Dwyer, P.D. 1969. Population ranges of *Miniopterus schreibersii* (Chiroptera in south-eastern Australia. *Australian Journal of Zoology* 17: 665–686.

Feng, J., Chen, M., Li, Z.-X., Zhao, H.-H., Zhou, J. and Zhang, S.-Y. 2000. Relationship between echolocation frequency and body size in eight species of Horseshoe Bats (Rhinolophidae). *Current Zoology* 48: 819 – 823.

Goodwin R.E. 1979. The bats of Timor: systematics and ecology. *Bulletin of the American Museum of Natural History* 163: 73–122.

Helgen, K.M. 2004. Report on a preliminary survey of the mammals of East Timor. In: *Preliminary studies on the biodiversity of mammals and aquatic insects in East Timor*. Unpublished report by D.A. Polhemus and K.M. Helgen.

IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>. Downloaded on 16 February 2012.

Jones, G. 1996. Does echolocation constrain the evolution of body size in bats? *Symposium, Zoological Society of London*, 69: 111–128.

Kingston, T., Francis, C.M., Akbar, Z. and Kunz, T.H. 2003. Species richness in an insectivorous bat assemblage from Malaysia. *Journal of Tropical Ecology* 19: 67–79

Kitchener, D.J. and Maryanto, I. 1993. Taxonomic reappraisal of the *Hipposideros larvatus* species complex (Chiroptera: Hipposideridae) in the Greater and Lesser Sunda Islands, Indonesia. *Records of the Western Australian Museum* 16: 119–173.

Kitchener, D.J. and Suyanto, A. 2002. Morphological variation in *Miniopterus pusillus* and *M. australis* (*sensu* Hill 1992) in southeastern Asia, New Guinea and Australia. *Records of the Western Australian Museum* 21: 9–33.

Kitchener, D.J., Adams, M. and Boeadi 1994. Morphological and genetic relationships among populations of *Scotorepens sanborni* (Chiroptera: Vespertilionidae) from Papua New Guinea, Australia and Indonesia. *Records of the Western Australian Museum* 17: 31–42.

Kitchener, D.J., and Suyanto A. 1996. Intraspecific morphological variation among island populations of small mammals in southern Indonesia. In: *Proceedings of the first international conference on eastern Indonesian-Australian vertebrate fauna, Manado, Indonesia, November 22-26, 1994*. (eds. D.J. Kitchener and A. Suyanto.) pp. 7–13.

Kitchener, D.J., Cooper, N. and Maryanto, I. 1995. The *Myotis adversus* (Chiroptera: Vespertilionidae) species complex in eastern Indonesia, Australia, Papua New Guinea and the Solomon Islands. *Records of the Western Australian Museum* 17: 191–212.

Kitchener, D.J., K.P. Aplin, and Boeadi. 1991a. A new species of *Rattus* from Gunung Mutis, South West Timor Island, Indonesia. *Records of the Western Australian Museum* 15: 445–465.

Kitchener, D.J., How, R.A. and Maharadatunkamsi 1991b. A new species of *Nyctophilus* (Chiroptera: Vespertilionida) from Lembata Island, Nusa Tenggara, Indonesia. *Records of the Western Australian Museum* 15: 97–107.

Kitchener, D.J., Konishi, Y. and Suyanto, A. 1996. Morphological variation among eastern Indonesian island populations of *Hipposideros bicolor* (Chiroptera: Hipposideridae), with descriptions of three new subspecies. *Records of the Western Australian Museum* 18: 179–192.

McKenzie, N.L. and Muir, W.P. 2000. Bats of the southern Carnarvon basin, Western Australia. *Records of the Western Australian Museum* Supplement 61: 465–477.

Milne, D.J., Jackling, F.C., Sidhu, M., and Appleton, B.R. 2009. Shedding new light on old species identifications: morphological and genetic evidence suggest a need for conservation status review of the critically endangered bat, *Saccolaimus saccolaimus*. *Wildlife Research* 36: 496–508.

Milne, D.J. 2002. *Key to the bat calls of the Top End of the Northern Territory.* Parks and Wildlife Commission of the Northern Territory, Technical Report No. 71.

Norberg, U.M. and Rayner, J.M.V. 1987. Ecological morphology and flight in bats (Mammalia; Chiroptera): wing adaptations, flight performance, foraging strategy and echolocation. *Philosophical Transactions of the Royal Society of London* B 316: 335–427.

Parnaby, H.E. 2009. A taxonomic review of Australian Greater Long-eared Bats previously known as *Nyctophilus timoriensis* (Chiroptera: Vespertilionidae) and some associated taxa. *Australian Zoologist* 35: 39–81.

Pavey, C.R. and Milne, D.J. 2004. *Bat survey of the Ira Lalaro area, Lautem District, Timor-Leste.* Unpublished report by Department of Infrastructure, Planning and Environment, Northern Territory Government, Australia to EPANZ Services Pty Ltd, New Zealand, April 2004.

Pottie, S.A., Lane, D.J.W., Kingston, T. and Lee, B.P.Y.-H. 2005. The microchiropteran bat fauna of Singapore. *Acta Chiropterologica* 7: 237–247.

Richards, G.C. 2005. The PNG gas project: a study of bat faunal biodiversity and an assessment of potential impacts. Prepared by Greg Richards and Associates Pty Ltd for Enesar Consulting Pty Ltd, July 2005. Included as 'Annex 05. Biodiversity survey results: Bats at Hides, Nogoli and Benaria in 2005.' in the PNG LNG Project Environmental Impact Statement Part II. Existing Environment, prepared by Coffey Natural Systems Pty Ltd for Esso Highlands Ltd, January 2009.

Richards, G.C. 2008. The PNG liquefied natural gas project: a study of bat faunal biodiversity and an assessment of potential impacts. Prepared by Greg Richards and Associates Pty Ltd for Coffey Natural Systems Pty Ltd, July 2008. Included as 'Annex 06. Biodiversity survey results: Bats at Juha North, Juha South, Baia River, South Karius and Deviation Camp in 2008.' in the PNG LNG Project Environmental Impact Statement Part II. Existing Environment, prepared by Coffey Natural Systems Pty Ltd for Esso Highlands Ltd, January 2009.

Robinson, M. 1996. A relationship between echolocation calls and noseleaf widths in bats of the genera *Rhinolophus* and *Hipposideros*. *Journal of Zoology* 239: 389–393.

Rodrigues, L., Ramos Pereira, M., Rainho, A. and Palmeirim, J. 2010. Behavioural determinants of gene flow in the bat *Miniopterus schreibersii*. *Behavioral Ecology and Sociobiology* 64: 835–843.

Ruedi, M. 1995. Taxonomic revision of shrews of the genus *Crocidura* from the Sunda Shelf and Sulawesi with description of two new species (Mammalia: Soricidae). *Zoological Journal of the Linnean Society* 115: 211–265.

Simmons N.B. 2005. Order Chiroptera. pp. 312–529 In *Mammal species of the world: a taxonomic and geographic reference.* 3rd edition ed by D.E. Wilson and D.M. Reeder. Johns Hopkins University Press: Baltimore.

Tian, L., Liang, B., Maeda, K., Metzner, W. and Zhang, S. 2004. Molecular studies on the classification of *Miniopterus schreibersii* (Chiroptera: Vespertilionidae) inferred from mitochondrial cytochrome b sequences. *Folia Zoologica* 53: 303–311.

Zhang, S., Zhao, H., Feng, J., Sheng, L., Wang, H. and Wang, L. 2000. Relationship between echolocation frequency and body size in two species of hipposiderid bats. *Chinese Science Bulletin* 45: 1587–1589.

Table 1. Summary of bat species known from the island of Timor, with notes on their identification and IUCN conservation status.

Species[1]	**Comment on taxonomy, identification and presence on Timor**	**IUCN status**[2]
Family Pteropodidae (Fruit bats and flying-foxes)		
Sunda fruit bat *Acerodon mackloti*	Confirmed, recently collected by Helgen (2004) near Lospalos.	Vulnerable A3cd
Indonesian short-nosed fruit bat *Cynopterus titthaecheilus*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor.	LC
Moluccan naked-backed fruit bat *Dobsonia moluccensis*	Unpublished observations on a single museum specimen by Helgen (2004), no published accounts, record doubtful. Closest record is Roti Island (Corbet and Hill 1992).	LC
Western naked-backed fruit bat *Dobsonia peronii peronii*	Observed at Lenahara cave by Pavey and Milne (2004), accepted to be on Timor.	LC
Lesser dawn bat *Eonycteris spelaea*	Captured by Pavey and Milne (2004), accepted to be on Timor.	LC
Dagger-toothed long-nosed fruit bat *Macroglossus minimus*	Captured by Armstrong (2007), accepted to be on Timor.	LC
Keast's tube-nosed fruit bat *Nyctimene keasti*	No records on Timor since Andersen (1912 cited in Goodwin 1979). See Simmons (2005) for taxonomy cf. *N. cephalotes.*	Vulnerable B1ab(ii,iii)
Gray flying-fox *Pteropus griseus*	Records accepted (Goodwin 1979, Corbet and Hill 1992, Simmons 2005). Collected by Pavey and Milne (2004).	DD
Lombok flying-fox *Pteropus lombocensis*	Not included by Corbet and Hill (1992) but present according to Kitchener and Suyanto (1996), review of Simmons (2005).	DD
Temminck's flying-fox *Pteropus temminckii*	Record doubtful (Simmons 2005).	Vulnerable A2c
Large flying-fox *Pteropus vampyrus*	Records accepted (Goodwin 1979, Corbet and Hill 1992).	NT
Geoffroy's rousette *Rousettus amplexicaudatus*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor.	LC

Continued next page ...

Table 1. Summary of bat species known from the island of Timor, *continued*.

Species[1]	Comment on taxonomy, identification and presence on Timor	IUCN status[2]
Family Emballonuridae (Sheath-tailed bats)		
Bare-rumped sheath-tailed bat *Saccolaimus saccolaimus*	Accepted to be on Timor (Simmons 2005)	LC
Indonesian tomb bat *Taphozous achates*	Collected from West Timor (Kitchener and Suyanto 1995). Nominate species on other islands in Nusa Tenggara.	DD
Black-bearded tomb bat *Taphozous melanopogon*	Accepted to be on Timor (Simmons 2005).	LC
Family Rhinolophidae (Horseshoe bats)		
Canut's horseshoe bat *Rhinolophus canuti timoriensis*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor. Taxonomy follows Csorba et al. (2003).	Vulnerable B1ab(iii) *E
Sulawesi horseshoe bat *Rhinolophus celebensis parvus*	Captured by Pavey and Milne (2004) and echolocation calls recorded by Armstrong (2007), accepted to be on Timor. Taxonomy follows Csorba et al. (2003).	LC *E
Timorese horseshoe bat *Rhinolophus montanus*	Described by Goodwin (1979) as a taxon distinct from *R. philippinensis*, elevated to species status by Csorba (2002) and Csorba et al. (2003). Echolocation calls recorded by Armstrong (2007), endemic to Timor.	DD *E
Unidentified Large-eared horseshoe bat *Rhinolophus* aff. *philippinensis*	Captured, and echolocation calls recorded by Armstrong (2007), currently under taxonomic investigation (Armstrong et al. ms in prep.). Calls distinct from *R. montanus*. Might be referrable to either *R. p. achilles*, *R. p. maros* or a new taxon.	NE *E?
Family Hipposideridae (Leaf-nosed bats)		
Bicoloured leaf-nosed bat *Hipposideros bicolor hilli*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor (Goodwin 1979; Kitchener et al. 1996).	LC *E
Diadem leaf-nosed bat *Hipposideros diadema diadema*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor (Simmons 2005). Timor is the type locality of this species.	LC
Sumban leaf-nosed bat *Hipposideros sumbae* aff. *rotiensis*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor. Kitchener and Maryanto (1993) examined a single specimen from Campalong in West Timor and referred it to the subspecies *rotienesis*, pending further collection.	LC *E?

Continued next page ...

Table 1. Summary of bat species known from the island of Timor, *continued*. *See over for footnotes ...*

Species[1]	Comment on taxonomy, identification and presence on Timor	IUCN status[2]
Family Vespertilionidae (Evening bats)		
Unidentified Hairy-winged bat *Harpiocephalus* aff. *harpia*	Captured by both Pavey and Milne (2004) and Armstrong (2007) and designated as *Murina* aff. *cyclotis*. Subsequent examination shows this to be either *Harpiocephalus harpia* or a related new species on the basis of skull features (Armstrong et al. ms in prep.).	NE *[E?]
Unidentified woolly bat *Kerivoula* sp.	Captured by both Pavey and Milne (2004) and Armstrong (2007). Species status still under investigation (Armstrong et al. ms in prep.).	NE *[E?]
Unidentified tube-nosed bat *Murina* aff. *florium*	First captured by Pavey and Milne (2004), specimens undergoing further examination (Armstrong et al. ms in prep.).	NE *[E?]
Large-footed myotis *Myotis adversus adversus*	Recorded to date from West Timor only (Kitchener et al. 1995).	LC
Unidentified long-eared bat *Nyctophilus* sp.	Specimens collected from near Maubisse (Helgen 2004) are possibly *Nyctophilus heran* which is on Lembata Island (Kitchener et al. 1991b), unlikely to be the same species as in Australasia, which was until recently (Parnaby 2009) known as *N. timoriensis*.	NE *[E?]
Unidentified pipistrelle *Pipistrellus sp.*	Widespread, occurs around villages, see comments in Goodwin (1979), Simmons (2005). Genetic studies recently suggested that the form resembling *P. tenuis* captured by Armstrong (2007) is not this taxon, and taxonomic status is undergoing further examination (Armstrong et al. ms in prep.).	NE *[E?]
Sody's yellow house bat *Scotophilus collinus*	See Simmons (2005) for taxonomic summary – *S. kuhlii* not on Timor. Captured by Pavey and Milne (2004) but misidentified as a possible new species of *Taphozous*.	LC
Northern broad-nosed bat *Scotorepens sanborni*	Collected from West Timor only (Kitchener et al. 1994). Present in New Guinea (Bonaccorso 1998) and northern Australia (Churchill 2008), likely to be found across Timor.	LC
Greater bamboo bat *Tylonycteris robustula*	Present on basis of two historical specimens in the BMNH (London) labelled as being from Timor (Goodwin 1979). No other records.	LC
Family Miniopteridae (Bent-winged bats)		
Little bent-winged bat *Miniopterus australis*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor.	LC
Large bent-winged bat *Miniopterus magnater*	Present according to Simmons (2005).	LC
Australasian bent-winged bat *Miniopterus oceanensis*	Captured by both Pavey and Milne (2004) and Armstrong (2007). Previously referred to as *M. schreibersii*, updated according to Appleton et al. (2004) and Tian et al. (2004).	LC
Small bent-winged bat *Miniopterus pusillus*	Captured by Pavey and Milne (2004), distinct subspecies on Timor (Kitchener and Suyanto 2002; Simmons 2005).	LC

[1] Nomenclature follows IUCN (2012) preferentially, then Simmons (2005). [2] IUCN (International Union for Conservation of Nature) conservation status (IUCN 2012). DD: Data Deficient; LC: Least Concern; NT: Near Threatened; NE: Not Evaluated, no conservation status yet available. Taxa that are potentially new to science are given a status of NE. *[E] denotes endemic species or subspecies on Timor island, and *[E?] denotes possible endemic taxon, pending further taxonomic study (e.g. Armstrong et al ms in prep.).

Table 2. Species identified at each site from overnight recordings made with AnaBat detectors (raw results; NC: needs confirmation).

Date	Serial	Site	Site code	Habitat	UTM	*18 sh.cFM*	*21 sh.cFM*	*25 cFM*	*32 st.cFM*	*37 st.cFM*	*28 ICF R. aff. philippinensis*	*38 ICF Rhinolophus montanus*	*41 st.cFM*	*47 st.cFM*	*54 st.cFM*	*55 sCF Hipposideros diadema*	*63 st.cFM Miniopterus australis*	*72 ICF Rhinolophus canuti*	*86 ICF Rhinolophus celebensis*
10/12/2011	5334	Suai	–	–	–	◆	◆	◆	–	◆		–	◆		–	–	–	–	–
11/12/2011	80095	Suai	–	–	–	–	◆	◆	–	–		–	◆		◆	–	◆	◆	–
12/12/2011	5334	Suai	–	–	–	◆	◆	◆	–	◆		–	◆		◆	–	◆	–	–
12/12/2011	80095	Suai	–	–	–	◆	◆	◆	–	◆		–	◆		◆	–	◆	◆	–
16/12/2011	80095	Betano	AN9	Hilltop / woodland	51L 802026 8986789	◆	◆	◆	◆	◆		◆	◆		◆	◆	◆	◆	◆
16/12/2011	81220	Betano	AN8	Woodland	51L 802663 8986322	–	◆	◆	–	◆		–	◆		◆	–	◆	–	◆
19/12/2011	5334	Beacu	AN14	Near coastal scrub	51L 217134 9010159	◆	◆	◆	–	–		–	◆		◆	–	◆	–	–
7/02/2012	5334	Suai	AN15	Woodland	51L 752256 8971670	–	◆	◆	◆	◆	–	–	◆	–	◆	–	◆	◆	◆
7/02/2012	80095	Suai	AN16	Woodland	51L 753670 8972774	–	◆	◆	◆	◆	–	–	◆	◆	◆	◆	◆	◆	◆
8/02/2012	5334	Suai	AN15	Woodland	51L 752256 8971670	–	◆	◆	–	◆	–	–	◆	–	◆	–	◆	◆	–
8/02/2012	80100	Suai	AN17	Open water / dam	51L 755080 8971473	–	◆	–	◆	◆	–	–	◆	◆	◆	◆	◆	◆	◆
8/02/2012	81220	Suai	AN18	Large fig trees	51L 754700 8972975	–	◆	◆	◆	–	NC	–	◆	–	◆	–	◆	◆	◆
13/02/2012	80100	Viqueque	AN23	Low hill / grassland	52L 211964 9018060	–	◆	◆	◆	◆	–	–	◆	◆	◆	◆	◆	◆	◆

Table 3. Summary of variables from representative call sequences of the species identified and the call types recognised.

Species (FM body type)	**s,p[1]**	**Duration (msec)[2]**	**Max Frequency (kHz)[2]**	**Char frequency (kHz)[2]**
18 sh.cFM	7,30	11.3 ± 3.3 7.1 – 20.6	18.8 ± 1.7 16.3 – 21.0	17.9 ± 1.4 15.8 – 19.9
21 sh.cFM	4,17	10.1 ± 2.1 7.1 – 14.3	22.9 ± 1.0 21.4 – 25.1	21.5 ± 0.4 20.6 – 22.1
25 cFM	3,13	8.2 ± 2.2 4.7 – 12.3	27.7 ± 2.1 26.0 – 32.4	24.8 ± 0.8 23.7 – 26.3
32 st.cFM	4,84	5.8 ± 1.6 3.0 – 10.3	40.4 ± 7.8 31.1 – 60.2	31.8 ± 0.8 29.5 – 33.5
37 st.cFM	4,35	4.9 ± 1.3 3.2 – 8.1	41.6 ± 3.6 37.0 – 51.6	37.3 ± 0.7 36.4 – 39.2
41 st.cFM	9,82	6.5 ± 2.3 3.1 – 14.0	46.4 ± 6.0 41.0 – 64.0	41.5 ± 1.0 39.0 – 44.4
47 st.cFM	3,39	5.0 ± 1.1 3.0 – 7.1	50.0 ± 3.8 44.9 – 59.3	46.5 ± 1.7 44.0 – 49.7
54 st.cFM	7,50	3.4 ± 0.6 2.0 – 5.4	65.2 ± 6.0 54.1 – 80.0	54.0 ± 0.9 51.3 – 55.9
63 st.cFM Little long-fingered bat *Miniopterus australis*	9,50	4.8 ± 1.4 3.1 – 9.8	70.5 ± 5.1 62.5 – 82.5	62.7 ± 1.1 60.6 – 65.0
Species (CF body type)	**s,p[1]**	**Duration (msec)[3]**		**Char frequency (kHz)[4]**
28 lCF Large-eared Horseshoe bat *Rhinolophus* aff. *philippinensis*	1,1	50+	—	27.8
38 lCF Timorese horseshoe bat *Rhinolophus montanus*	4,10	69+	—	38.1 ± 0.8 36.4 – 39.8
55 sCF Diadem leaf-nosed bat *Hipposideros diadema diadema*	5,24	13.5 ± 2.2 10.4 – 18.2	—	54.6 ± 0.4 53.7 – 55.2
72 lCF Canut's horseshoe bat *Rhinolophus canuti timoriensis*	5,58	9.2 ± 17.1 0.2 – 65.2	—	71.1 ± 0.8 69.6 – 72.7
86 lCF Sulawesi horseshoe bat *Rhinolophus celebensis parvus*	1,3	36+	—	86.0 ± 0.6 85.1 – 87.9

[1] s,p: number of sequences measured, combined total number of pulses measured; [2] Mean ± SD; range; [3] Mean ± SD; range; partial calls only were available for some species; [4] The frequency with the greatest or peak number of cycles, designated as 'Fpz' in AnalookW; Mean ± SD; range.

Table 4. Echolocation call categories based on the morphology of the dominant type of search-phase pulses in high quality sequences (adapted from de Oliveira (1998a,b) and Corben and O'Farrell (1999); examples are not scaled equally). Pulses generally consist of three main sections: an initial frequency sweep (IFS), followed by the main body (BST: Body Sub Type), and ending in a terminating frequency sweep (TFS). The shape of the pulse is represented by the codes in the form '*IFS.BST.TFS*', prefixed by a value representing the mean characteristic frequency in kHz. Note that most CF pulses have a recognisable initial upward frequency sweep, and all have a terminating frequency sweep, so the IFS and TFS descriptors are not used for this Body Sub Type.

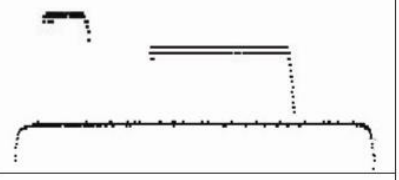
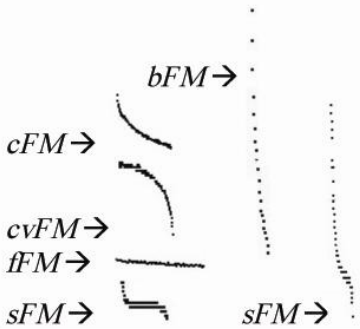
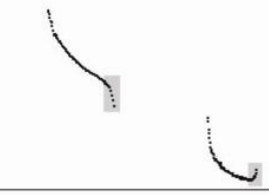
Code	Description	Example
CF	**Constant Frequency main Body Sub Type (BST)**	
sCF	Short duration (<15 ms)	
mCF	Medium duration (15 – 30 ms)	
lCF	Long duration (>30 ms)	
FM	**Frequency Modulated main Body Sub Type (BST)**	
bFM	Broadband, slightest degree of curvature only, no significant development of serpentine component (*sFM*)	*bFM*→
cFM	Curved, simple or curvilinear trace	*cFM*→
cvFM	Convex curved, essentially cFM rotated 180°	*cvFM*→
fFM	Flat or with a very slight curve, narrowband, not *CF*	*fFM*→
sFM	Serpentine, generally S-shaped	*sFM*→ *sFM*→
	Initial Frequency Sweep (IFS)	
i.	Inclined, a narrowband increasing frequency sweep	
sh.	Short, shallow or narrowband frequency sweep	
st.	Steeply decreasing, broadband frequency sweep	
	Terminating Frequency Sweep (TFS)	
.d	Drooped, decreasing frequency sweep following the characteristic frequency in the main body of the call	
.h	Hooked, increasing in frequency following the characteristic frequency	

Table 5. Comments on the taxonomic identification of the bat call types defined in this survey.

18 sh.cFM	Most likely attributable to the bare-rumped sheath-tailed bat *Saccolaimus saccolaimus* on the basis of call frequency, and also the commonly observed pattern of alternating the characteristic frequency in successive pulses (e.g. Milne et al. 2009). Capture or observation in a spotlight of bats in flight would be required for confirmation.
21 sh.cFM	Attributable to one of the sheath-tailed bats on Timor: either the Indonesian tomb bat *Taphozous achates*, the call of which has not yet been characterised; or the bare-rumped sheath-tailed bat *Saccolaimus saccolaimus*, which produces a variety of call types. One or both of these species might produce this call type. Capture or observation in a spotlight of bats in flight would be required for confirmation.
25 cFM	Most likely attributable to the black-bearded tomb bat *Taphozous melanopogon* based on reference calls described in Pottie et al. (2005) and other unpublished information, however reference calls are not available from Timor, and have not been compared with those from *T. achates*. The call type designation should be used until further information is available for a confident retrospective identification, since there may be geographic variation in characteristic call frequency and/or taxonomic issues that will have a bearing on this identification.
32 st.cFM	Possibly attributable to a large vespertilionid such as Sody's yellow house bat *Scotophilus collinus* (cf. the calls of *S. kuhlii* in Pottie et al. 2005). Capture would be required for identification.
37 st.cFM	Most likely attributable to a large species of bent-winged bat such as the western long-fingered bat *Miniopterus magnater*, based on the similarity of the characteristic frequency with calls of this species in New Guinea (K.P. Aplin and K.N. Armstrong unpublished data), or one of the larger vespertilionids such as *Scotophilus collinus* (cf. the calls of *S. kuhlii* in Pottie et al. 2005). Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
28 lCF Rhinolophus* aff. *philippinensis	One very poor quality call sequence had signals with characteristics indicating the possible presence of a previously unrecognised species of *Rhinolophus* in the *philippinensis* group, as first discovered by Armstrong (2007). The taxonomic affiliation of this form has yet to be established, and it may be referrable to *R. philippinensis achilles*, *R. p. maros*, or a taxon new to science.
38 lCF Rhinolophus montanus	Attributable with high confidence to the Timorese horseshoe bat *Rhinolophus montanus* based on the remarkably low characteristic frequency and long duration of calls. While reference calls are not available for *R. montanus*, this species belongs to the *philippinensis* group of *Rhinolophus* that typically produce calls with a characteristic frequency somewhere below 45 kHz. The other undescribed *philippinensis*-group *Rhinolophus* also present on Timor is larger and produces calls with a characteristic frequency of c. 27 kHz (Armstrong et al. ms in prep.), allowing *R. montanus* to be identified through a process of elimination.

Continued next page ...

Table 5. Comments on the taxonomic identification of the bat call types, *continued*.

41 st.cFM	One of several candidate species in the Miniopteridae or Vespertilionidae. Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
47 st.cFM	One of several candidate species in the Miniopteridae or Vespertilionidae. Some echolocation calls had a body type of *sFM*, typical of *Miniopterus*. Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
54 st.cFM	One of several candidate species in the Miniopteridae or Vespertilionidae. Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
63 st.cFM Miniopterus australis	One of several candidate species in the Miniopteridae or Vespertilionidae. Based on reference calls collected by Armstrong (2007), this call could be attributable to the little long-fingered bat *Miniopterus australis*. Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
55 sCF Hipposideros diadema diadema	Attributable based on reference calls collected by Armstrong (2007) and elsewhere such as in Papua New Guinea (Leary and Pennay 2011).
72 lCF Rhinolophus canuti timoriensis	Attributable based on reference calls collected by Armstrong (2007).
86 lCF Rhinolophus celebensis parvus	Attributable based on calls collected by Pavey and Milne (2004) and Armstrong (2007).

Table 6. Summary of species identified at each locality from overnight recordings made with AnaBat detectors (NC: needs confirmation). The relative abundance (RA) of each species is given for Suai, based on the proportion of observations over 9 AnaBat recording nights.

	Beacu	**Betano**	**Suai**	**(RA)**	**Viqueque**
18 sh.cFM	◆	◆	◆	0.3	–
21 sh.cFM	◆	◆	◆	1	◆
25 cFM	◆	◆	◆	0.9	◆
32 st.cFM	–	◆	◆	0.4	◆
37 st.cFM	–	◆	◆	0.8	◆
28 lCF R. aff. *philippinensis*	–	–	NC	0.1	–
38 lCF Rhinolophus montanus	–	◆	–	0	–
41 st.cFM	◆	◆	◆	1	◆
47 st.cFM	–	–	◆	0.2	◆
54 st.cFM	◆	◆	◆	0.9	◆
55 sCF Hipposideros diadema	–	◆	◆	0.2	◆
63 st.cFM Miniopterus australis	◆	◆	◆	0.9	◆
72 lCF Rhinolophus canuti	–	◆	◆	0.8	◆
86 lCF Rhinolophus celebensis	–	◆	◆	0.4	◆
No. AnaBat nights	1	2	9		1
Total richness	6	12	13		11

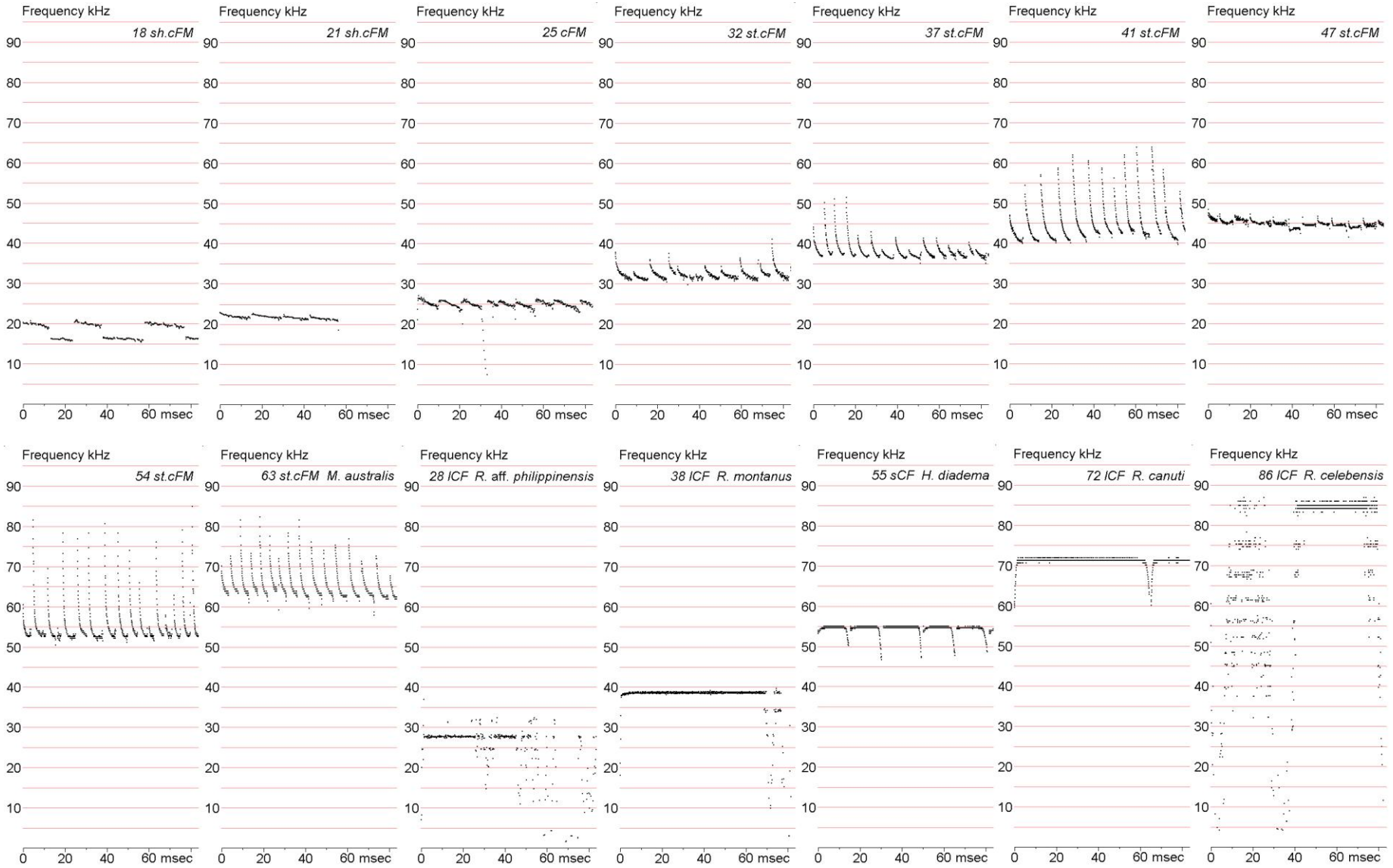


Figure 1. Representative call sequences of the species identified (time is compressed between pulses).

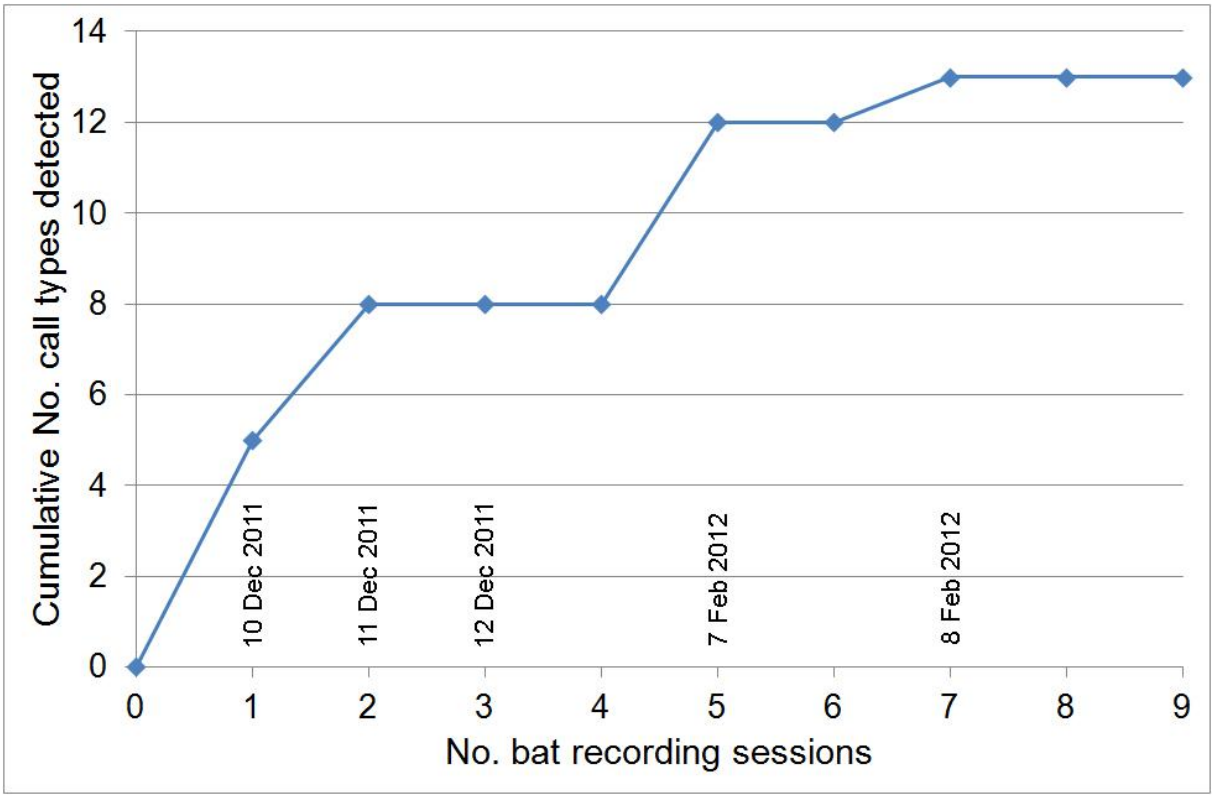


Figure 2. Species accumulation curve for Suai, based on surveys in December 2011 and February 2012. Multiple deployments were in different habitats at Suai on 12 Dec 2011, 7 Feb 2012 and 8 Feb 2012.

Appendix 7 – Conservation Significant Fauna Species Risk Assessment

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
Mauremys reevesii Reeves' Turtle	EN			x	*Mauremys reevesii* is native to most of temperate and subtropical China, North Korea and South Korea; populations also occur in Taiwan, Hong Kong and Japan, though these may be historic introductions by humans (Fong and Chen 2010). Populations recorded from Timor (Indonesia), Timor-Leste and Palau certainly originated from human introductions. Historically a common and widespread species, *Mauremys reevesii* is now a rare species in the wild. This species natural habitat includes shallow wetlands and the land that immediately surrounds them.	This species presence in Timor-Leste is due to historic human introduction and is far outside its nominal distribution. No wetland habitat type exists in the project area suitable for this species to become resident.	Unlikely
Fregata andrewsi Christmas Island Frigatebird	CR		App I		The Christmas Island Frigatebird *Fregata andrewsi* is the rarest of the five species of the family Fregatidae and breeds only on Christmas Island. When not breeding, Christmas Island Frigatebirds range widely around South-east Asia and the Indian Ocean, and are occasional visitors to the shores of Java, Sumatra, Bali, Borneo, the Andaman Is, Darwin and the Cocos (Keeling) Islands (Gore 1968, Marchant and Higgins 1990). It is possible the young birds are nomadic and wander widely until they reach breeding age; however, adults have also been seen far away from the island. It	An uncommon vagrant to Timor-Leste. There have been two recent records for Timor-Leste: a male at Cristo Rei 1 March 2003 and a female at Comoro River on 11 March 2006.	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					has been speculated they may breed somewhere in the Anamba-Natuna islands (Chasen 1933, Gibson-Hill 1947), but this was based only on sightings in the vicinity of these islands.		
Esacus magnirostris Beach Thick-knee	NT				The Beach Thick-knee is widespread around coasts from the Andaman Islands, India, Mergui Archipelago, Myanmar, islands off peninsular Thailand, and Peninsular Malaysia through Indonesia, Brunei, the Philippines, Papua New Guinea, the Solomon Islands, Vanuatu, New Caledonia (to France) and Australia. Pairs may be found on most beaches within its range; including short stretches of muddy sand among mangroves, coralline sands on atolls and prime surf beaches (Garnett and Crowley 2000). Beaches associated with estuaries and mangroves are particularly favoured. Adults are sedentary, although the species has a tendency for wide-ranging vagrancy. It lays a single egg in a scrape in the sand at the landward edge of the beach, often using the same area repeatedly. It forages mainly in the intertidal zone on crustaceans and other invertebrates (Garnett and Crowley 2000). This species qualifies as Near Threatened because it has a small population. If the population is found to be in decline it might qualify for up listing	One individual was recorded at one location within the Suai development area; this record was in the coastal mangroves of the development area. The project area lies within this species expected distribution. The Beach Thick-knee is expected to be found within the marine coastal environments / habitats of the project area.	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					to a higher threat category.		
Charadrius peronii Malaysian Plover	NT				The Malaysian Plover is a breeding resident in Vietnam (scarce in Cochinchina), Cambodia (rare), peninsular Thailand (local and uncommon), Peninsular Malaysia (scarce to locally common), East Malaysia, Singapore (rare), Brunei (apparently declining), Philippines (widespread but uncommon) and Indonesia (local around coasts and offshore islands of Sumatra, uncommon on and around Borneo and Bali, very rare on mainland Java; uncommon and sparsely distributed in the Lesser Sundas and the Sulawesi subregion). It frequents quiet sandy bays, coral sand beaches, open dunes and artificial sand-fills, where it lives in pairs, generally not mixing with other waders. This species is classified as Near Threatened because it is likely to have a moderately small population which, owing to the development pressures on the coastal areas it inhabits, is likely to be undergoing a decline.	This species typical distribution and migratory pathways are outside the project area and its general vicinity. Potential to be an uncommon vagrant.	Possible
Charadrius javanicus Javan Plover	NT				The Javan Plover is typically restricted to Java and the Kangean Islands in Indonesia; this species may be found as a vagrant in Timor Leste. The taxonomic status of this species is extremely unclear and records attributable to it are therefore sparse;	This species may be an uncommon vagrant to Timor Leste. Suitable marine coastal foraging habitat is	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					nevertheless, it was recently found common in southern Madura. Whilst it may prove widespread, its population is likely to be small and declining. It occurs on sandy beaches, mudflats and adjacent open areas around the coasts. This species has a narrow range in which development and recreation are putting pressure on critical breeding habitats. It is likely to have a moderately small population, and this is thought to be declining; it is consequently classified as Near Threatened.	present	
Numenius madagascariensis Far Eastern Curlew	VU				The Far Eastern Curlew breeds in eastern Russia, from the upper reaches of the Nizhnyaya Tunguska river east though the Verkhoyarsk mountains to Kamchatka, and south to Primorye and north-eastern Mongolia. It has been recorded as a non-breeding visitor to Japan, North Korea, South Korea, mainland China, Hong Kong (China), Brunei, Bangladesh, Thailand, Vietnam, Philippines, Malaysia, Singapore, with most birds wintering in Australia, but also in Taiwan, Indonesia, Papua New Guinea, and New Zealand (del Hoyo *et al.* 1996). The species breeds on open mossy or transitional bogs, moss-lichen bogs and wet meadows, and on the swampy shores of small lakes; in the non-breeding season it is essentially coastal, occurring at estuaries,	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					mangrove swamps, saltmarshes and intertidal flats, particularly those with extensive seagrass (Zosteraceae) meadows. It often roosts in salt-marshes, behind mangroves, or on sandy beaches (del Hoyo *et al.* 1996). This species has been up listed to Vulnerable owing to a rapid population decline which is suspected to have been primarily driven by habitat loss and deterioration. Further proposed reclamation projects are predicted to cause additional declines in the future.		
Numenius arquata Eurasian Curlew	VU				Eurasian Curlew is widely distributed breeding across Europe from the British Isles, through north-western Europe and Scandinavia into Russia extending east into Siberia, east of Lake Baikal. It winters around the coasts of north-west Europe, the Mediterranean, Africa, the Middle East, the Indian Subcontinent, South-East Asia, Japan and the Sundas. The species breeds on upland moors, peat bogs, swampy and dry heathlands, fens, open grassy or boggy areas in forests, damp grasslands, meadows (del Hoyo et al. 1996), non-intensive farmland in river valleys (Hayman et al. 1986), dune valleys and coastal marshlands (del Hoyo et al. 1996). Non-breeding During the winter the species frequents muddy coasts, bays and estuaries	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					(del Hoyo et al. 1996) with tidal mudflats and sandflats (Snow and Perrins 1998), rocky and sandy beaches with many pools (Johnsgard 1981, Snow and Perrins 1998), mangroves, saltmarshes (Snow and Perrins 1998), coastal meadows (Johnsgard 1981)and muddy shores of coastal lagoons8, inland lakes and rivers (del Hoyo et al. 1996). This widespread species remains common in many parts of its range, and determining population trends is problematic. Nevertheless, declines have been recorded in several key populations and overall a moderately rapid global decline is estimated. As a result, the species has been uplisted to Near Threatened.		
Limosa limosa Black-tailed Godwit	NT				The Black-tailed Godwit has a large discontinuous breeding range extending from Iceland to the Russian far east, with wintering populations in Europe, Africa, the Middle East and Australasia (del Hoyo *et al*. (1996). The species migrates southwards between late-June and October Australasia (del Hoyo *et al*. (1996). In its breeding range it mostly inhabits areas with high grass and soft soil (del Hoyo *et al*. 1996, Johnsgard 1981), occasionally using sandy areas (Johnsgard 1981). This species tends to winter in freshwater habitats (del Hoyo *et al*.	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					(1996), including swampy lake shores, pools, flooded grassland and irrigated rice fields (del Hoyo *et al*. (1996). Subspecies *islandica* and *melanuroides*, however, often winter in brackish habitats (del Hoyo *et al*. (1996) such as sheltered estuaries and lagoons with large intertidal mudflats (Johnsgard 1981), sandy beaches, salt-marshes and salt-flats (del Hoyo *et al*. 1996). Although this species is widespread and has a large global population, its numbers have declined rapidly in parts of its range owing to changes in agricultural practices. Overall, the global population is estimated to be declining at such a rate that the species qualifies as Near Threatened.		
Calidris tenuirostris Great Knot	VU				The Great Knot breeds in north-east Siberia, Russia, wintering throughout the coastline of South-East Asia, and also on the coasts of Australia, India, Bangladesh, Pakistan, and the eastern coast of the Arabian Peninsula (del Hoyo *et al*. 1996). The species breeds on gravelly areas covered with lichen and patches of herbs, heather (del Hoyo *et al*. 1996), *Empetrum* spp., *Dryas* spp. and *Vaccinium* spp. (Johnsgard 1981), or alternatively on areas with a continuous layer of lichen and scattered stunted larch *Larix* spp. or dwarf pine *Pinus pumila* (del Hoyo *et al*. 1996). In	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					its wintering range the species occurs in sheltered coastal habitats such as inlets, bays, harbours, estuaries and lagoons with large intertidal mud and sandflats, oceanic sandy beaches with nearby mudflats (del Hoyo *et al*. 1996, Higgins and Davies 1996), sandy spits and islets, muddy shorelines with mangroves and occasionally exposed reefs or rock platforms (Higgins and Davies 1996). This species has been uplisted to Vulnerable owing to a rapid population decline caused by the reclamation of non-breeding stopover grounds, and under the assumption that further proposed reclamation projects will cause additional declines in the future.		
Limnodromus semipalmatus Asian Dowitcher	NT				Asian Dowitcher has a disjunct breeding range in the steppe regions that extend from west to east Siberia, Russia, and south into Mongolia and Heilongjiang in north-east China. It has been recorded as a non-breeding visitor to Japan, North Korea, South Korea, mainland China, Hong Kong (China), Taiwan (China), Kazakhstan, Uzbekistan, India, Bangladesh, Sri Lanka, Myanmar, Thailand, Vietnam, Philippines, Malaysia, Singapore, Brunei, Indonesia, Papua New Guinea, Australia and New Zealand. It breeds in extensive freshwater wetlands in the steppe and forest steppe	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					zones. Suitable habitats include lake shores, river deltas, flooded meadows and grassy bogs along rivers with short grass and sedge vegetation (del Hoyo *et al*. 1996), and areas of bare mud (Johnsgard 1981). During the non-breeding season it occurs in sheltered coastal environments, primarily estuarine and intertidal mudflats, lagoons, creeks and saltworks (del Hoyo *et al*. 1996). It will also roost on sandy beaches or in shallow lagoons during this season (del Hoyo *et al*. 1996). This species is classified as Near Threatened because, although it is quite widespread, it has a moderately small population overall and this is thought to be in decline, owing primarily to destruction of its wintering grounds. An even more rapid population decline may take place in the future owing to climate change.		
Turacoena modesta Slaty Cuckoo-Dove	NT				The Slaty Cuckoo-dove is restricted to Timor-Leste, West Timor and Wetar, Nusa Tenggara, Indonesia, where it is generally uncommon or rare. Historical records indicate that it was once fairly common, at least locally on Wetar and in West Timor, even near settlements. A paucity of recent records, despite extensive searching, suggests that a marked decline has occurred in West Timor. However, recent	The Slaty Cuckoo-dove was recorded on five occasions at Suai development area. This species is expected to forage and nest within the deciduous forest and woodlands of the project area.	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					survey work in Timor-Leste revealed it to be frequent in a wide range of habitats (Trainor *et al*. (2004). It inhabits primary and tall secondary monsoon-forest, often where this habitat is drier or more open, and also vine thickets, thickly vegetated gullies and eucalyptus woodland with dense understorey, from sea-level to 1,770 m (Trainor *et al*. 2007a, Mauro 2003). As it has been found in "more or less open areas near villages", it probably has a degree of tolerance to habitat degradation, and in Timor-Leste appears to be more common in patchy landscapes (forest edge, secondary forest, woodland with scattered figs, Eucalyptus savanna or non-Eucalyptus woodlands with tropical forest trees in gullies or on scattered rock outcrops) (Trainor *et al*. 2007a). This species is classified as Near Threatened because recent surveys in Timor-Leste have shown it to be more abundant than once feared, and to inhabit a wider range of habitats. However, it is still suspected to be declining moderately rapidly owing to the levels of hunting and rates of habitat loss, and it is therefore classified as Near Threatened.		
Gallicolumba hoedtii Wetar Ground-Dove	EN				The Wetar Ground Dove occurs in West Timor and Wetar, Nusa Tenggara, Indonesia, and Timor-Leste. This species is	This highly rare pigeon was recorded 20 km to	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					one of the rarest pigeons in the world (Timor and Wetar) and may have specialised habitat requirements. In Timor-Leste, it was found in 2005 in spring forest at Foho Lulik, on the south coast near the Indonesian border (Lambert *et al.* 2006). No other regular sites are known anywhere, but traders in Dili indicated that captured birds were obtained from the Natarbora area, which includes a wild area of swamp forests, secondary forests and wetlands in the Sungai Clere region of Manufahi (Same) and Manatuto districts. Birds seen appeared to have a strong association with the spring habitat, but more survey work is needed on the broad coastal plain on Timor-Leste's south coast. It is believed to be absent from Nino Konis Santana National Park in the far-east (Lambert *et al.* 2006). It inhabits lowland monsoon-forest, and possibly woodland, up to 950 m. In West Timor two of the three records have been from "forest near a clearing" and "fairly undisturbed hill forest". Its habitat receives highly seasonal rainfall, but it is not known whether it makes any dispersive movements, e.g. in response to bamboo seeding events, as in several of its congeners (Trainor *et al.* 2007b). It is possible that this species is associated with bamboo, and thus partly nomadic (Lambert *et al.* 2006). Birds found recently in Timor-	the west of the Suai development area. Suitable habitat is present in the project area and despite being extremely rare this species can be expected to occur. Considering the rare appearance of this species in the wild determines that it may 'possibly' occur as opposed to 'likely'.	

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					Leste were only found within gallery forest and remnant trees bordering a wide stream, suggesting wet forest - possibly even only that associated with flowing water - is important breeding habitat (Lambert *et al.* 2006). It has been presumed to be largely solitary and to forage on the ground like its congeners but it appears to call from, and nest in, the canopy (Lambert *et al.* 2006). It appears to be a dry-season breeder. This species qualifies as Endangered because it has suffered a very rapid population decline which is expected to continue as a result of severe lowland habitat loss and hunting. A healthy population may survive on Wetar, but further surveys are required to establish its current status.		
Treron psittaceus Timor Green-Pigeon	EN				The Timor Green-pigeon is endemic to Timor-Leste, West Timor and its satellite islands, Semau (though there is no recent data) and Roti, Nusa Tenggara, Indonesia, where it appears to be uncommon or rare, and apparently very local. It has been infrequently recorded during recent fieldwork, although it is perhaps overlooked owing to its inconspicuous and very wary disposition. It inhabits primary and tall secondary, lowland dry and monsoon-forest, mostly in the extreme lowlands, straggling up to 1,000 m (Mauro 2003,	This species is typical localised in their distribution and may be nomadic in response to the fruiting cycle of Fig trees. Suitable habitat is present in the project area and general vicinity, it is expected that this species may occur.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					Trainor and Soares 2004 and Trainor *et al.* 2007a). It may be nomadic in response to the fruiting cycle of figs, and is usually encountered in small flocks containing tens of birds, exceptionally up to 140 individuals (Trainor *et al.* 2007a). It is thought to have declined recently throughout West Timor, but is more common in Timor-Leste (Trainor *et al*. 2004). The population of this species is suspected to be declining very rapidly, concurrent with the rapid reduction in its lowland forest habitat. As a result, it is classified as Endangered.		
Ducula rosacea Pink-headed Imperial-Pigeon	NT				The Pink-headed Imperial Pigeon is restricted to Indonesia and Timor-Leste, where it occurs in four Endemic Bird Areas (Northern Nusa Tenggara; Timor and Wetar; Banda Sea Islands; Northern Maluku) and five Secondary Areas (Seribu Islands; Masalembu; Kangean; Salayar and Bonerate Islands; Tukangbesi Islands). It inhabits forest, scrub and farmland up to 600 m. Despite this wide range, the species appears to have become very rare at least in some areas, and rather uncommon elsewhere. Although it has quite wide range, this species is uncommon and probably has a moderately small population, hence its classification as Near Threatened. It is much sought after by hunters and suffers	Two individuals were recorded perched at Betano. This species is expected to occur at all three sites in habitats that provide foraging, sheltering and nesting potential.	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					from the effects of habitat degradation and is therefore thought to be declining.		
Ducula cineracea Timor Imperial-Pigeon	EN				The Timor Imperial-pigeon is endemic to the mountains of Timor-Leste, and West Timor and Wetar, Nusa Tenggara, Indonesia, with recent reports from only three localities. It is locally common, but presumed to be declining as available habitat continues to shrink. It is presumably resident, perhaps making local altitudinal movements, in Montane forest and monsoon woodland between 600 m and 2,200 m. It is reportedly common in native eucalyptus forest. This pigeon qualifies as Endangered because it has a small population within a very small range (with only four recent locations), and this is suffering severe habitat loss, degradation and fragmentation, such that continuing population declines are likely.	This species is a highland specialist (Montane Forest) and is not expected to occur in the coastal environments of the project area	Unlikely
Cacatua sulphurea Yellow-crested Cockatoo	CR				The Yellow-crested Cockatoo is endemic to Timor-Leste and Indonesia, where it was formerly common throughout Nusa Tenggara (from Bali to Timor), on Sulawesi and its satellite islands, and the Masalembu Islands (in the Java Sea). It has undergone a dramatic decline, particularly in the last quarter of the 20th century, such that it is now extinct on many islands and close to extinction on most others. It inhabits forest	Generally highly localised in response to suitable habitat. Up to 11 individuals were recorded on five occasions within the Suai development area only.Generally this species was	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					(including evergreen, moist deciduous, monsoon and semi-evergreen), forest edge, scrub and agriculture up to 500 m on Sulawesi, and 800 m (sometimes 1,500 m) in Nusa Tenggara. On at least some islands (e.g. Sumba), it appears heavily dependent on closed-canopy primary forest. On others, it survives despite the total clearance of original vegetation, indicating that its habitat requirements are somewhat flexible. Breeding takes place from September to May on Sumba (Walker *et al*. 2005). It nests in tree cavities with specific requirements, tending use chink in the trunk or branch, or a pre-existing nest-hole made by another species, often in dead, snagged or rotting trees (Walker *et al*. 2005). This species of cockatoo has suffered (and may continue to suffer) an extremely rapid population decline, owing to unsustainable trapping for the cagebird trade. It therefore qualifies as Critically Endangered.	recorded foraging and roosting in Sheoak (*Casuarina equisitifolia*) as well as individuals seen flying overhead. This species upon local advice generally translocate up and down the coast.	
Psitteuteles iris Iris Lorikeet	NT				Iris Lorikeet is restricted to Timor and Wetar, Indonesia and Timor-Leste. This species is reported to be not uncommon on Timor-Leste, it still survives in reasonable numbers in West Timor and it is, or at least once was, locally not uncommon on Wetar. It occurs in monsoon forest up to 1,500 m, and also in open eucalypt savannah. This	Suitable foraging, sheltering and nesting habitat exist in the project area for this species, as well as being in the typical distribution boundary and is	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					poorly known species has a moderately small population, and it is likely to be declining owing to trapping and habitat loss; it therefore qualifies as Near Threatened.	therefore expected to occur.	
Aprosmictus jonquillaceus Olive-shouldered Parrot	NT				The Olive-shouldered Parrot is restricted to Timor and Wetar, Indonesia and Timor-Leste, where it occurs on Timor, Wetar and Roti. The species is found up to 2,600 m in monsoon forest, acacia savanna, lightly wooded cultivation and scrubby second growth. This species is listed as Near Threatened because it is believed to have a moderately small, fragmented population, and to be undergoing a continuing decline owing possibly to trapping and forest loss. However, little is currently known about the population size and structure of, and threats to, this species. Further information may indicate it is more threatened.	This species of parrot occurs over a wide range of mostly lowland habitats, and appears to be commonest in *Eucalyptus* woodlands, open forests and coastal environments typical of the project area.	Likely
Todiramphus australasia Cinnamon-banded Kingfisher	NT				The Cinnamon Banded-kingfisher is restricted to four Endemic Bird Areas (Northern Nusa Tenggara; Sumba; Timor and Wetar; and the Banda Sea Islands, the first three with nominate *australasia*, the last one with races *dammeriana* and *odites*), in Indonesia and Timor-Leste. Its distribution within this fairly wide area is, however, very patchy, and it is generally uncommon. This species is a closed-canopy specialist,	It is expected that this species will be found in suitable habitats across all project areas.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					occurring in monsoon forest at 0-700 m. It is also found in secondary habitats such as gardens and cultivated areas, provided that sufficient canopy cover remains. This species is listed as Near Threatened as it has a moderately small and fragmented population which is likely to be declining owing to habitat loss.		
Bradypterus timoriensis Timor Bush-Warbler	NT				The Timor Bush-warbler is endemic to the island of Timor, Lesser Sundas, and is only known from two specimens collected at 1,800 m on Gunung Mutis, West Timor, in 1932, and a sight record (August 1972) from forest at 1,800 m near to Same, Timor-Leste (Dickinson *et al*. 2001). There have been a number of searches by competent observers, although it is likely to be very skulking and easily overlooked (Trainor *et al*. 2007a, Lambert *et al*. 2006). This very poorly known species has been classified as Near Threatened owing to concerns that burning and grazing may be causing a moderately rapid decline in the area of habitat suitable for it. However, rediscovery and subsequent fieldwork may provide data which lead to this threat status being amended.	The project area does not contain any Montane Forest type habitat; given the study areas' proximity in the landscape specifically coastal and near coastal, it is highly unlikely this highly cryptic and poorly documented species occurs.	Unlikely
Heleia muelleri Timor White-eye	NT	x			The Timor White-eye is restricted to Timor, Indonesia and Timor-Leste, where it is	Suitable habitat does occur in the	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					generally uncommon and local, although it can be moderately common in ideal habitat. This species occurs up to 1,300 m in monsoon forest. It appears to favour lower-lying areas with closed-canopy forest, and may not persist in secondary habitats. This species is scarce and local within its restricted range, and is likely to have a small global population size. It is suspected to be declining moderately rapidly owing to ongoing habitat loss. It is currently considered Near Threatened, and further studies are urgently required in order to clarify the magnitude of threats facing it.	project study areas and despite this species being highly cryptic and difficult to identify it is expected this species should occur	
Ficedula timorensis Black-banded Flycatcher	NT	x			The Black-banded Flycatcher is restricted to Timor, Indonesia and Timor-Leste where it appears to be uncommon or locally common, but may be frequently overlooked. It occurs up to 1,200 m in the dense undergrowth of monsoon forest, apparently preferring areas with limestone boulders and rocky scree slopes. Although it has been found in degraded forest patches, it shows a preference for primary habitats. It typically forages alone or in pairs, within 2 m of the ground in dense undergrowth, gleaning insects or making short sallying flights. This species has a moderately small range within which moderately rapid declines are owing to ongoing loss and	This species shows a preference for primary forests but has also been recorded in degraded habitat types. Generally speaking the project area contains very little primary forest but does contain secondary forests and plantation / agriculture habitat opportunities. It is expected that this	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					clearance of lowland forest. As a result it is classified as Near Threatened.	species may occur in low abundance.	
Saxicola gutturalis Timor Bushchat	NT				Timor Bushchat is restricted to the island of Timor (Indonesia and Timor-Leste) and its satellite islands of Roti and Semau (nominate *gutturalis* on Timor and Roti, race *luctuosa* on Semau). Given its restricted range the total population is not thought to be large. It occurs up to 1,200 m in monsoon forest and scrubby savanna. In West Timor it is present even in very small remnant pockets of woodland but is largely excluded from savanna and open scrub by the Pied Bushchat *S. caprata*. It forages on insects by gleaning and sallying in the canopy and in tall shrubbery beneath. It nests mainly October-November, but also May-June. This species is listed as Near Threatened because it may have a moderately small, fragmented population that is undergoing a continuing decline owing to extensive forest loss within its restricted range. However, little is currently known about its population size; further information may indicate its status warrants evaluation.	One individual at Suai development area was recorded. The disparity of records for this species might be a reflection of little survey work conducting for this species and for avian species as a whole. It is expected that this species may occur broadly across suitable habitat types for the south-coast of Timor-Leste.	Recorded
Zoothera dohertyi Chestnut-backed Thrush	NT				Chestnut-backed Thrush is restricted to three Endemic Bird Areas (Northern Nusa Tenggara; Sumba; Timor and Wetar) in	The project area does not contain habitat suitable for	Unlikely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					Indonesia and Timor-Leste. It is considered generally uncommon to rare, only locally common at higher elevations, and is probably already extinct on Lombok and close to extinction on Sumbawa. It occurs at 400-1,700 m in semi-evergreen, lower Montane and Montane forest, occurring at highest densities within primary forest. It is usually solitary but may assemble when at a food source. It has been recorded associating with Chestnut-capped Thrush *Z. interpres*. It is generally less shy and retiring than other *Zoothera* thrushes in the region. It typically forages on the ground. Juveniles have been recorded from July-September but singing within this period suggests an extended breeding season. This species is listed as Near Threatened because there are some indications that its population is fragmented and undergoing a continuing moderately rapid decline owing to trapping. However, little is currently known about the population size and structure of, and threats to, this species. Further information may indicate it is more threatened.	this species specifically a lack of Montane Forest. This elusive bird is generally found at an altitude above 1,100 m and given the project area is coastal and near coastal in origin suggests this species is highly unlikely to occur.	
Zoothera peronii Orange-banded Thrush	NT				The Orange-banded Thrush is restricted to the Banda Sea Islands, Indonesia and Timor-Leste, where it is generally common on Roti and West Timor (race *peronii*), Timor-Leste, Wetar and Romang, Babar	This species of thrush occurs in a wide variety of forest types including secondary forests	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					and Damar (race *audacis*). It occurs up to 1,200 m in forest (including monsoon forest). Although it has been found in degraded patches, it appears to favour areas with closed-canopy forest, which are constantly diminishing. It is largely terrestrial and solitary but will aggregate in small numbers if feeding in fruiting trees. Seen in the mid and upper canopies as well as on the ground. This species is listed as Near Threatened because there are some indications that its population is fragmented and undergoing a continuing moderately rapid decline owing to trapping and loss of lowland forest. However, little is currently known about the population size of and the threats to this species. Further information may indicate it is more threatened.	and occasionally regenerating swidden fields suggests this species is likely to occur.	
Lonchura fuscata Timor Sparrow	NT				The Timor Sparrow is restricted to Timor-Leste, West Timor, and its outlying islands, Semau and Roti, Indonesia, where it is widespread, but generally sparsely and patchily distributed. It is locally moderately common, being described as uncommon to abundant in Timor-Leste (Trainor *et al*. 2004) where recent surveys at two sites along the Laivai River located several groups of 30-50 birds within a few hectares in a short period at both sites, suggesting a likely population total in the thousands for	This species have been found in substantial populations in dry degraded savanna-woodland landscapes (especially river valleys associated with irrigated ricefields) specifically on the	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					the entire river region (Trainor *et al*. 2004). It mainly frequents the extreme lowlands, sometimes ascending hills to around 700 m, where it regularly occurs as individuals or in small groups of three to five birds, occasionally mixed with other granivorous birds, and can form larger flocks with groups of 30-50 recently recorded (Trainor *et al*. 2004). It forages on or near the ground in grassland, lightly wooded cattle-pasture, scrub, overgrown gardens, deciduous or degraded monsoon-forest and the margins of cultivation, and in Timor-Leste was found in *Eucalyptus alba* savanna, ricefields, severely degraded coastal shrublands and riparian woodland dominated by *Casuarina* (Trainor *et al*. 2004). This species is listed as Near Threatened because recent assessments suggest that the population may experience a moderately rapid decline as a result of habitat loss and increasing exploitation for the cagebird trade.	north coast of Timor Leste but is not restricted to this location. Further survey effort and research into this species will give a greater understanding of its ecological requirements.	
Acerodon mackloti Sunda Fruit bat	VU				A coastal species occurring from sea level up to 450 m asl, and roosts in colonies of 300-500 individuals in secondary forest and gardens.	Distributed throughout the large islands of Nusa Tenggara, its presence on Timor has been confirmed recently (Helgen 2004). Large	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
						colonies of this species would be significant if present in the project area.	
Nyctimene keasti Keast's Tube Nosed Fruit Bat	VU				Roosts and forages in tall vegetation, gardens, feeding on fruit; very little information is available for this species.	No records on Timor since Andersen (1912 cited in Goodwin 1979). Found elsewhere in Indonesia, but the poorly known taxonomic relationships in this genus limit knowledge of distributions and conservation advice.	Unlikely
Pteropus temminckii Temminick's Flying-fox	VU		App II		Reported from tropical moist forest, not likely to occur in large colonies.	Found in the central Moluccan islands, Simmons (2005) regards its distribution on Timor-Leste as doubtful.	Unlikely
Pteropus vampyrus Large Flying-fox	NT		App II		This species generally ranges through much of continental and insular Southeast Asia. On the mainland, it has been reported from	This species occurs in primary and secondary forests	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					southern Myanmar, southern Vietnam (possibly southern Cambodia), through much of Peninsular Malaysia to Singapore. The species is found over much of Indonesia, being recorded from the islands of Sumatra, Bangka, the Mentawi Islands (Sipura, North Pagai and South Pagai), the Krakatau Islands, Java, Bali, Lombok, Sumbawa, Sumba, Savu, the Anamba Islands, the Natuna Islands (Bunguran Besar) and Siantan. It is present on the island of Timor (Timor-Leste and Indonesia), and on Borneo (Brunei, Indonesia and Malaysia). This tree roosting species is tolerant to some habitat disturbance; it occurs in primary and secondary forest and uses adjacent agricultural areas for feeding (Bates *et al*. 2008). In view of the species wide range, it seems probable that it is present in many protected areas. There is a need to protect important roosting sites for this species, and to regulate any hunting pressure.	and thus should be expected to occur in such habitat types of the project area.	
Rhinolophus canuti timoriensis Canut's Horseshoe Bat	VU				Roosts in caves, and has been recorded foraging in a variety of habitats including intact primary forest, riparian zones and over grasslands adjacent to rocky outcrop (Armstrong 2007).	Distinct subspecies found on Timor, other distributional records in Java, Nusa Barong and Bali, where it is apparently	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
						uncommon. Possibility of occurrence if rocky outcrop and caves are nearby, records in the project area are significant. This species was recorded at Suai and Betano.	
Sus celebensis Sulawesi Warty Pig	NT			x	The Sulawesi Warty-pig is found in the lower east portion of the oriental region and the upper west portion of the Australian region. *Sus celebensis* is common in the northern, central and eastern Sulawesi Island. Available evidence supports that this species formerly occurred throughout Sulawesi, as well as the neighboring islands of Selayer, Muna, Buton, Peleng, Lembeh and the Togain Islands. The species is now scarce in Southern Sulawesi and may also be extinct on the nearby Selayar due to the virtual deforestation of these areas. Wild pigs referred to as feral *S. celebensis* have been extensively introduced in Indonesia on the islands of Halmahera, Flores, Timor, Lendu, Simeuleu, and Nias Islands, and the domesticated forms of *S. celebensis* can be seen on the islands of Roti and Savur. (Macdonald 1993). Celebes wild boars are	This species may have been introduced to Timor-Leste and may possibly be expected to occur as a domestic animal in subsistence agriculture.	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					reported to occur in a wide variety of habitats on the Indonesian Islands, including rainforests, swamps, high grassland terrains, and agricultural areas. They are found at altitudes up to moss forest at about 2300 m, but they prefer valleys. (Huffman, 1999, Parker, 1990).		
Rusa timorensis Javan Rusa	VU			x	The Javan Rusa is believed to be native only to Java and Bali in Indonesia. It has been introduced to many other islands of the Indo-Pacific region. Some introductions apparently took place in antiquity within present-day Indonesia, to the Lesser Sunda islands, Maluku (= Molucca) islands (including Buru and Seram), Sulawesi, and Timor. This species is essentially a tropical and subtropical grassland species but is highly flexible, with successful populations in forests, mountains, shrublands and marshes.	Despite being listed as Vulnerable upon the IUCN Red List, this species is historically an introduced species from neighbouring Indonesia. Introduced populations are not assessed as being conservation significant.	Likely
Bos javanicus Banteng	EN			x	The Banteng (*Bos javanicus*), also known as tembadau, is a species of wild cattle found in Southeast Asia. Banteng have been domesticated in several places in Southeast Asia, and there are around 1.5 million domestic Banteng, which are called Bali cattle. These animals are used as working animals and for their meat. Bali has been introduced to Timor-Leste, where they	This species was intermittently recorded across the three project areas. Despite being listed as Endangered upon the IUCN Red List, this species is historically an	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					have established stable feral populations.	introduced species from neighbouring Indonesia. Introduced populations are not assessed as being conservation significant.	